ATE EPILOGUE COMPREHENSIVE REPORT

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EXECUTIVE SUMMARY

This report presents the findings and the case write-ups from the study "Exploring Past Investment in Learning through Grant-funded Undergraduate Advanced Technology Education Centers (EPILOGUE)," a two-year study which examined the processes and structures that allow centers to have an impact on advanced technological education after their grant funding ended. By sharing what we've learned, we hope education initiatives within and beyond ATE may deliberately and efficiently plan for scaling early in their work.

The findings draw from interviews, archival documents and public information about ten ATE centers. Six of these centers have concluded grant funding, three are included because their partnership approach is so unique and one was included because it is a successor to a prior Center. The report will provide you with an overview of the purpose of the project, some background on prior efforts that helped frame how we approach the work, what we know about scaling and sustaining educational innovations and a summary of each center. This will be followed by the presentation of findings with examples from the centers. If you would like to better understand the history of each center involved, you can find short case write ups at the end of this report.

Participating centers include:

- SpaceTEC
- Center for the Advancement of Process Technology (CAPT)
- Midwest Center for Information Technology (MCIT)
- Consortium for Alabama Regional Center for Automotive Manufacturing (CARCAM)
- Nashville Centers (SEATAC/TNIT)
- Bio-Link
- InnovATEBIO
- CyberSecurity Centers
    - Center for Systems Security and Information Assurance (CSSIA)
    - National CyberWatch
    - National Cybersecurity Training & Education Center (NCyTE)

Key Findings

Across the cases, there were six major themes uncovered:

Partnerships

All centers require strong partnerships, especially with industry, to fulfill their mission. Partnerships have different purposes and can change based on the evolution of the work. Types of partnerships observed include:

- A community of practice may bring together groups of individuals to build capacity as educators, often sharing knowledge and skills.
- Partnerships with professional organizations can accelerate scaling.
- Individual strategic partnerships may be with other colleges that utilize curricular or training materials developed through the center, with organizations that fulfill niche services or with individuals who provide key consulting activities.

- Industry partnerships, by ensuring technical education is relevant and timely, support the development of curricular materials, internships and advisory services.
- Partnerships within the ATE community exchange new innovations, practices and resources.

Team formation

The right project team is essential at all stages of the work. Efforts may be initiated by industry, academics, or nonprofits. As the work evolves, so might the team. In many cases, the individuals that set the initial vision step back as those that can facilitate implementation move into higher levels of leadership. Additionally, the scope of work may evolve in a manner that shifts the balance of commitment and/or sense of ownership.

Leadership characteristics

ATE Centers rely on strong leadership. In addition to grant management responsibilities, leaders are tasked with steering the center, often through a constantly changing ecosystem. Several leadership characteristics and skills emerged that promote sustainability. Each center leader must be a champion of the educational mission, build and nurture relationships, and implement the grant. The balance of the leader's focus will vary based on the current phase or circumstance surrounding the grant.

Creating an independent organization

Sometimes sustaining an initiative means creating a new, independent organization. Knowing if and when to move to independence depends greatly on the relationship to the home institution including the alignment of mission, the revenue structures and the leadership structures in place versus those needed moving forward.

The role of the National Visiting Committee and the use of data and external evaluation

The National Visiting Committees (NVC) are used to help set strategic directions for the centers. A review of the center's strengths and challenges contextualized against current economic conditions. NVCs are particularly valuable in considering scaling and sustaining innovations of the center. External evaluation also offers an independent perspective. The evaluation findings can help a center pivot in response to contextual changes, create alignment between partner organizations and provide external perspective.

INTRODUCTION

Purpose of the study

This report presents the findings and the case write-ups from the study "Exploring Past Investment in Learning through Grant-funded Undergraduate Advanced Technology Education Centers (EPILOGUE)" a two year study designed to answer:

> What innovations, products and resources created by ATE centers continue to influence technician education after center funding ends?

By sharing what we've learned we hope education initiatives within and beyond ATE may deliberately and efficiently plan for scaling early in their work. Our findings are related to six major themes we uncovered through case study exploration:

- Partnerships
- Team formation
- Leadership characteristics
- Creating an independent organization
- The role of the National Visiting Committee
- Use of data and external evaluation

The findings draw from interviews, archival documents and public information about 10 ATE centers. Six of these centers have concluded grant funding, three are included because their partnership approach is so unique and one was included because it is a successor to a prior Center. This report was written for anyone involved with scaling or sustaining educational initiatives. The report will provide you with an overview of the purpose of the project, some background on prior efforts that helped frame how we approach the work and what we know about scaling and sustaining educational innovations and a summary of each center. This will be followed by the presentation of findings with examples from the centers. If you would like to better understand the history of each center involved, you can find short case write ups at the end of this report.

This work is for you!

This report is designed to be of use to anyone who cares about scaling or sustaining an educational innovation. Knowing the lasting impact of the centers may be useful to several audiences:

- Current center PIs may benefit from learning from their predecessors about how to scale and/or sustain elements of their centers and other topics that they may need to consider as they try to impact technical education.
- Proposers of new centers may gain a greater awareness of planning for scale and/or sustainability.
- Reviewers of ATE center proposals may be better equipped to judge the proposals.

History

I've been involved with the ATE community since serving as an evaluator of the 2008 Synergy: Research, Practice, Transformation project (SynergyRPT). The SynergyRPT project brought 13 centers together regularly over four years to tackle the wicked problem of scaling and sustaining educational innovations.

Synergy utilized aspects of problem-based learning, building communities of practice and effective professional development. That approach is useful with such wicked problems[1] (those that are often ill defined or not well understood, defy simplistic approaches, and resist easy resolution). They are usually interdependent and often symptomatic of other problems. As the evaluator for that project, I spent many hours interviewing the participants, observing meetings, and working with the experts to understand both the topic as well as the impact of the project on the Centers. Many of the center PIs that participated have been stalwarts of the ATE community and learning from them was transformative. Gerhard Salinger, my Co-PI on this project, was the program officer for the Synergy project and reports that the impact of SynergyRPT became clear through the annual reports of participating centers. Over the course of the SynergyRPT project, we found centers partnering to exchange ideas and model practices around work processes, rather than content areas. One of the lessons learned in that setting was that it was more important to explore how we do our work rather than the content focus. This report is built around that finding by focusing on conditions and structures that promote sustainability, not necessarily content areas.

In 2017 Gerhard reached out to SageFox with the idea of studying what happens to innovations developed by ATE Centers after grant funding ends. He said he'd seen so many wonderful materials and approaches to technical education over the years, but wasn't sure what their consequence had been.

At the 2017 PI meeting, Gerhard and I proposed this study to participants and found a strong willingness to participate and an eagerness for answers. When we published our call for participation, we received 17 responses. At the 2018 PI meeting, we were repeatedly asked what we've learned, though our project had only been funded for two months. There is a real eagerness within the community to ensure our labors of love, which reflect these educators' commitment to technical education, are sustained.

Why we chose centers that sunset

NSF has funded centers for STEM education through several programs as a mechanism of scaling, sustaining and supporting other programmatic efforts. The ATE program has made significant investments into national, regional and resource centers to promote collaborations of community colleges and the scaling and sustainability of advanced technological education at community colleges that educate students for participation in the high technology workforce.

Many of these centers were active over several funding cycles to serve to aggregate the knowledge of technician education in a particular field. Often a particular center started out as a project and then became a regional center before becoming a national center. Some went on to become resource centers. During the life of the centers, much was learned through third-party evaluation, participation in the annual ATE program data collection effort led by EvaluATE (NSF 1600992) and annual project reports. ATECentral (NSF 1261744) has served as a resource hub promoting the work of ATE centers and projects within and beyond the community including a section on sustainability. However, this information was never investigated to determine what exactly centers do and the impact they have on the community. A 2007 report investigated what organizational parts of centers remained after funding ceases (Reid, Jacobs, Ivanier & Morest, 2007) painting a bleak picture, as reporters found that the structure of the

[1] https://en.wikipedia.org/wiki/Wicked_problem

center usually disappears when the funding ceases. This project offered a moment for additional reflection not on what remains structurally, but how centers change the environment for technician education.

The Epilogue study mainly reviewed the spread of innovation from sunsetted centers; However, active centers and projects have spread innovations as well. A few are detailed at the end of the report.

This is not an evaluation report!

Through this study, case histories of the centers were developed using PI reflections, project artifacts such as evaluation reports, NVC reports and other materials. The interview guide was designed to understand the purpose of the center and identify an element worthy of deeper exploration. That is to say, the case histories are NOT comprehensive reports of each center, nor are they evaluation reports. Rather they provide a story of how one component of their educational efforts was sustained over time. Similarly, there are likely other examples and lessons to be learned that did not come forward based on the sample and initiative chosen for deeper exploration.

Thank you!

A huge number of people were involved in this study from the advisory board, to former PIs, their industry partners and evaluators and members of the ATE community more broadly who entertained me with informal conversations of sustainability during the 2018 and 2019 PI meetings. To all of them I owe a debt of gratitude for their time and thoughtfulness.

Rebecca Zarch, PI
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A [brief] History of the ATE Program

In 1992, the US Congress passed the Scientific and Advanced-Technology Act (SATA[2]) requiring the National Science Foundation to establish a program "of awarding competitive grants to accredited associate-degree-granting colleges which can provide competency-based technical training in advanced-technology occupational fields."

In developing the program, NSF tweaked the terms of SATA to fit it into the NSF culture. The program was named Advanced Technological Education (ATE) to emphasize education for technician occupations rather than training for specific jobs. The Program is founded on the premise that technicians need particular knowledge, skills and abilities. Early on the ATE program established that, though it was not primarily a transfer program to four-year colleges, the projects should allow the opportunity for transfer. As many community colleges had two tracks – academic (allowing transfer) and not-for-credit courses, there was a concern that the ATE program could fall into the chasm that existed between these tracks.

[2] https://www.congress.gov/bill/102nd-congress/senate-bill/1146

The planning for the ATE Program started with a workshop in which selected two-year college faculty met with business and industry leaders. Collaboration with business and industry has been a requirement for projects and centers since the conception of the Program. Many industries have made both financial and in-kind contributions to ATE projects and centers. In return, technicians are better educated and occupation-ready, creating a mutually beneficial relationship.

ATE Centers

SATA called for "centers to serve as national and regional technical education clearinghouses and models for other colleges and secondary schools." The ATE program established centers in various disciplines with significant funding for four years to support projects in those disciplines. Planning grants were encouraged for those considering proposals for centers. Some of the initial centers served to bring multiple projects together. One center worked with industry and professional organizations to establish standards for programs in information technology; another became the go-to resource for colleges establishing programs for environmental technicians. Projects saw the centers as sources of good information. Collaboration with centers became a strong point in project proposals to the ATE program. Annual visits from a National Visiting Committee (NVC) to each center provided the opportunity for further collaboration. All Centers were required to have an NVC composed of representatives from industry, other community colleges, and other projects. Visits are designed to review the progress of the center and make recommendations to the PI and to NSF.

Community and Collaboration

The ATE Program established an annual conference of principal investigators of ATE projects and centers with attendance negotiated into the grant documents. These conferences encouraged interactions between principal investigators to share emerging practices. The showcases of projects and centers sparked conversations and further collaborations among two-year college faculty. Although there might be competition between principal investigators in securing funding; once funding was attained, there was collaboration – "coopetition." The ATE PIs became part of a family.

The American Association of Community Colleges (AACC) planned and organized the annual Principal Investigators' meetings[3] through a grant in 1993, which has continued annual meetingsWith a planning committee that includes PIs and program officers, the content of the meeting and its structure is highly relevant to the participants. The showcases, during which the community can visit projects and centers exhibiting their work, is the heart of the meeting, allowing time for conversation and collaboration. Projects are invited to nominate students to attend the conference,engage in a special program, present and discuss their projects and network. For many students the ATE PI conference is their first airplane ride and conference experience. In keeping with the community-driven model, each conference ends with a session in which the center directors meet with the ATE leadership to discuss current issues facing the community.

Faculty Development and Grant Support

The ATE program established programs and practices[4] to help two-year college faculty achieve success in preparing grant proposals and managing the NSF awards. In the first years, six-page preliminary proposals

[3] https://www.aacc.nche.edu/programs/advanced-technological-education/
[4] https://www.ccdaily.com/2021/03/ate-supports-multiple-mentoring-initiatives/

were encouraged and reviewed in panels. The responses include advice to strengthen the proposal. Though this practice ended, the American Association of Community Colleges and Florence Darlington CC established workshops (Mentor-Connect[5]) in which a community college could propose a project and receive an experienced mentor to guide them.

Evaluation Support

The Evaluation Center at Western Michigan University became the evaluator for the ATE program (EvaluATE[6]). Together with the lead program officers, a survey of ATE projects and centers was developed. The survey provides annual data that is used to report on the program to Congress. The response rate is over 90% because the program officers insist that the projects respond to the survey. The survey contains a dedicated section so that ATE researchers can ask questions of existing projects and centers. All projects and centers were required to have an evaluator and an evaluation plan. EvaluATE built the capacity for project evaluation by holding workshops for PIs and evaluators. It now provides webinars, resource materials, newsletters, workshops, and opportunities for ATE community members to engage around issues related to evaluation in the pursuit of excellence in technical education.

Program Information Hub

ATE Central[7] was founded by Internet Scout Research Group, based at the University of Wisconsin-Madison. In its role as an information hub for the ATE community, a core component of the project is an online searchable repository that aggregates and archives instructional and professional development resources and materials developed by ATE projects and centers. Since its inception in 2008, the project has expanded to include an array of services and tools designed to support and amplify the efforts of the ATE community, including publications, workshops and webinars focused on topics like outreach, accessibility, and sustainability. Tools created by the ATE Central team include the Microsite Service, which provides an editable website for every new ATE grantee, the ATE Fact Sheet, which presents a continuously-updated dashboard of information about the ATE program, and ATE 101, an online guidebook for new grantees.

National Visiting Committees

The PIs formed collaborations and supported one another by serving on each other's National Visiting Committees. Some PIs became leaders in programs funded by other agencies such as the Department of Labor TAACCCT[8] projects. Some PIs became so invested in the program to an extent that ways were found to keep them active in the Program even after their project or center ended. The projects and centers also provided experiences that a few PIs used to move into positions of leadership as deans and presidents of community colleges and in agencies of state governments. PIs began to serve on national committees including study committees at the National Academies. With the present reduction in the number and duration of centers, the PIs from centers being sunsetted are working together with new PIs so that new centers build on the work of older centers. With fewer centers there will be more collaboration with and mentoring of projects.

[5] https://www.mentor-connect.org/
[6] https://evalu-ate.org/
[7] https://atecentral.net/
[8] https://www.dol.gov/agencies/eta/skills-training-grants/community-colleges

HI-TEC Conference

After several centers requested funds for technician education conferences, in 2009 the ATE program supplied seed funding for the High Impact Technology Exchange Conference (HI-TEC[9]). It is a conference that also includes industry and educators without ATE grants to discuss technician education. The conference continues to be self-sustaining. In addition, the ATE sponsored the development of webcasts that supported the infrastructure such that projects and centers could concentrate on the content.

THE STUDY APPROACH

This study uses a case study approach, a useful methodology when multiple sources of evidence are needed to expose a range of variables (Yin, 2009). Case studies offer an opportunity to explore themes in depth and in context, rather than produce generalizable knowledge (Stake, 1995). When examining the topic of scaling, case studies with multiple perspectives are particularly valuable (Scheirer & Dearing, 2011). By exploring the lasting impact of ATE centers that span a range of technical areas, educational innovations and communities, the EPILOGUE study is designed to illuminate the variation in which sustainability can be achieved.

Advisory Board

An advisory board provided expert guidance at key project moments including feedback on the selection of centers, the case write ups, and the final report. The breadth of the advisory team has greatly enriched this study and the study team wishes to express deep gratitude. Members of the advisory board and their expertise include:

Board Member	Relevant expertise
Ann Beheler, Collin College	Principal Investigator, National Convergence Technology Center, longtime observer of the ATE community
Chris Dede, Harvard University	Researcher on scaling and sustaining educational innovations
James Dearing, Michigan State University	Researcher on the diffusion of innovations, including the adoption and implementation of new evidence-based practices, programs and technologies
Arlen Gullickson, Western Michigan University, Emeritus	Former PI of EvaluATE, longtime observer of the ATE community
Duncan McBride	Former NSF Program Officer, ATE

[9] https://www.highimpact-tec.org/

Protocol Development

Each interview was guided by a semi-structured protocol. The protocol was developed to be flexible enough to accommodate a diverse range of project types and approaches but consistent enough to uncover the structures and conditions that allowed for sustainability.

Several theoretical frameworks were considered when developing the protocols:

- Collective Impact
- Social Learning Theory
- Scaling up innovations
- Diffusion theory and innovation attributes
- Business Model Canvas / Lean LaunchPad

Information about these frameworks and links to additional resources can be found in Appendix A.

Data Sources

The primary source for the center stories is the oral history provided by the center PIs over the course of several interviews. Some of the centers' evaluators and/or industry partners also participated in interviews during which time they shared their perceptions of the center's legacy. Interviews were not typically recorded but detailed notes were taken during the conversations.

When possible, centers provided their National Visiting Committee (NVC) reports, evaluation reports, and center-delivered presentations or articles. In several cases, so much time had lapsed that these reports were no longer available or accessible. A natural disaster (flood) destroyed the reports from one center.

	Interview			Project reports and documentation		
Center	PI / Co-PIs	Industry Representatives	Evaluator	Evaluation Report	NVC	Other reports & documentation
SpaceTEC	X			X	X	X
CAPT	X	X				X
MCIT	X	X	X	X	X	X
Nashville Centers (SEATAC/TNIT)	X			X		X
CARCAM	X		X			X
Bio-Link	X	X	X			X
InnovATE*BIO*	X					X
CYBER SECURITY	X		X	X	X	X

Table 1: Data sources for each case write up

Additional data sources include publicly available information such as award abstracts, newspaper articles, and information available through ATE Central and/or publications as part of the PI meetings.

Thematic Exploration

The first year of the project focused heavily on building the case stories of each of the participating centers. At first, the study team had hoped to have a framework flexible enough for consistent reporting on each center (history, highlighted innovation, evolution, sustainability and lessons learned). The center stories, however, were so complex and varied that the framework became too limiting.

Each preliminary case write-up was reviewed by the Advisory Board for a) themes to explore in future interviews b) insights based on their contextual knowledge of the center and/or c) themes that emerged across centers.

The case write-ups were also reviewed by the Center PIs to ensure the story was captured accurately and, given that the case stories are succinct whereas the center histories are complex, were reflective of the appropriate themes.

The second year of the study involved constructing final case stories and developing the cohesive narrative around the individual write-ups that would bring value to the community. Although this report presents a variety of themes related to sustaining an educational innovation, the reality is the themes are tightly interwoven, highly responsive to the local context and cannot be implemented in isolation. The ATE program is designed to improve America's skilled technical workforce. Each center was funded to address a technical area with a particular set of activities. Yet each center operated in the context of a larger institution with unique policies and culture. The case examples are therefore intended to be descriptive, but causal claims cannot be made. With this in mind, the study team presents a set of themes that emerged in relation to ensuring the sustainability of an educational innovation. The findings to the following themes are presented below:

- Partnerships
- Team formation
- Leadership characteristics
- Moving to an independent organization
- The role of the National Visiting Committee
- Use of data and external evaluation

Recruitment and Selection of Centers

Over the last 25 years, the NSF ATE program has funded nearly 60 centers. Some centers have lasted decades while others were short lived. This study is designed to capture the lasting impact of centers, thus the centers in this study were purposefully selected to ensure that each center had evidence of demonstrable impact.

Selection of centers involved direct recruitment and an open invitation to participate in the study. At the 2018 ATE PI meeting the study was promoted among the community. PIs of centers that had completed their NSF grant funding were encouraged to apply. Recognizing that many of the PIs would not be at the

meeting, Co-PI and former Program Officer Gerhard Salinger reached out to former PIs and encouraged them to apply.

Interested PIs were asked to respond to a request for participation via a short form through which PIs identified their center, date ATE funding concluded, technical area, and a brief description of the innovation the PI thought might be worth pursuing. There were 17 applicants representing 16 centers that applied to participate.

The project PIs conducted an initial review of centers with an eye towards the following criteria for inclusion:

1. There was evidence that an innovation was sustained in some form.
2. The center had to have sunset, ideally over 12 months prior.

Familiarity with the center also factored in while vetting centers to include. In some cases the project PI team's personal knowledge about the center's history and the story the center might share was included in the rationale.

Twelve centers were then invited to participate in an exploratory conversation (see appendix C) with the PIs during which the potential innovation for exploration was discussed more deeply. Six inactive centers were selected for participation at the end of the recruitment period: Bio-Link, CARCAM, CAPT, MCIT, SpaceTEC and TNIT/CITE (later expanded to include prior center iterations including SEATAC and TFLATE).

In the summer of 2019, Co-PI Salinger suggested that the three cyber security centers, CSSIA, CyberWatch National and CyberWatch West (Now NCyTE) would make an interesting addition to the study as the three centers were highly collaborative and leveraged each other for sustained funding for cyber security technical education. The three centers were thus brought on as one case example to explore the structural conditions that promote collaboration.

Finally, during the course of this study, the InnovATE*BIO* Center launched, evolving from the work under Bio-Link. The transition between the two centers is captured.

CASE STUDY PARTICIPANTS

SpaceTEC

SpaceTEC[10] was formed through ATE center funding by three titans of the space industry in 2002. SpaceTEC served to train and certify aerospace technicians with portable credentials. Scaling was part of the design from inception. The organization followed a strategic plan of developing a network of community colleges co-located with space centers to develop curriculum and train students, running the grant like a space contract. When the original Center became a resource center with significantly less funding, SpaceTEC moved on to only developing certifications, thus leaving curricular innovations to the individual colleges. Now, 20 years later and with over 100 partners, SpaceTEC is an independent organization and serves as the developer of certifications for the aerospace industry for ASTM.

[10] https://d22ace60-40a6-43a2-9b7a-def4421bc8a8.filesusr.com/ugd/a99d33_c4cfd9cfe79048018d2a00c9ea292bdd.pdf

Center for the Advancement of Process Technology (CAPT)

The Center for the Advancement of Process Technology (CAPT)[11] was formed in 2002 to further support the work underway at the College of the Mainland (COM) in the process technology sector through a partnership with the newly formed Gulf Coast Processing Technology Alliance (GCPTA). ATE funding allowed CAPT to accelerate the impact of GCPTA by formalizing the materials associated with the new Process Technology (PTEC) associates degree program. CAPT created course materials, textbooks and training programs and leveraged the GCPTA to disseminate these educational supports. Ultimately, the GCPTA took on a national presence as the North American Process Technology Alliance (NAPTA). NAPTA absorbed the CAPT materials and took responsibility for ongoing review, dissemination, and certification exams. CAPT closed in 2011 with the work living on through NAPTA, which is the standard bearer of the PTEC curriculum, used by over 50 Process Technology programs in community colleges across the country

Midwest Center for Information Technology (MCIT)

Run through an Omaha-based non-profit, the Midwest Center for Information Technology (MCIT)[12] was established in 2001 as a consortium of ten previously disconnected community colleges in Nebraska, Iowa, and North and South Dakota with the participation of some four-year colleges and industry. It ran through 2015, bringing together the regional colleges into a networked improvement community to provide professional development for faculty to prepare a local information technology workforce. The member colleges continue to collaborate.

Nashville Centers

A progression of ATE projects and centers in Nashville, Tennessee[13] supported multiple innovations to define a new model for technological teaching and learning – a model that would contextualize technological content for students and teachers within pedagogy grounded by the latest knowledge in cognitive science. The Tennessee IT Exchange Center (later known as the Center for Information Technology Education, CITE) was organized to disseminate and scale the innovations developed through two previous ATE grants (TEFATE and SEATEC) and a concurrently funded companion ATE project (The Case Files). A groundbreaking partnership between faculty at Nashville State Community College and researchers at Vanderbilt University opened a new perspective for educators from both institutions for problem-based case learning. Each grant was leveraged to solve another piece of the puzzle of skill development for the technical workforce. The "Nashville Model" of career education spread to Nashville high schools is now used in high schools across the country.

Consortium for Alabama Regional Center for Automotive Manufacturing (CARCAM)

The Consortium for Alabama Regional Center for Automotive Manufacturing (CARCAM)[14] positioned itself as the trusted intermediary between the Alabama Automobile Manufacturing Association (AAMA) and 15 of the 24 community colleges in Alabama to facilitate a pipeline of students prepared to work in

[11] https://d22ace60-40a6-43a2-9b7a-def4421bc8a8.filesusr.com/ugd/a99d33_66e2afb4528d47e89d6b26e9669d96ab.pdf
[12] https://d22ace60-40a6-43a2-9b7a-def4421bc8a8.filesusr.com/ugd/a99d33_f1591378e50a4f20a150478af1e5bffb.pdf
[13] https://d22ace60-40a6-43a2-9b7a-def4421bc8a8.filesusr.com/ugd/a99d33_d422fa1cd8f347029605f12bab4f045b.pdf
[14] https://d22ace60-40a6-43a2-9b7a-def4421bc8a8.filesusr.com/ugd/a99d33_cbaa03cf037a4c8c850830b89b6f8e10.pdf

auto manufacturing. By demonstrating the value of the education and training for all stakeholders, CARCAM provided the background setting for the current administration of state-appropriated scholarships for students in the automotive fields. These small scholarships reach hundreds of students and are built into the state budget.

Bio-Link & InnovATE*BIO*

Bio-Link[15] was launched in 1998 as "Bio-Link: A National Advanced Technological Education Center for Biotechnology," When Bio-Link sunset in 2018, over 40 states had taken advantage of Bio-Link offerings through over 109 programs. An accomplished center, Bio-Link worked to create a national network of for information sharing to foster communities of practice that enhance the preparation of skilled technicians; deepend and diversified industry outreach and engagement to ensure that training programs nationwide respond to industry needs and; increased access to and use of educational and training resources to improve student skill attainment. This report has two sections 1) a focus on a sub-component of the center, the Bio-Link Depot and 2) the transition to the InnovATE*BIO* Center[16].

Bio-Link Depot

The Bio-Link Depot, a subcomponent of the Bio-Link Center, was formed in 2002 at the request of industry. Its purpose was to connect Northern California teachers with science supplies and equipment for their classrooms. When upgrading, restructuring or moving, companies donate their excess materials; the Depot then distributes the materials to teachers who need them. The Depot has become a gathering place where teachers meet, pick up equipment and supplies, and also donate their time and ideas. The Depot is now a 501(c)3 non-profit organization, partially supported by environmental organizations through donations and grants, as the redirected biotech supplies and equipment that are donated reduce deposits into the landfill.

InnovATE*BIO*

InnovATE*BIO* is leveraging the assets developed under Bio-Link and continuing and expanding efforts that were successfully piloted under Bio-Link. Several Bio-Link spin-off innovations have been brought under the banner of InnovATE*BIO* to facilitate coordination and dissemination among the network. The InnovATE*BIO* leadership has expanded, and the center which launched at the start of the pandemic has embraced virtual tools for expanding the network.

Center for Systems Security and Information Assurance (CSSIA), National CyberWatch, & National Cybersecurity Training & Education Center (NCyTE)

When the earliest Cybersecurity centers were funded, it was thought that a four-year degree was needed to be successful in the cybersecurity workforce. Three community-college focused centers, The Center for Systems Security and Information Assurance (CSSIA), the National Cybersecurity Training & Education Center (NCyTE; formerly CyberWatch West), and the National CyberWatch Center formed to support community colleges. The three Centers are a consortium of Cybersecurity centers funded through the National Science Foundation (NSF) Advanced Technological Education (ATE) program that have a long history of cooperation. Collectively, the three centers address the common problem of

[15] https://d22ace60-40a6-43a2-9b7a-def4421bc8a8.filesusr.com/ugd/a99d33_a72d0ccab51b4512b8edac65bb6d120a.pdf
[16] https://d22ace60-40a6-43a2-9b7a-def4421bc8a8.filesusr.com/ugd/a99d33_7bf9f9354e0d42e891a03fa60351ec7a.pdf

preparing the technical cybersecurity workforce by focusing on complementary efforts, resulting in a synergistic approach. Each center has its own areas of focus, including mentoring, faculty development, curriculum, student assessments and cyber competitions, that build upon and complement each center's work. Understanding the conditions that allowed these centers to achieve such deep collaboration may be of use to other centers and synergistic seeking to expand their reach and spread their innovations.

FINDINGS

Partnership

All centers require strong partnerships, especially with industry, to fulfill their mission yet the nature of the partnerships vary based on the center structure and goals. Some centers are designed to develop communities of practice, others are designed to rely heavily on partnerships with professional organizations and all of them have individually strategic partnerships. In all cases identifying and promoting the shared goals provide the foundation for strong working relationships.

Communities of partners Several of the Centers in the study gathered large groups of partners around a common goal. Sometimes called "communities of practice" or "professional learning communities" these groups of individuals come together to build capacity as educators, often sharing knowledge and skills. Though the group has a shared topical interest, the members typically apply the knowledge back in their own context. Often partners come together as a condition of the grant but the impact of their time together is based on the value members perceive. The foundation of any community begins with trust. Establishing trust is critical and the ATE centers profiled built trust in several ways:

- Demonstrating awareness of the technical education and workforce needs
- Leverage the resources each partner can provide to maximize value
- Establishing norms of interaction that support collaborative and equitable participation. This includes a culture of respect for one another's perspectives and diverse forms of expertise.
- Facilitating and/or communicating a set of shared goals
- Partnership goals take into account team members' work demands and roles in their respective organizations
- Providing evidence of progress against these goals
- Holding face-to-face meetings that allowed the members in the community to network and collaborate. These face-to-face meetings also created a shared sense of history.

MCIT brought together previously disconnected educators from 10 different colleges to provide a collective community of professional development, guided by member and industry needs. MCIT used an on-going needs assessment approach to ensure the agenda was community driven. The MCIT PI team was flexible enough to respond to the needs of both the individuals and the capacity of the group. Members all felt enough value was received from the content and the relationships to ultimately self-support their participation.

The PI from CARCAM brought together a community of institutions across the state with industry representatives to address the automotive manufacturing technical education needs felt by all members. Individual campuses involved with CARCAM were typically represented by a specific faculty member who developed relationships with local employers and with the CARCAM PI. Through this relationship information was communicated efficiently. Similarly each college had a relationship with a specific industry partner. This structure allowed colleges to customize the programs to meet the specific training needs of the manufacturer and facilitated student experiences such as coops, internships and apprenticeships. Quarterly industry and educational leadership meetings provided the opportunity to stay current on the workforce needs and educational programming across the state and engage in statewide networking. Many of the faculty who were involved early on have moved up into administrative positions such as Deanships, raising the profile of CARCAM and associated opportunities.

In Nashville, the community of partners was less clearly defined than seen with CARCAM. The PI championed technical education with stakeholders across the educational pipeline through the community to foster awareness, partnerships, and coordination of efforts. Doing so resulted in an independent organization designed to transform the K-14 educational system with a strong industry partnership. This organization, "Alignment Nashville" serves as a backbone to the wide scale education reform efforts by promoting a common agenda, shared data and a communication hub among partners.

InnovATE*BIO* was designed to expand and support the network built under Bio-Link. The network itself was engaged to define the scope and purpose of the new Center. Maintaining and growing the network required moving from a high-touch approach which was important as the community and the field of biotechnology education formed and matured under Bio-Link to a more virtual and nimble model as the community grows. InnovATEBIO has leveraged the resources of the community to act as a knowledge broker and facilitator for the network. This allows more people to access the resources and has promoted a rapid-response to needs as they arise. Most importantly, the center is able to facilitate a shared vision and represent the value of community college biotechnology education as an important component of the Biotechnology workforce with industry, professional organizations and government.

Though the communities looked different, there were several characteristics evident across these projects:

- The community members (academic and industry) gathered around a shared goal.
    - In-person meetings were essential for developing trust and relationships .
    - The PI served as the intermediary between faculty and industry.
- There was a clear point-of-contact at each institution, even if multiple people were involved.
    - The leadership primarily liaised directly with faculty representatives from partner colleges rather than administrators.
- Data served as an anchoring point for continued engagement and direction setting.
- There are defined expectations for members creating a sense of mutual obligation.

Partnering with professional organizations[17]

Scaling an innovation can be accelerated when endorsed or supported by a professional organization. Professional organizations have large networks of potential adopters and offer credibility. Professional organizations can also offer a portal to broader workforce needs within a sector.

The PI of CAPT worked closely with a key industry representative to ensure the curricular development was aligned with the training needs of industry. Ultimately, the curricular materials developed under CAPT were absorbed by a professional organization to ensure wider scalability. In this case the PI was able to let go of the product. Although PI Raley "liked the idea of COM being the center of attention, I understood where they were coming from. The membership of CAPT was limited" and NAPTA would have a wider reach.

After developing curriculum through SpaceTEC that met industry needs, the center then developed testing materials. A partnership with the American Society for Testing and Materials (ASTM), has been essential for the longevity of the center. ASTM has over 12,000 standards globally, and is the body that the FAA recognizes as the owner of industry standards. ASTM standards for avionics is the only avionics standards recognized in the US and ASTM needed a certification agency. ASTM partnered with SpaceTEC, SpaceTEC provides the credentialing against these standards. SpaceTEC now operates with a fee-for-service credentialing center.

InnovATE*BIO* partners with a professional organization on an annual survey of the Coalition of State Biosciences Institutes (CSBI). The CSBI is a collaboration of 42 state bioscience trade organizations and the Biotechnology institute; an offshoot of lobbying groups. CSBI runs an annual survey which was funded in part by the Center. The annual survey asks employers across the country what their hiring needs will be for the next year and what skills they are seeking. By partnering with CSBI InnovATE*BIO* is able to connect with employers in each state, identify national and regional trends and help their members prioritize educational innovation to the local need.

Individual-strategic partnerships

All of the centers have strategic partnerships with individual organizations that help advance the work. These partnerships can be with other colleges that utilize curricular or training materials developed through the center, with organizations that fulfill niche services or with individuals who provide key consulting activities.

The Bio-Link Depot developed relationships with local biotech firms who donate lab materials equipment when upgrading their labs. The Depot warehouses these materials and equipment and facilitates their distribution to local teachers. The Biotech companies get tax breaks and the teachers get needed materials creating a mutually beneficial relationship that is relatively easy for the partners to access.

[17] Not every industry has a professional organization with which to partner. Often, there may be a professional organization but the specifics of the project and the priorities of the professional organization do not align in a manner to support widespread scaling.

Carrying out the effort was beyond the mission of a community college, thus a separate entity had to be formed and a new warehouse had to be found.

CARCAM partnered with the Alabama Automotive Manufacturers Association (AAMA) to facilitate the management of theri scholarship program. CARCAM, as the leading authority on automotive education in Alabama, positioned itself to manage a scholarship process for the companies by vetting the programs and students that meet the companies' needs, awarding scholarships to students in the CARCAM programs.

Industry Partnerships

In the ATE community industry partnerships are critical for ensuring technical education is relevant and timely. Almost all of the centers' efforts involve relationships with individual organizations seeking to develop a well prepared technical workforce. It is through these partnerships that projects and centers are able to develop curricular and training materials that prepare students to be workforce ready. Investment from industry partners in physical and in-kind donations create authentic learning environments for students and often students prepared through these programs greatly reduce the training burden of companies.

Centers that develop curriculum find engaging industry representatives is critical for creating timely and relevant materials. SpaceTEC and CAPT both had an industry representative on their teams early in the process, supported by companies. In each case, the training provided by the ATE programs allowed the local companies to hire well-prepared employees, saving significantly on recruiting and training costs. In Alabama, the automotive industry also benefited from the graduates of the CARCAM-affiliate program, trusting that the educational curriculum prepared students for both the technical work but also the interest and motivation to be successful in the automotive manufacturing field.

CARCAM and SpaceTEC are also two examples of centers that have a wide geographic reach. In each of these instances the partner academic institutions develop relationships with local employers to ensure that the overarching programming provided by the center is responsive to the local needs. These partnerships allow for the educators and industry to exchange ideas, monitor the relevancy and success of the project and to bring local needs to the larger network.

Centers that promote faculty development also benefit from industry partnerships. Industry representatives on the advisory board involved with MCIT all volunteered their time. Their involvement in MCIT led them to become more appreciative of the relationship between the technical education institutions and the impact on the industry. In Tennessee, the Ford Foundation invested heavily in the Problem Based Case Study approach after seeing the benefit to the community across the K-16 educational spectrum.

Partnering within the ATE community

The ATE community is built on a value of collaboration as evident in the annual PI meeting which is designed to showcase innovative efforts and promote cross-project networking and collaboration. The three cybersecurity centers profiled in this study are collaborating across centers to ensure community college students nationwide have access to high quality cyber education by taking regional approaches, and yet by specializing in different areas they are able to leverage expertise and best practices efficiently.

Over the course of interviews several PIs spoke about innovations and practices learned from other centers that they utilized in their work-- MCIT adopted the Working Connections model developed through a previous Center and several of the centers participated in the CITE Synergy conferences around case-based project teaching and learning. Often partnership within the ATE community happens in an ad-hoc manner. The ATE program provides several community-building supports that promote cross-project/center awareness and knowledge exchange.

The ATE center model emerged as a way to centralize best practices and information in domain-specific areas. Other resources have been funded that benefit the work of the community including:

- EvaluATE[18] which provides support and the opportunity for the community to engage around issues related to evaluation in the pursuit of excellence in technical education.
- ATE Central[19], an online portal and collection of materials and services across the ATE community. The site also aggregates information into a library of the materials developed by ATE centers and projects
- Mentor Connect[20] is a leadership development and outreach initiative to increase the capacity of faculty at two-year colleges to prepare and submit competitive proposals to the National Science Foundation (NSF) ATE Program.
- MentorLinks[21], an NSF-supported program designed to help colleges develop or strengthen technician education programs in STEM fields through mentoring, professional development opportunities, and technical assistance.

Questions to Consider About Partnerships

- Purpose of the partnership
  - Is the partnership beneficial for program design, implementation, and/or scaling the innovation?
  - Are your partnerships going to be individual or will there be a community of partners?
- Identifying partners:
  - Who else is addressing the problem you are, be it wholly or partially? There may be opportunities to align efforts around a complex problem.
  - Are there people or organizations who indirectly benefit from your efforts that may be outside of your target community yet would be valuable partners?
- Managing a partnership:
  - What community norms will guide a community of practice? Who needs to be included, what will be the communication expectations, and what will be the roles and responsibilities of each member?
  - Who will manage the relationships including building and sustaining trust?
  - What are the financial and other resource arrangements?
- When part of a larger institution:

[18] https://www.evalu-ate.org/
[19] https://atecentral.net/
[20] https://www.mentor-connect.org/
[21] https://www.aacc.nche.edu/programs/mentorlinks/

- What is the attitude of administrators in the institution towards collaboration? In what ways can they help or hinder potential partnerships?
- What opportunities do partnerships present in advancing your efforts and advancing the institutional mission?

Resources

- The Working Partners project has a wealth of resources for establishing and maintaining different types of partners (i.e. advisory board, curricular development and review, faculty PD, incubation/entrepreneurship, instructional support, program support, sponsored research and workplace-based learning). There is a tool kit and a set of case studies.
- Communities of Practice, or Social Learning Environments provide a framework for groups to work together on common challenges. Beverly and Etienne Wenger-Trayner provide wonderful resources for creating and measuring value in a social learning community. Learn more at https://wenger-trayner.com
- Collective Impact brings people together in a structured way, to achieve social change. The model has five components: A shared research agenda, shared metrics, a communications strategy, fosters mutually reinforcing activities and has a strong backbone organization that facilitates the work across groups. Learn more at https://www.collectiveimpactforum.org/ and https://www.hbs.edu/competitiveness/documents/business-aligning-for-students.pdf
- Research-Practice partnerships have been defined as long-term collaborations between researchers and practitioners that leverage research to address persistent problems
- of practice (Coburn, Penuel, & Geil, 2013). Many of the lessons learned apply to educator-industry partnerships as well. Learn more about the conditions of healthy partnerships here: https://rpp.wtgrantfoundation.org/wp-content/uploads/2019/09/Assessing-Research-Practice-Partnerships.pdf
- The CyberSecurity write up in this report identifies the conditions and structures that led to a strong partnership.
- Developing a Business and Industry Leadership Team (BILT) can be beneficial. ATE has provided a toolkit for Implementing the BILT Model of Business Engagement[22] and a summary of best practices[23].

Team Formation

This project did not focus on the origin stories of each center, rather on specific elements of the centers; however, it is useful to understand the team structures particularly during the early phases of the work. Each of the projects included academics and industry partners and several included non-profits (MCIT), state agencies (CARCAM) and research organizations (Tennessee centers) on their core team. Having organizationally diverse representation on the team is essential for ensuring the quality of the educational innovation, the relevance of the material, and access to cutting edge technology. Additionally the team membership can help generate broad based support which may promote scaling and/or sustainability. As the strategic priorities of the grant shift and mature, the team membership also shifts.

[22] https://atecentral.net/downloads/6126/BILT-Toolkit-092518.pdf
[23] https://www.atecenters.org/wp-content/uploads/2016/07/CCTA_BILTBestPractices_web.pdf

Grant initiated

The genesis of the grants were primarily driven by industry or academia with a few exceptions in which another partner (non-profit or state) were key to grant conception. Developing a technological workforce requires a multifaceted approach that relies on the close alignment of industry and academia. In almost all cases, the partnerships formed resulted in a technological workforce education program that was mutually beneficial.

Industry initiated

Industry-initiated projects often developed in response to a critical gap in workforce preparation due to the policies that govern the industry. In these cases, the industry representatives partnered with local educational institutions to better align curriculum to the basic training needs and industry standards for technicians. The industry also invested in infrastructure to ensure students were being prepared on modern equipment so they would be "Day one" ready when entering the workforce.

In the early part of the 21st century, the space industry was struggling with a contract-based system in which technicians had to be trained and certified with each new contract, often moving between companies. Though the same individuals were repeatedly hired, their credentials did not follow them between contract jobs. SpaceTEC was formed by three veterans of the space industry, one of whom had become a branch president of a local community college to create a training program run through the colleges, rather than through companies.

Historically, the chemical and refining industry hired hourly employees in maintenance and operations. The majority of maintenance workers were prepared through an apprenticeship program. By 1987, the apprenticeship approach had declined and the workforce was aging, creating a pending crisis for the Houston area petrochemical industry. Compounding the challenge was the reality that the hiring process for technicians didn't ensure that potential employees had the motivation and interest nor skills to succeed. CAPT created course materials, textbooks and training programs that ultimately made up a degree program aligned with the entry-training needs of the petrochemical industry. As the curricular materials were developed, one company recognized the need for investing in a talent pipeline and agreed to donate half of an employed trainer's time to College of the Mainland for 18 months to help develop the degree program. Later, the college utilized the industry relationships to secure internship opportunities and received a donation of expensive training equipment. The local industry was able to recruit well-trained and committed employees.

Academia initiated

Programs initiated by academics tend to focus on teaching and learning with new pedagogical approaches. These programs typically support a rapidly changing or emerging industry for which a set of measurable standards may not exist.

In Nashville, employers were looking for employees with both technical skills and the ability to problem-solve in a team setting, skills that couldn't be outsourced or automated. It soon became clear that to better prepare students, faculty would need to be prepared first. Changing teaching and learning to include a rich environment with contextualized workforce skills and active participation from students

was a bigger challenge than anticipated and involved much more than a focus on the instructors in isolation. The team had to develop an infrastructure within the institutions that would support the new change, create long-term partnerships with business and industry to provide the needed context in real-time, partner with educational institutions from pre-k through college, and build and maintain a structure that would connect all the partners in a way that would be sustainable

The Cybersecurity centers have collaborated to ensure that students across the nation have access to a quality cybersecurity education. These centers have advocated for and created programs that allow community college students to receive affordable and rigorous education by providing faculty training, access to competitions, and mentoring to other institutions providing cybersecurity education.

Non-profit initiated

Though less common, non-profit organizations can often serve a unique role in the ATE community when positioned at the nexus of industry and education. Many of these organizations exist to fill a gap in the school-to-workforce pathway through which they can facilitate relationships and coordinate efforts. The neutrality of these organizations can be appealing to multiple partners with similar goals. Finally, by serving as the fiduciary and grants-management authority the burden is alleviated for partners.

The MCIT center grant was submitted by a non-profit organization based in Omaha, NE focused on workforce development, the AIM center. Given the highly competitive landscape in the area, the non-profit organization provided neutral leadership to organize the colleges and also provided the fiscal oversight, which was complex and beyond the capacity of any of the partner colleges.

State-agency initiated

At the time CARCAM was funded, the state of Alabama had worked hard to court the automotive industry to replace the dying textile industry. In doing so, the state committed to companies that there would be a well trained workforce available. CARCAM was established to ensure this promise was met.

Team evolution over the life of the grant

As the work evolves, so might the team. In many cases the individuals that set the initial vision step back as those that can facilitate implementation move into higher levels of leadership. Additionally, the scope of work may evolve in a manner that shifts the balance of commitment and/or sense of ownership.

SpaceTEC began to meet an industry-driven need. The seniority of the PI within the college system was beneficial in the first phase of the project. As the curricular materials were completed and adopted nationally, the leadership team no longer had nor needed control over this part of the work. Rather, the project transitioned to coordinate and serve multiple academic institutions by providing the industry perspective and guidance. Ultimately, the grant-funded mission was met and the organization transitioned as an independent non-profit to support both industry and academia.

MCIT was formed by a non-profit organization that was instrumental in gathering a set of previously disconnected colleges to create a community devoted to faculty professional development. Over time, the

ownership and management of the community transitioned to MCC as the largest college while AIM continued to manage the finances and contracts.

Moving elements of the work to an independent organization requires a leader or team that can manage the new business. Most grants are submitted by a passionate dedicated leader. When the leadership is transferred to a leader with less dedication, experience demonstrates that the project soon closes.

Questions to Consider about Team Formation

When preparing for a proposal the following questions may be useful to consider the following team aspects:

- Is the idea meeting employer demand? A strong ATE proposal cannot come from academia's ideas alone, it needs to meet real workforce needs.
- What is the objective of the project, and how will it best be met?
    - If the program involves curricular materials and instructional approaches, new degree or certificate programs, or other elements that require approval of the college it is important to have a team member who can support achieving that endorsement.
    - If the project is focused on serving a direct industry training need for local industry, then having stakeholders from across the sector will ensure that the program is not company-specific yet valuable to specific companies.
    - If the project is focused on bringing a set of academic institutions together that are isolated, are competitive for grant funding, or confront other barriers to collaboration then having a neutral third party can be of value.
- Which institution is best situated to receive grant funding, including fiduciary and contractual oversight?
- What resources does each partner bring that may help the innovation advance (educational expertise, financial, training equipment, etc)?

As a grant evolves team considerations include:

- Who has influence that can promote wide-scale adoption of the innovation (either with other academic institutions or companies within the industry?)
- Who is needed to help influence the strategic direction of the innovation?

Resources

- While preparing a grant the ATE resource Mentor Connect[24] can provide guidance on the grant, including ensuring the right people are represented and contributing to the work
- Research-Practice Partnerships (RPPs) in education provide a framework for researchers and practitioners to engage in a mutual problem of practice, not unlike academia and industry in support of developing a technical workforce. RPP-related resources can be found on the WT Grant website[25].

[24] https://www.mentor-connect.org/
[25] https://rpp.wtgrantfoundation.org/

Leadership Characteristics

ATE Centers rely on strong leadership. In addition to grant management responsibilities, leaders are tasked with steering the center, often through a constantly changing ecosystem. Several leadership characteristics and skills emerged that promote sustainability. Each center leader must be a champion of the educational mission, build and nurture relationships, and implement the grant. The balance of the leader's focus will vary based on the current phase or circumstance surrounding the grant.

Champion of the cause with the college administration

The leader, typically the PI, must continually build a broad base of support for the technical education, including with the college administration which may hold significant power over the functionality of the center without significant involvement in the operations. In many cases this means keeping the college administration appropriately informed about the progress of the center. For example, the PI of NCyTE makes a point of providing updates to the college president who can then showcase the center's success with the board of trustees. When the trustees were aware of what was happening, they were excited about the work and also became champions of the center themselves, often citing it as one of the important initiatives of the college.

In some cases knowing when to "fly under the radar" is the best option. For example, in the face of frequent changes in institutional leadership, the Bio-Link PI was always careful about when to highlight the work of the center to garner greater support. Although the Depot was an essential part of the Bio-Link mission, it was not critical to the college's mission. Being on a remote campus allowed it to fly under the radar even through several administrative changes at the college. Depending on the needs of the administration, the Depot was either promoted or underplayed.

Developing and maintaining partnerships

None of the centers operate in isolation, they rely on close partnerships with professional organizations, other education providers and local stakeholders. In many cases the PI of the center came with a significant network of industry and academic professionals which were leveraged to develop the center. Once secure, leadership functions transitioned, either wholly or for individual components.

In the case of SpaceTEC the founding PI was a college president with 30 years of experience in the space industry affording him a strong reputation and set of relationships upon which to capitalize for the work. Once the center was established and partners were aware and supportive of the efforts, the PI retired. When he retired, a new PI was selected with strengths related to training and credentialing for space centers, allowing the center to transition to an independent entity.

The Bio-Link Depot emerged as part of the center's mission to support local Biotech educators and eventually became an independent organization. The PI developed a network of educators from K-12 through higher education and networked with industry throughout the biotechnology boom in the Bay Area. When it moved to an independent non-profit an executive director was hired who would be able to manage the operations of the Depot freeing up the PI to focus on other center initiatives.

In Nashville, the PI was able to unite a set of groups by capitalizing on the individual strengths and mission of each stakeholder to address a common goal. The PI used the emerging research and understanding of the problem of promoting STEM education across the educational pipeline to support the pedagogical innovations. Ultimately, these groups formed a new organization to serve as a backbone organizing structure to support the collective goals of the individual entities.

CAPT was formed when the college leadership recognized a unique opportunity to advance the work of a regional consortium through the ATE program. Taking advantage of the resources available through the college including PTEC curricular developments, the leadership liaised with an industry-led organization to fully develop and package the PTEC training program for broad dissemination to be handled through the consortium. The ATE center provided an opportunity to organize the curricular innovations into a robust program of study for broad dissemination.

Implement the grant

All ATE Centers are funded to implement the proposed plan but the nature of the plans vary based on the identified problem. In some cases the plan is based around a theory of change that has a linear path to the desired outcomes. In other cases, the outcomes are clear but reaching them is exploratory in design. Finally, none of the centers work independently-- when and how to partner with other organizations is critical for leveraging the skills and assets within the community to best serve the center stakeholders.

SpaceTEC had a specific objective of creating a technical workforce for the space industry that followed a linear progression. The grant was managed "like a space contract" in which each partner organization had a set of explicit activities and benchmarks to meet. An evaluator was used to provide external accountability.

In Nashville, the ATE centers evolved as the nature of the problem was better understood. What started as a plan for bringing more students into the technical education pathways at the community college evolved into a robust model of problem based case learning across the K-14 pipeline with significant industry involvement. The PI was able to bring together partners around a common problem of practice for which each partner leveraged their unique assets.

The PIs of the Cyber Centers take a holistic approach to a complex, national need to train a cybersecurity workforce. The centers collaborate closely to leverage the relative strengths of each partner. For example, the PI of CSSIA has a strong interest in research and faculty development, the PI of NCyTE is a champion of mentoring institutions developing and deepening their cybersecurity programs and the PI of CyberWatch focuses on curriculum development and assessment. Each of these PIs is motivated by the mission of improving and expanding access to cybersecurity education, and view partnerships as critical. As one said, "the [workforce] problem is so big we need each other. We're stronger as a group than if we're operating individually."

Listening to advisory and evaluation groups

Each center is required to have an external National Visiting Committee (NVC) that represents the stakeholders of the grant. The NVC meets at least annually to hear progress and make suggestions. For

the projects that furnished NVC reports, it was clear that PIs took the advice of their steering committees and evaluators seriously. Committees praised centers for responsiveness to prior years' recommendations. The value of an advisory group such as an NVC and a rigorous evaluation includes:

- Focusing on the project to ensure depth and rigor. The metrics used in a project are valuable to ensure all partners are working towards the same goals and meeting benchmarks. Evaluation can also determine if the learning objectives are being met, an important metric for deciding worthiness for scale and/or sustainability. For example, CARCAM's tracking of job hires and salary made an important economic argument for other colleges to join the consortium and for the state to offer financial support.
- Pivoting an innovation based on new information or a chance in the local context. For example, the MCIT project had an early goal of decreasing the number of IT openings in the region; However, with the dot.com bust, workforce jobs disappeared. PI Pensabene noted that " NSF is so different from other funders, you can persevere or pivot." MCIT pivoted to building the capacity of faculty to offer up-to-date IT courses and programs. Another example of a pivot is in Tennessee, where the Case Files project planned to generate revenue through the on-line sale of case study materials but ultimately this strategy was deemed unrealistic and instead the project focused on the faculty development to support the use of the case materials in the classroom.
- A steering committee at Bio-Link challenged the center to think about becoming a non-profit; However, as with many ATE grantees, the leadership is committed to their educational careers at their institutions and would not have the bandwidth to run an independent non-profit. Instead, the center spun off the Bio-Link Depot which would benefit from a separate legal structure and dedicated director.

Part of the effort to listen to advisory and evaluation groups involves transparency and preparation. One NVC report praised the center for their "noted ability to draw on advice provided by the committee and evaluators, using the information not only to measure outcomes but also strengthen the approach. The teams had performed a self assessment of strengths, weakness, opportunities and challenges; providing feedback to the NVC so that time was better allocated to addressing observations and fresh feedback. The team was impressed by the college's willingness to provide self-assessment." Other strategies include providing "read-ahead" materials so meeting time can be used for questions and strategy rather than updates.

Questions to Consider about Leadership

- Who in the leadership members' networks would make important partners, either as thought leaders, for advancing the mission, and/or dissemination efforts?
- Who within the larger academic institution, but outside the center, would be a strategic champion for the effort?
- Thinking about your current context, is it better at this time to promote your achievements and impact heavily, or to "fly under the radar"?
- What are the objectives of the grant? What structure will be best suited to accomplishing these objectives? Is the center leadership equipped to facilitate progress within the structure?
- What knowledge and skills does the leadership need to demonstrate to secure partner confidence?
- As the work evolves, is a new leader or structure more appropriate?

- Have you surrounded yourself with appropriate advisory and evaluative expertise who will be able to provide you with critical feedback on your efforts?

Resources

- ATE Central houses all things ATE including an overview of the work being done under ATE, a repository of resources produced under ATE funding, and calendar of events.
- EvaluATE is the evaluation learning and resource hub for PIs and evaluators.
- Developing a Business and Industry Leadership Team (BILT) can be beneficiaL as leaders look for partnership and guidance with industry. ATE has provided a toolkit for Implementing the BILT Model of Business Engagement[26] and a summary of best practices[27].
- The Working Partners[28] project has a wealth of resources for establishing and maintaining different types of partners (i.e. advisory board, curricular development and review, faculty PD, incubation/entrepreneurship, instructional support, program support, sponsored research and workplace-based learning). The site provides a tool kit and a set of case studies.

Moving to an independent organization

Sometimes sustaining an initiative means creating a new, independent organization. Knowing if and when to move to independence depends greatly on the relationship to the home institution including the alignment of mission, the revenue structures and the leadership structures in place versus those needed moving forward. Bio-Link Depot and SpaceTEC offer lessons learned about creating independent organizations.

Mission (mis)alignment

In some cases the mission of the center, or element of the center that is ready to go independent, no longer aligns with the mission of the academic institution. In these cases it may be that the institution no longer wants to support the particular element of the center, or independence may be initiated by the center as a way to advance its mission. The Bio-Link Depot fulfilled an important part of the grant objective to support teachers by connecting them with materials donated by the biotech industry. The Depot was not, however, critical to the CCSF mission of educating students. When the Depot was forced to find physical space apart from the college it realized it needed the authority as a legal entity to rent space and manage grants The Bio-Link advisory board decided that it was time to create a financially independent organization with its own governance and has since formed a 501(c)3 non-profit organization.

The National Cyber League[29] is a non-profit organization founded by four ATE centers and one university partner[30] that supports learning through cybersecurity competitions. The NCL provides "an ongoing virtual training ground for participants to develop, practice, and validate their cybersecurity knowledge and skills using next-generation high-fidelity simulation environments," which fulfilled a shared mission.

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[26] https://connectedtech.org/wp-content/uploads/2020/02/BILT-Toolkit-Sept-2018.pdf
[27] https://www.atecenters.org/wp-content/uploads/2016/07/CCTA_BILTBestPractices_web.pdf
[28] https://www.workingpartnersproject.org/
[29] https://nationalcyberleague.org/
[30] The George Washington University Cybersecurity & Privacy Research Institute and the Mid-Pacific Information and Communication Technologies (MPICT) Center, an NSF ATE funded center.

Although developed through grant funding, the NCL no longer relies on grants. NCL is now an independent non profit (501(C)(3)) organization supported through nominal student competition fees ($25), which schools often subsidize. The NCL board is made up of representatives from CSSIA, National CyberWatch and NCyTe with all of the incorporated labs developed by the ATE centers. By moving to a non-profit, all founding partners benefit from the service but are free to focus on other priorities.

In both cases, spinning off successful initiatives into independent organizations freed staff time to focus on other aspects of the center.

Revenue generation

NSF grants allow for revenue generation (though any revenue generated must be spent before requesting additional grant funding), however many academic institutions are not set up to manage a revenue-generating grant. Grant funding is unreliable, so revenue generation is often an essential element of program sustainability. For example, SpaceTEC created specific accounts to segregate the funds from the College's general revenue fund once it became a subsidiary of another organization. Revenues in excess of expenses from these contractual arrangements are set aside and currently equal approximately one year of operating expenses (including salaries) for SpaceTEC as a safeguard in the event NSF funding is not available.

Creating an independent authority

An independent organization may create a sense of impartiality that can be beneficial when seeking to scale and/or sustain an innovation. Many faculty want to create their own curricular materials and customize their pedagogical approaches to their own classrooms, creating an implicit bias against adopting materials created elsewhere. In some cases, creating an independent organization, either with or endorsed by a professional organization, removed the barriers to adoption.

In the case of SpaceTEC, once the center had met the goals of creating and propagating curricular materials and testing guidelines, moving towards an independent organization allowed it to offer credentialing services. This independence allowed it to serve as an unbiased testing organization that offered credentials for those in the space workforce. The revenue generated through the credentialing services allow it to be self-supporting. With a partnership with the ASTM and several military sites it further bolstered its reputation and value within the community.

Partnering to scale through an independent organization

In some cases, organizations already exist for which the novel innovation may be a perfect fit. Recognizing that NAPTA has greater influence than the College Of the Mainland, the CAPT center concluded it's grant and NAPTA absorbed the CAPT materials and took responsibility for on-going review, dissemination, and certification exams. CAPT closed in 2011 with the work living on through NAPTA which is the standard–bearer of the PTEC curriculum.

Staffing and Management

The ATE PIs are mostly college faculty who have stable employment and enjoy teaching. Moving to an independent organization is often personally risky and may not be professionally desired. In the cases in which study participants created independent organizations there were leaders within the center with

strong industry experience or backgrounds who felt this to be part of their career trajectory. For example, Steve Kane of SpaceTEC was an industry trainer who was brought in to support the project. Daniel Michael of Bio-Link Depot was a consultant who agreed to take on the Depot after working with the organization for several years.

Bio-Link, SpaceTEC and the Cyber Security centers created independent organizations. For each of them, the spin-off organizations were conceptualized and planned with a board. Once established, they have maintained a board that includes representation from the center from which it developed.

Questions When Considering an Independent Organization:

- How does the relationship to the home institution support the initiative? In what ways might it limit opportunity?
- Who will run the new organization? What experience is necessary?
- What will the governance of the new organization look like?
- What will be the relationship to the prior host academic institution?
- Are there key partnerships that can position the organization as central to an industry?
- What will be the revenue structure? What will be covered through fee-for-service, products, or grants?

Resources

Although not used by the ATE centers profiled, NSF does offer some support for projects looking to translate their innovations to independent organizations through the NSF STTR program[31].

Role of NVC (Advisory and Knowledge Exchange)

The National Visiting Committee

Each center is guided by a National Visiting Committee (NVC). The current NSF ATE solicitation[32] (NSF 21598) describes the NVC expectations as follows:

> For NSF ATE center proposals, the budget should include provisions for a National Visiting Committee (NVC) to visit the center at least on an annual basis. An NVC is a group of experts who provide advice to the project staff, assess the plans and progress of the project (and make reports both to the project leadership and to NSF), and enhance the dissemination of the project's products. Typically, ATE Centers enlist eight to ten members. The proposal should include only the names of NVC members who have agreed to serve should an award be made. After an award is made, the cognizant NSF program officer will work with the grantee to finalize NVC membership. The proposal should address how the NVC will be used in the project.

Note, many of the center's are part of an ecosystem that has other advisory boards in place.

[31] https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505362
[32] https://www.nsf.gov/pubs/2018/nsf18571/nsf18571.pdf

NVC membership

The center choses members for the NVC, often selecting peers in the ATE community and academic and industry experts in the field. Committees are diverse and require the approval of NSF. One of the ways ATE facilitates the exchange of information between centers is through NVC participation. For example, the Cybersecurity Centers are all represented on each other's boards allowing them to strategize and collaborate. CSSIA, the first funded center, helped guide the formation of CyberWatch West and together they supported NCyTE.

NVC guidance

The NVC reports are used to help set strategic directions for the center. A review of the center's strengths and challenges contextualized against current economic conditions. NVCs are particularly valuable in considering scaling and sustaining innovations of the center. For example they offer guidance on when to create an independent entity, or when to abandon a particular strategic effort. The NVC will also review the center's finances to ensure that strategic decisions are aligned with available resources.

Preparing for an NVC visit

NVCs are so valuable, preparation is important. In Tennessee, the CITE project prepared for the visit by reflecting on their work over the last year. This self assessment was valuable as detailed by the NVC in the executive summary:

The team was impressed by the college's willingness to provide self-assessment as they exhibited a demonstrated ability to draw on advice provided by the NVC's year one visit and subsequent report. The self-assessment of strengths, weaknesses, opportunities and challenges provided feedback to the NVC so that time was better allocated to addressing additional observations. (CITE, Year 2 NVC report, 2004)

Resources

ATE National Visiting Committee handbook[33]

Role of Data and Evaluation

Evaluation is an important tool over the life of a project. Formative evaluation is used to help shape the program by using landscape data, performance data and participant feedback (among others) to inform the design phase of the program. Formative evaluation takes into account the context of the program and the experiences of participants and other stakeholders for continuous improvement purposes. Summative evaluation is important for monitoring how well the program is meeting goals. Often performance metrics, employment rates, use of curricular materials and the like are used to document the program success. Both types of evaluation and evidence are important for documenting and describing the value of an innovation when seeking to scale the effort. Often evaluation reports are appended to annual reports submitted to NSF.

The role of the external evaluator is to be a "critical friend." External evaluators are useful for documenting how and why a program makes the decisions it does and holding a project accountable to the

[33]https://www.evalu-ate.org/library/nvc-handbook_nov2017/#:~:text=ATE%20centers%20are%20required%20to,to%20the%20center%20they%20serve.

proposed goals. The evaluation reports provided for this study and interviews with evaluators involved provided a historical overview of the center and how various elements contributed to the overall project goals and objectives.

Every center included in this study used evaluation and feedback to improve the effectiveness of the intervention. There are several ways in which evaluation data can be used. For example, they can help a center pivot in response to contextual changes, create alignment between partner organizations and provide external perspective.

In Tennessee, one of the proposed projects made a significant pivot when it became clear that the proposed dissemination strategy would not be feasible. The evaluation team was able to help reformulate the plan while maintaining fidelity to the proposed goal of providing faculty with access to needed materials. The external evaluation team, from Stewart, Wright & Associates, LLC, guided their evaluation to consider for each of the project goals:

1. Outcomes—What do we want to do?
2. Activities—How will we do it?
3. Measures—How will we know we did it?

The SpaceTEC evaluation provided a reporting framework for each partner institution which allowed the center to aggregate the site-level impact to document participation and impact nationally. The evaluator also included overall impressions of the project which took into account both prior NVC feedback and provided guidance for future NVC engagement.

Evaluators are also used more informally to provide guidance. For example, an evaluator of one of the Cyber Centers who was interviewed for this project recalls having to help the center stay within scope noting "On many occasions I have said out loud "remember, they gave you 4 million, they didn't give you 30 million dollars" because [the center] want to do a lot!" Similarly, this evaluator was able to recognize when the center had "tapped into a need" and reconsider the focus of the center. He noted some projects have many elements and one "takes off and becomes bigger than anyone anticipated" and the team may want to do more, but with finite resources, it comes with tradeoffs. Looking at the data can help clarify what should be prioritized.

Questions to Consider for Evaluation Support

- What role are you looking for an evaluator to fill? (Critical friend, external monitoring, bridge to other connections, statistician, etc.)
- What will be the relationship between the evaluator and any partners?
- Is your evaluator aware of all the constraints and affordances of your project so that they can make informed recommendations?
- Thinking about how your project/center has engaged with your evaluator to date, is there anything about that relationship that needs to shift?
- How can your evaluator support you in preparing for your NVC visit?

Resources

EvaluATE[34] is the evaluation support center for the National Science Foundation's Advanced Technological Education program.

Other Considerations

Curriculum

At the start of this effort we sought to understand what might be sustained beyond curricula with a general understanding that "curriculum doesn't scale/sustain" in a vacuum. This proved to be true. In our conversations with Centers we learned that developing curricular materials may be important, particularly early in a grant. However, sustainability of curricular materials depends on:

- Maintaining currency of the curriculum over time
- Maintaining access including current web links
- Exceptionalism, expressed through significant results or endorsements of professional organizations or other high-influence bodies.

The Centers in this study that had developed curricular materials as part of the grant often transitioned to defining a set of industry endorsed skills or standards (See SpaceTEC, CARCAM, CAPT and InnovATE*BIO*). These standards can then be used locally to guide the development curricular materials that meet the local context. The curriculum was part of a larger strategic vision for the center.

Workforce Development Context

Each Center prioritized preparing advanced technicians for the local workforce and industry context greatly influenced the challenges and opportunities available. Three cases illustrate the challenge in creating a workforce development pathway directly tied to the economic conditions in that sector:

CAPT was influential as the industry moved away from hiring high school graduates and training them through an apprenticeship to recruiting from the community college PTEC training programs, in which graduates started with more advanced skills and safety training.

Bio-Link and InnovATE*BIO* operate in a context in which they are trying to change the culture of the biotechnology sector to hire from two year colleges in addition to the four year schools. In many (but not all) regions the industry is flooded with applicants, allowing them to require a bachelors' degree. There has been some traction in working with startups, who are less competitive for applicants than bigger companies. InnovATE*BIO* is working with industry, professional organizations and government agencies to promote the value of two year graduates for the biotechnology field.

CARCAM grew in tandem with the automotive industry. When the state incentivized companies to come to Alabama, they assured the industry that there would be a well qualified workforce. CARCAM was the backbone for the technician training programs to promote training fundamentals and support the education-industry partnerships across the state.

[34] https://www.evalu-ate.org/

Each of these examples is overly simplified, but points to the importance of close relationships with industry, responsiveness to the local context and the need for capacity building activities to reflect industry needs.

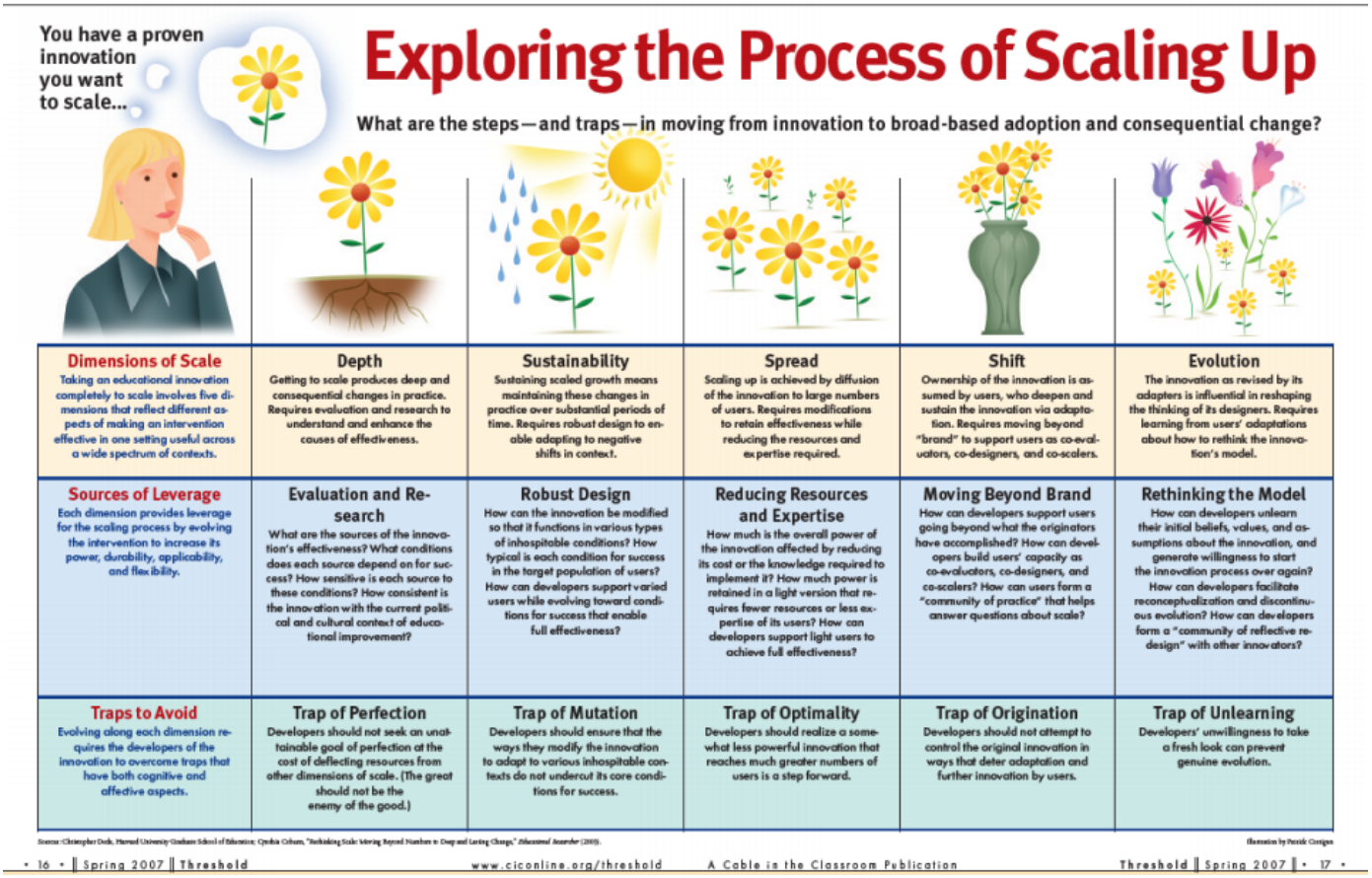
APPENDIX A

The EPILOGUE study was informed by four distinct frameworks that have contributed to our understanding of scaling and sustaining innovations. A short summary of each is presented below with resources provided if you'd like to learn more.

Scaling up an innovation, Chris Dede

Chris Dede developed a framework for scaling educational innovations that include five dimensions:

1. Depth: evaluation and research to understand and enhance causes of effectiveness
2. Sustainability: robust-design to enable adapting to negative shifts in context
3. Spread: modifying to retain effectiveness while reducing resources and expertise required
4. Shift: moving beyond "brand" to support users as co-evaluators, co-designers, and co-scalers
5. Evolution: learning from users' adaptations about how to rethink the innovation's model



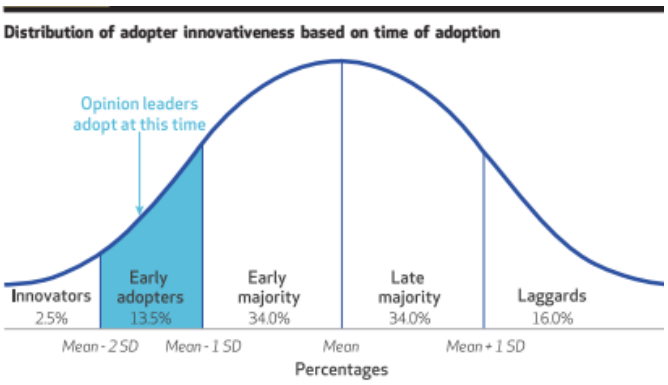
The Five Dimensions for Attaining Scale: Implications for Higher Education Initiatives Chris Dede Harvard University

Planning for scaling up early in a project is critical. Innovations that are not worthy of spreading and should not scale. Engaging with rigorous evaluation and research is critical when proving an innovation, but the design should take sustainability into account. Spread, shift and evolution require an openness to letting go of control and learning from others' experiences with the innovation.

You can learn more about scaling up educational innovations at: [BEST SOURCE?]

Attributes of an innovation that promote diffusion

Everett Rogers developed the initial model for diffusion of innovations in 1962 which posits that new innovations or ideas gain traction when they are embraced by a small but influential number of people ("early adopters"). Subsequent adopters follow a bell curve as the idea or innovation diffuses. Diffusion is inherently a social process and takes time.



SOURCE Modified from Rogers EM, Diffusion of innovations (see note 9 in text). NOTES This exhibit i based on Everett Rogers's meta-review of empirical diffusion studies. SD is standard deviation.

There are seven attributes of innovations that help promote diffusion. James Dearing provided a wonderful summary to the Synergy community in 2010:

1. Compatibility: the extent to which an innovation fits with preexisting routines, beliefs and norms
2. Cost: the extent to which an innovation is less costly relative to alternatives
3. Simplicity: the extent to which an innovation is easy to understand
4. Adaptability: the extent to which an innovation can be customized by an adopter without decreasing effectiveness
5. Effectiveness: the extent to which an innovation is better than an alternative
6. Observability: the extent to which the results of using an innovation are visible
7. Trialability: the extent to which an innovation can be tried with low or no risk.

Not all attributes are present in all innovations that have successfully diffused. Depending on the context, different elements may take higher priority (though compatibility, cost and simplicity are a good place to start!). Because diffusion is a social process, understanding the influence network is critical. Knowing who the opinion leaders are, or the decision makers, can help you target your efforts.

You can learn more about innovation attributes at Dearing, J. W. (2009). Applying diffusion of innovation theory to intervention development. Research on social work practice, 19(5), 503-518.

Social Learning Theory

Many of the efforts profiled include the development of a professional network, community, of partnerships that promote the exchange of knowledge and resources. Social learning theory says that learning is fundamentally a social phenomenon. Etienne and Beverly Wenger-Trayner have developed a model of value creation originally applied to communities of practice to understand the extent to which the activities of the community/network have changed the participants. The framework (see figure 1) begins with a learning interaction. From this interaction there are four increasingly-powerful types of value created:

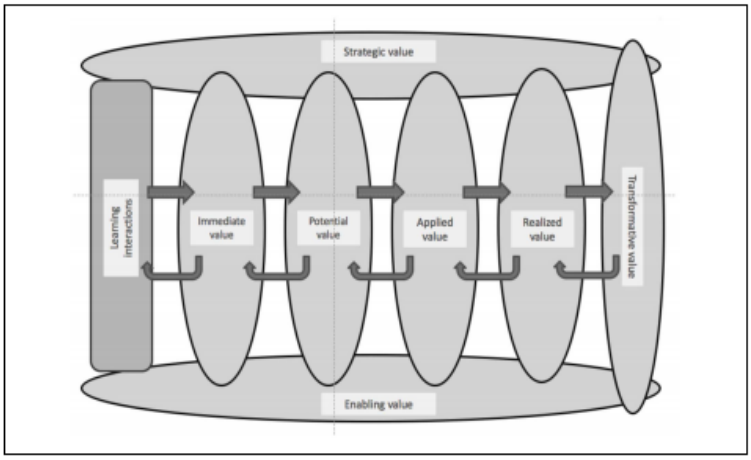


Figure 1. Value-creation framework.

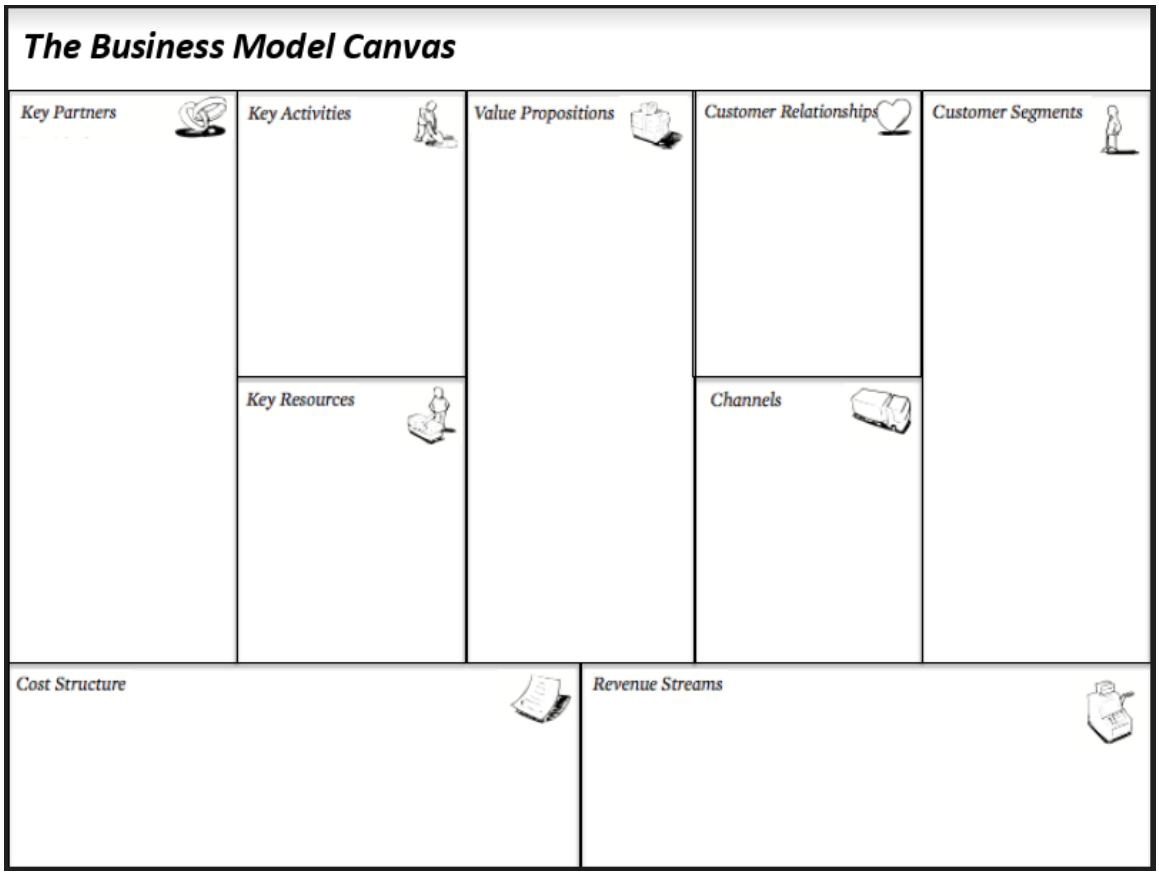
- Immediate value: the activities and interactions between members have value in and of themselves
- Potential value: the activities and interactions of cycle 1 may not be realized immediately, but rather be saved up as knowledge capital whose value is in its potential to be realized later.
- Applied value: knowledge capital may or may not be put into use. Leveraging capital requires adapting and applying it to a specific situation.
- Realized value: even applied new practices or tools are not enough. A change in practice does not necessarily lead to improved performance, so it is important to find out what effects the application of knowledge capital is having on the achievement of what matters to stakeholders …
- Transformative value: people's identities or the broader environment are deeply changed
- Strategic value: Stakeholders are engaged to ensure learning makes a difference.
- Enabling value: better at supporting or enabling social learning.

Each element is connected by feedback loops. The value created through a community takes time and nurturing, and an openness to being responsive to the feedback generated.

More about social learning theory and value creation can be found here: https://wenger-trayner.com/

Business Model Canvas and Customer Discovery

The I-Corps-L™ program was developed and organized around Alexander Osterwalder's Business Model Canvas (see figure XX below), Steve Blank's Customer Discovery Process developed as part of the Lean LaunchPad methodology.



The business model canvas provides a structure for self-assessing viability of scaling an innovation:

- Customer Segments. This building block defines the different groups of people or organizations an enterprise aims to reach and serve.
- Value Propositions. This block describes the bundle of products and services that create value for a specific customer segment. Value propositions are delivered to customers through communication, distribution and sales channels.
- Channels. This block describes how a company communicates with and reaches its customer segments to deliver value propositions.
- Customer Relationships. Customer relationships are established and maintained with each customer segment. This block describes the types of relationships a company establishes with specific customer segments.
- Revenue Streams. Revenue streams result from value propositions successfully offered to customers. This block represents the cash a company generates from each customer segment – costs must be subtracted from revenues to create earnings.
- Key Resources. Key resources are the assets required to make a business model work.
- Key Activities. These work by performing a number of key activities. This block describes the most important things a company must do to make its business model work.
- Key Partnerships. Some activities are outsourced and some resources are acquired outside the enterprise. This block describes the network of suppliers and partners that make the business model work.
- Cost Structure. The business model elements result in the cost structure.

To learn more about the business model canvas and related supports visit

- https://www.asee.org/i-corps-l/resources/business-canvas-model
- https://venturewell.org/i-corps/

Collective Impact

Collective impact offers a structure for bringing together disparate groups around a common goal. The structure includes:

1. Common Agenda—All stakeholders have a shared vision for change, including a common understanding of the problem and a joint approach for solving it through agreed-upon activities.
2. Shared Measurement—All service-providing participants (schools, nonprofits, and government agencies) consistently collect data and measure results to ensure efforts remain aligned and accountable. Mutually
3. Reinforcing Activities—Service activities are aligned through a mutually reinforcing action plan.
4. Continuous Communication—All stakeholders agree to consistent and open communication to build trust, articulate mutual objectives, and foster cooperation.
5. Backbone Support—A separate organization, called a backbone, is created to manage Collective Impact and is staffed with personnel to serve the initiative and coordinate participating organizations and agencies

To learn more about collective impact visit https://www.collectiveimpactforum.org/