Technology and Innovation, Vol. 22, pp. 359-373, 2022
Printed in the USA.

ISSN 1949-8241 • E-ISSN 1949-825X
http://dx.doi.org/10.21300/22.3.2022.9
www.technologyandinnovation.org

APPLYING A 'MENTOR-PROTÉGÉ' APPROACH TO BROADENING PARTICIPATION OF HBCU'S IN THE NATIONAL INNOVATION NETWORK

Thaddeus McEwen[1], Jessica Fields[2], Caesar R. Jackson[3], Jill Keith[4], Cira Cardaci[2], Nhi Tran[2], and John A. Blaho[2]

1. Center of Excellence in Entrepreneurship and Innovation, North Carolina A&T State University, Greensboro, NC, USA
2. Innovation and Applied Research Division, City University of New York, New York, NY, USA
3. Department of Mathematics and Physics, North Carolina Central University, Durham, NC, USA
4. Department of Biochemistry, Biomedical Research Infrastructure Center, Winston-Salem State University, Winston-Salem, NC, USA

Innovation is one of the most important drivers of economic growth, yet only 8% of minorities, 12% of women, and < 0.05% of African Americans are recognized as innovators. However, a comprehensive analysis of nearly all doctoral dissertations from 1977 to 2015 shows that although individuals from under-represented minority groups demonstrated greater scientific innovation, their contributions are rarely further adopted compared to equally impactful contributions by majority groups. In this instance "rarely further adopted," as noted by Hofstra et al. (1), means that the "novel contributions by gender and racial minorities are taken up by other scholars at lower rates than novel contributions by gender and racial majorities, and equally impactful contributions of gender and racial minorities are less likely to result in successful scientific careers than for majority groups." Access to the wealth of potential innovations — going largely unnoticed and underutilized — from under-represented minority groups can be achieved, in part, by engaging science and engineering students, faculty, and staff at Historically Black Colleges and Universities (HBCUs) in entrepreneurship through the use of the Innovation Corps (I-Corps) curriculum with adaptations to fit the education and research environments at HBCUs. A consortium of three North Carolina universities and the NYC Regional Innovation Network (NYCRIN) I-Corps Node established a partnership developing a specialized Lean LaunchPad training program for HBCU students, faculty, and staff. Implementation followed a three-step train-the-trainers 'mentor-protégé model, where new instructors 'see one, do one, be one' while learning to deliver the curriculum. The overarching goals of this initiative are to evaluate the effectiveness of this approach in broadening participation in I-Corps and mainstreaming the innovation capacities of HBCUs. The authors include instructors from the collaborating institutions, who trained and served as the teaching team for regional and national cohorts. Included are the rationale for creating the program, partnership selection, instructor and team recruitment, best practices for the 'mentor-protégé model, and outcomes for the cohorts. This contribution is a unique opportunity for other faculty to learn from practitioners about the challenges and successes involved in creating such a new multi-institutional entrepreneurship training paradigm.

Key words: HBCU; I-Corps; Innovation; Academic entrepreneurs; Entrepreneurship education; Teaching; Experiential learning; Fostering diversity; Equity; Inclusion

---

Accepted: January 1, 2022.
Address correspondence to John A. Blaho, Ph.D., Innovation and Applied Research Division, City University of New York, 555 West 57th Street, Suite 1407, New York, NY 11075. USA, Tel +1-646-664-3446. Email: john.blaho@cuny.edu

INTRODUCTION AND RATIONALE

A coalition of Historically Black Colleges and Universities (HBCUs) in North Carolina partnered with a National Science Foundation (NSF) Innovation Corps (I-Corps) Hub to develop an initiative that provides a customized I-Corps and Lean LaunchPad® Methodology training opportunity for its HBCU faculty and students. This article includes the rationale for the project, description of implementation, and project outcomes.

Innovation Is an American Imperative

According to Stephan Monterde, director of strategic corporate innovation at Cisco, innovation has become an imperative for both corporations and society. Approximately 25% of U.S. productivity will be generated by innovation. In a study of senior executives by the Boston Consulting Group, 75% indicated that innovation was among the top three priorities of their companies (2). Innovation is the implementation of a new or improved product or business process that differs significantly from previous products or processes and that has been introduced in the market (3). A major asset for America's innovation system is its public research universities. The Bayh-Dole Act of 1980 contributed to a boom in new technology companies by incentivizing universities to sell and license technology generated from federally-funded research (4,5). However, state funding of U.S. public institutions has been declining over the past decade, whereas other nations are increasing investment and overhauling their higher-education systems to turn universities into engines of innovation-led growth (5). Therefore, to maintain its leadership position in the global economy, the United States, through federal support, must reinforce the nearly 200 public research institutions (5) — as well as the emerging research institutions, including HBCUs (6) — which provide the foundations for our own knowledge-based technological and economic growth.

Broadening Participation in U.S. Innovation

Behind every technological innovation is the innovator — an individual or a team of individuals responsible for the hard scientific or engineering work (7). Fundamental to the concept of innovation is the innovator's intent to create something of economic value, something that offers benefits to the consumer and provides economic returns to the innovator (8). Therefore, innovation and innovators are primary drivers of economic growth and prosperity (8,9). However, a substantial portion of U.S. innovation talent is being underutilized. The demographics of U.S. innovators include only 12% of women who were born in the United States, and U.S.-born minorities (including Asian Americans, African Americans, Hispanics, Native Americans, and other ethnicities) represent only 8% of U.S. innovators. African Americans, despite comprising 13% of the native-born population of the United States, comprise just 0.5% of U.S.-born innovators (7). The United States must increase the participation and utilization of all talent for innovation in our nation to sustain global economic leadership.

The United States has achieved world prominence in higher education primarily through a unique blend of research and teaching at universities. About 200 public research universities in the United States have long been the backbone of America's innovation system, conducting 62% of federally-funded research (5). However, there are nearly 1,500 institutions, known as emerging research institutions (ERIs), available to broaden the base of universities that can undertake research so that the United States can remain a leader in the global economy (10). The Federal Demonstration Partnership (FDP) defines ERIs as those generating federal funding of less than $20 million annually for research and development (R&D) and that are funded by at least two FDP federal agencies. Some of the 102 HBCUs are emerging research institutions (11). HBCUs constitute only 3% of the postsecondary institutions in the United States, yet they award 17% of all science, technology, engineering, and math (STEM) baccalaureate degrees earned by African Americans (12). In addition, it is found that 24% of the African Americans who earned a doctorate in science and/or engineering received their bachelor's degree from an HBCU (13). One of the deciding factors in applicants' acceptance into graduate degree programs is previous research experience, and STEM students at HBCUs seem to be engaged in research experiences at a higher rate than African American students at predominantly

white institutions (14). Therefore, even though less than 1% of federal R&D expenditures go to HBCUs (15), and despite all the challenges they face (the lack of institutional support for research common to institutions with small endowments and an excessive teaching load, which does not permit adequate time for research, grant writing, and publishing), faculty at HBCUs continue to engage their students in authentic research experiences. This means there exists a large pool of researchers and innovators at HBCUs who are generating new knowledge, tools, and techniques but who are underutilized resources for the innovations that can help drive the U.S. economy (6,16,17).

To address the need to broaden participation in the innovation space, three North Carolina HBCUs, North Carolina A&T State University (NCATSU), North Carolina Central University (NCCU), and Winston Salem State University (WSSU), came together to develop an NSF proposal to examine the use of the I-Corps program and the Lean LaunchPad Methodology to foster entrepreneurial mindsets and produce innovations in HBCUs that are primarily undergraduate-focused institutions. The overall goal of the project was to see how the innovation capability of HBCUs could be activated through I-Corps and to increase their participation in the NSF I-Corps Program.

NATIONAL SCIENCE FOUNDATION INNOVATION CORPS (NSF I-CORPS)

I-Corps Process

I-Corps is an NSF-sponsored entrepreneurship education program for scientific researchers and students that is rooted in the Lean LaunchPad Methodology — a relatively new approach for creating businesses. The I-Corps program includes a hands-on experiential curriculum that is a hypothesis-driven, evidence-based approach that is more likely to ensure the success of a venture. Traditionally, entrepreneurship has been defined by writing a business plan, completing a five-year financial forecast, using the forecast to raise money, and then starting the company. This approach has resulted in founders spending lots of time and money on business start-up only to experience high failure rates. I-Corps replaces the traditional method and helps researchers function as entrepreneurs to develop hypotheses on their value propositions and then get out of the building to test them through customer interviews. Based on the feedback, they will continue, pivot, or abandon the product idea. I-Corps is success-oriented, where success is defined by achieving scalable, repeatable business models. This approach reduces the time and risk associated with translating promising ideas from lab to market by helping researchers become entrepreneurs who launch products that customers genuinely need and who ultimately add value to society.

The I-Corps Program includes a seven-week training course in which startup-like teams receive grant funding to conduct customer discovery and validate a business model using what's called a Business Model Canvas. Lean LaunchPad is an experiential entrepreneurship method developed by Steve Blank that encourages startup founders to translate their visions for their companies into experiments to test through the process of customer discovery (18). Courses implementing the methodology do so in a flipped classroom style and require students to go beyond the laboratory and interview stakeholders directly.

Teams in the National I-Corps program consist of an entrepreneurial lead, a technical lead, and an industry mentor. The entrepreneurial lead is typically a graduate student or postdoctoral researcher, while the technical lead is usually the faculty principal investigator who led the development of the technology. The team is advised as they go through the curriculum by an industry mentor, who is an expert in the field or an experienced entrepreneur. This team structure, and the rigor of the required work, is intended to mimic that of an early-stage startup founding team. The program was born of the NSF's interest in translating fundamental discoveries in science and engineering into commercial solutions that could fill a market need. It aims to develop entrepreneurial mindsets amongst its participants and to increase the economic impact of federally-funded research (19). Throughout the course, teams learn to create hypotheses about components of a proposed business model and test those assumptions by talking to individuals in their market's ecosystem (18). I-Corps teams learn how to build and leverage

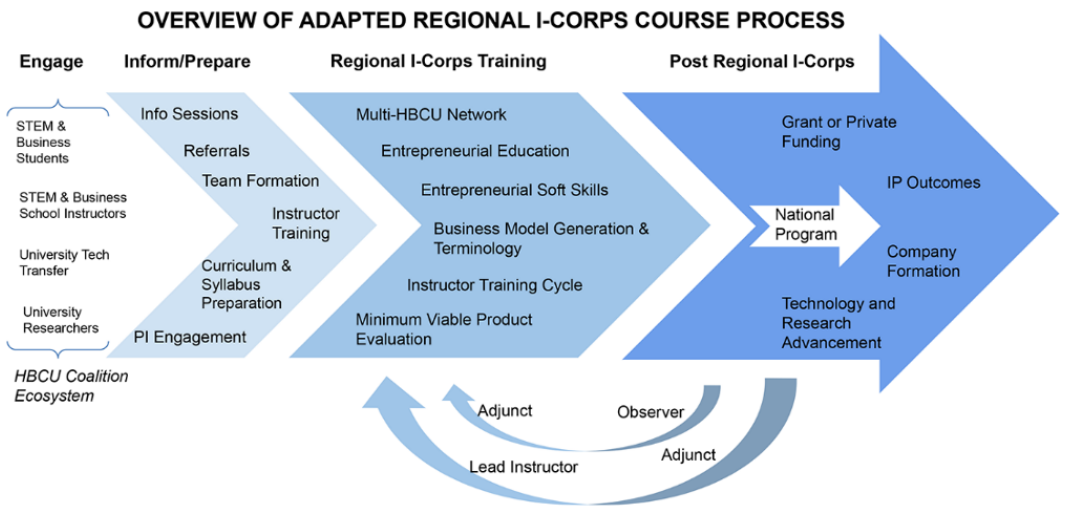

Figure 1. Process of the adapted Regional I-Corps program.

a national network to meet potential customers and gather the appropriate information to de-risk an initial business model.

The NSF I-Corps program facilitates delivery of I-Corps courses nationwide throughout the year and is hosted by multi-university nodes or single university sites (19). The I-Corps course discussed in this paper highlights a multi-university collaborative Regional I-Corps program (Figure 1). Regional I-Corps courses are intended to serve as a pipeline to the National I-Corps program or to initiate the preliminary commercial assessment of an early-stage project or idea. Much like a National I-Corps course, Regional I-Corps courses are typically taught by a team of instructors. Teaching teams are made up of core instructors and adjuncts and may include observers. Instructors possess the varied experience — as college professors, experienced entrepreneurs, former I-Corps participants, and industry professionals — that is needed to guide and teach young startups. Regional I-Corps programming engages STEM students, mentors, and instructors from different universities, incubators, and medical centers in forming teams to learn the fundamentals of Lean LaunchPad. After completing the course and gaining soft entrepreneurial skills, students have a specific understanding of market needs to inform future iterations of the technology or of their commercialization plans. After I-Corps, teams may move on to apply for government grants, such as Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) grants, or to pursue private funding. Alumni of I-Corps have also used the learnings of the course to acquire initial customers and profits or to explore alternate applications for their intellectual property, such as additional, novel licensing opportunities.

Team Reporting Metrics

I-Corps was included in the American Innovation and Competitiveness Act, which states that I-Corps should continue to promote strong entrepreneurship training and mentorship by investing in and supporting female entrepreneurs. To support the NSF's mission of creating an inclusive community of innovators, the NSF has extended this mandate to include individuals from under-represented groups (19). See the statistics reported to congress in the NSF I-Corps 2021 Biannual Report related to participation of I-Corps teams from under-represented groups in Table 1. The effort to improve these numbers drove the motivation to increase participation from HBCUs, create new courses, and forge relationships such as the multi-university coalition currently being discussed.

Table 1. NSF I-Corps Reporting Metrics of Teams with Members from Under-Represented Groups

Year	Program Start	2017 - 2018	2019 - 2020
Number of teams trained	1908	509	593
Teams with one or more members from under-represented groups	1012 (53%)	289 (57%)	366 (62%)
Number of individuals trained who are from under-represented groups	1432 (25%)	437 (27%)	568 (30%)
Number of Entrepreneurial Leads who are from under-represented groups	668 (30%)	207 (33%)	283 (38%)

Note: This report defines under-represented groups in science and engineering as individuals who identify as: 1) being a woman, 2) being Black or African American, American Indian, Alaska Native, and/or Native Hawaiian or Other Pacific Islander, 3) being of Hispanic origin, and 4) being a person with a disability (19).

NSF I-Corps Hubs

The I-Corps Program was chosen as the key strategy for tapping into the underutilized innovation potential at the three collaborating HBCUs. The primary goal of I-Corps is to reduce the time and risk associated with translating promising ideas and technologies from the laboratory to the marketplace. Therefore, researchers and innovators at these HBCUs could benefit from the I-Corps approach to explore the commercial viability of their scientific outputs and ideas by engaging in customer and industry discovery. NSF has structured Hubs, built on the successful I-Corps Nodes and Sites, to implement the I-Corps Program (20). The term "Hub" refers to a consortium of institutions, including the Lead and Partner institutions. The I-Corps Hubs form the new operational backbone of the National Innovation Network, a network of universities, NSF-funded researchers, established entrepreneurs, local and regional entrepreneurial communities, and other federal agencies. The NSF I-Corps Hubs work collaboratively to build and sustain a diverse and inclusive innovation ecosystem throughout the United States.

IMPLEMENTATION

After receiving NSF grant funding for the project, the three collaborating North Carolina HBCUs searched for an established and well-connected partner to guide and assist them in project development and implementation of I-Corps. They chose to partner with the New York City Regional Innovation Node (NYCRIN), one of first newly established NSF I-Corps Hubs. The NYCRIN team assisted the North Carolina HBCU coalition with the development of syllabi and curriculum materials, provided coalition project leaders with training in the development and delivery of the I-Corps program, supported project staff in the utilization of course management tools and software, made NYCRIN resources available, connected coalition project leaders to the I-Corps National Innovation Network, and facilitated exposure and participation of coalition project leaders in the National I-Corps program. The partnership has been successful and beneficial for both parties and could serve as a model for other HBCUs interested in activating the innovation potential of students and faculty. The keys to the success of the partnership have been a relationship based on mutual respect,

a genuine interest in engaging the innovation talent of a diverse range of participants, and the experience and competence of all parties in working with minority groups.

Mentor-Protégé Approach to Training the Trainer

Train-the-trainer is an educational model familiar in professional development across a number of disciplines, and its use spans community organizations, private industry, and U.S. government offices (21). The purpose of train-the-trainer is to engage master trainers in coaching new trainers, who are less experienced with a particular topic or skill or with training overall. A train-the-trainer workshop can produce a pool of instructors who can then teach the material to other people (22). One potential concern is that information or knowledge may be diluted when intermediate trainers are employed and another is that the newly-trained trainers may not go on to conduct training sessions (21). Mentoring is another way adults gain new knowledge and skills. Mentoring is a personal relationship in which a more experienced individual acts as a guide, role model, teacher, and sponsor in the development of a less experienced protégé. The mentor-protégé model is deeper than simply training the trainer, as the mentor provides the protégé with knowledge, advice, challenge, and support in the protégé's pursuit of becoming a full member of a particular community of professionals (23). Similar relationships have been promoted in graduate and public health education programs (23). The I-Corps curriculum is based on the Lean LaunchPad entrepreneurship methodology (24,25) and was new to the HBCU project leaders. Therefore, the NCATSU, NCCU, and WSSU coalition, with NYCRIN partnership, was established to start up and guide project activities in alignment with the NSF I-Corps Program. The NYCRIN teaching team serves as a mentor to the NCATSU, NCCU, and WSSU coalition project leaders (who are the protégés). This mentor-protégé approach was an effective means of developing the capability at the HBCU coalition institutions to deliver the I-Corps curriculum to their students, faculty, and staff as well as to build a pipeline of new HBCU I-Corps instructors to grow their local teaching teams.

Mentoring is an intentional activity where the mentor serves as a role model to the protégé, conscientiously carrying out responsibilities while actively engaging the protégé in growth-producing activities, providing guidance and feedback on observed performance, and nurturing to foster the full maturation of the protégé's potential capabilities (26). Consequently, there is a symbiotic relationship between mentor and protégé, as they assist each other to meet mutual objectives. There are distinct stages in the mentor-protégé relationship, including initiation, cultivation, and transformation. During the initiation stage, challenging work begins, and the protégé provides technical assistance to the mentor, while the mentor recognizes and encourages opportunities for interaction centered on work-related tasks. During the cultivation stage, there are frequent and meaningful interactions, where both mentor and protégé derive numerous professional and personal benefits from the relationship. During the transformation stage, the protégé no longer needs parent-like coddling, requires less guidance from the mentor, and works more autonomously, so the relationship between the mentor and protégé becomes more peer-like.

The NSF-funded project involved training project leaders and other faculty from the coalition HBCUs in the I-Corps teaching practices. The training followed a cyclical model in which a trainer, the NYCRIN partner serving as the mentor, coached the HBCU coalition group — the protégés — by gradually guiding them through all aspects associated with I-Corps teaching. HBCU coalition protégés first served as observers to the NYCRIN teaching team in a real I-Corps course provided to a cohort of teams in a Regional I-Corps program. Then, in subsequent I-Corps events, HBCU coalition protégés joined the NYCRIN teaching team as adjuncts in a co-teaching capacity. This mentor-protégé training approach provides an immersive learning experience for the HBCU coalition trainees while, at the same time, delivering the I-Corps program to cohorts of team participants who gain hands-on experience in business model testing. In fact, I-Corps cohort team participants' satisfaction level was high for the I-Corps course hosted by the project, which included HBCU coalition faculty members serving as adjuncts and observers. Facilitated by the NYCRIN teaching team, HBCU coalition trainees engage in the

planning and execution of the I-Corps teaching process in preparation for becoming lead instructors with their own I-Corps cohort teams and serving as mentors to protégés from their own institutions. This cyclic process offers a way to produce a larger pool of diverse I-Corps trainers who can serve the HBCU coalition institutions and the NYCRIN node.

Project Operation

Implementation of the mentor-protégé project was structured around several I-Corps training events that occurred during the period from Fall 2020 to Summer 2021. The key objectives for project implementation were the following:

1. Adapt the I-Corps and Lean LaunchPad Methodology curriculum to HBCU settings and populations;
2. Provide training for HBCU faculty members to become instructors, advocates, and leaders in I-Corps and the Lean LaunchPad Methodology; and
3. Manage the delivery of cohorts of I-Corps Teams consisting of HBCU students, faculty, and staff.

Figure 2 is a graphic depicting implementation of the mentor-protégé model in the I-Corps training of HBCU faculty.

The first training event was a Regional I-Corps program hosted by the NCATSU, NCCU, and WSSU coalition and conducted by the NYCRIN teaching team. Other than being delivered virtually on Zoom, this was a typical Regional I-Corps course, which ran once a week for seven weeks from September 23 to November 4, 2020. The NYCRIN Node provided the technical support and operational infrastructure, including the IYE (InYourEcosystem) platform used as the course management system. The participating cohort teams were recruited and selected from the three NC HBCUs and from regional NYC universities. The initiation stage of the mentor-protégé relationship was facilitated via this Regional I-Corps event. Faculty (protégés) from the NCATSU, NCCU, and WSSU coalition participated as observers of the NYCRIN teaching team, who delivered the full I-Corps program to the participating cohort teams. The protégés observed the NYCRIN teaching team as they delivered the whole I-Corps curriculum and guided the participating cohort teams in experiential learning — from customer discovery to company building. Observers were initiated by studying the syllabus and the course videos, being on orientation calls where the NYCRIN teaching team reviewed the run-of-show, attending pre-flight meetings before each session, and participating in de-briefing meetings after each session. No teaching responsibilities were involved during this initiation stage.

The next training event was a National I-Corps cohort conducted by the NYCRIN teaching team and sponsored by the NSF. This National I-Corps program was also delivered virtually and ran for seven weeks, with one session per week, from January 13 to February 23, 2021. The participating cohort teams were from universities all over the United States as far south as Florida and as far west as Texas. The cultivation stage of the mentor-protégé relationship was facilitated via this National I-Corps event. The protégés, the NCATSU, NCCU, and WSSU coalition faculty, advanced from being observers to being adjunct instructors to the NYCRIN teaching team in a National I-Corps cohort. As adjunct instructors, protégés were engaged more in the I-Corps training program by commenting on the Business Model Canvases and presentation slides of the participating cohort teams, participating in the questioning and critiquing of the participating cohort teams' presentations, supporting the NYCRIN teaching team during sessions in the form of active chats and backchats in the course management system, shadowing cohort teams as they were guided through the I-Corps program by NYCRIN teaching team members, and participating in office hours for cohort teams with NYCRIN teaching team members. NYCRIN mentors further cultivated NCATSU, NCCU, and WSSU coalition protégés by engaging them as adjunct instructors and judges in other major activities of the NYCRIN Node, such as regional innovation challenge competitions and I-Corps short courses. As the cultivation of protégés continued, they gained more I-Corps experience, contributed more to I-Corps programming, and carried out more I-Corps program responsibilities.

The last training event was an adapted Regional I-Corps course hosted and conducted by the NCATSU, NCCU, and WSSU coalition teaching team. The participating cohort teams consisted of students, faculty, and staff from the three HBCUs.

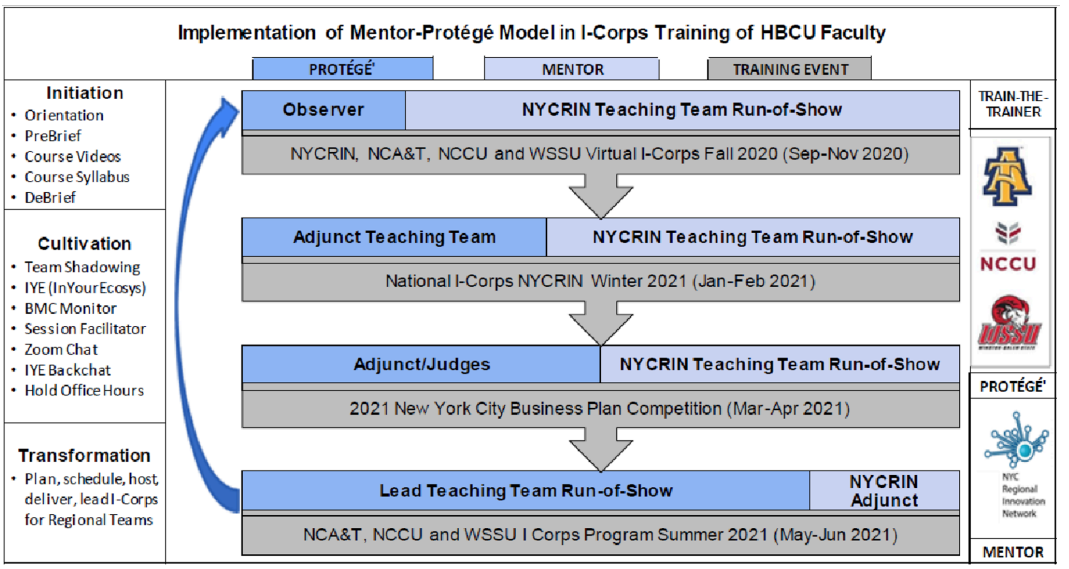

Figure 2. The schematic outlines the features of the NC HBCU Coalition and NYCRIN mentor-protégé relationship.

The adapted Regional I-Corps event facilitated the transformation stage of the mentor-protégé relationship, where the NCATSU, NCCU, and WSSU coalition teaching team fully ran the show while the NYCRIN mentors supported as adjunct instructors and peers. The adaptations made for this Regional I-Corps event were specific to the HBCU environment and participants. The event was scheduled and held during the summer months when faculty and students were free of academic year responsibilities. This Regional I-Corps was delivered virtually and ran for four weeks, with two sessions per week, from June 2 to June 29, 2021. This schedule helped to reduce conflicts with potential student summer research and internship experiences, on which they depended to generate income for themselves and to cover their educational costs. This schedule also minimized time taken away from faculty conducting summer research and generating summer salary for themselves. In running the show for this adapted Regional I-Corps, the NCATSU, NCCU, and WSSU coalition teaching team recruited and selected participating I-Corps teams, planned the run-of-show sequence and adapted the course outline, taught the I-Corps sessions, moderated presentations from participating I-Corps teams, and provided office hours to participating I-Corps teams. In addition, the NCATSU, NCCU, and WSSU coalition teaching team recruited faculty from their institutions to serve as observers, orienting and mentoring them through the adapted Regional I-Corps event. Therefore, this mentor-protégé model is self-perpetuating: NYCRIN mentors trained the NCATSU, NCCU, and WSSU coalition faculty who contributed to Regional and National I-Corps courses, and then those former protégés recruited and trained new teaching team members to assist in propagating I-Corps on these HBCU campuses.

ON I-CORPS TEACHING TEAM DEVELOPMENT

Best Practices

Best practices were followed to facilitate the training of trainers by the teaching teams. To ensure synergy, meetings were held prior to and after each session. During the "pre-brief," a review of what would be presented, who would lecture, what must be emphasized to the I-Corps participants, and what their expected progress should be was covered. After each session, the post-brief or "debrief" covered a review of the needs of the participants based on their team presentations, an assessment of what went well, and a determination of whether any topic needed

to be re-emphasized. Importantly, office hours were also used to augment the training of observers and adjuncts on how to guide I-Corps participants concomitant with individual teams receiving further assistance.

Challenges

Challenges regarding time constraints, emphasizing key points, and encouraging participants were evident during all I-Corps program sessions. As is customary amongst academics, members of the teaching team had the challenge of meeting at a time conducive for everyone. To circumvent this, meetings were often held in the evenings when all members could attend. The teachers were also challenged with emphasizing to participants that they (i) were NOT selling their product but discovering what their potential customers needed or wanted, (ii) were learning who their customer(s) were, (iii) were testing to find the best product-market fit, and (iv) were evaluating whether revenues could be generated that would exceed costs. It was found that it took at least 30 interviews for participants to determine if they had a minimum viable product (or service) and a potential consumer base that would purchase it. During this effort, I-Corps participants sometimes had to pivot and often needed help and stimulation to press on in finding a path forward to a viable business model. The teaching team served as a source of motivation, inspiration, and encouragement for participants to stay on task and endure to the end of the program.

Lessons Learned

Observers progressed to adjuncts and teachers in less than a year by using the train-the-trainer approach. A WSSU faculty I-Corps participant received a lot of support from others in his department and was even provided with leads when seeking potential customers. This activity was also reviewed favorably in faculty members' annual evaluations. Highlights included the development of the trainee instructors into ecosystem program leads and the tighter integration of ecosystem resources through the incorporation of a What's Next panel during the finale. These results demonstrated the building of a support network for local entrepreneurs.

ON I-CORPS PARTICIPANTS' DEVELOPMENT

Best Practices

To ensure the interview questions were meaningful and directed towards the best potential customers, mandatory office hours allowed the teaching team to advise the I-Corps participants in a more individualized setting. Office hours were useful for encouraging participants in the event they had to pivot from what they initially thought about the value of their product, technology, or service. Participants also needed guidance in completing the nine blocks of the Business Model Canvas (27,28) to help them determine if they had a viable product that would yield a return on investment. The Business Model Canvas allows the participating teams the opportunity to use the scientific method to validate or invalidate guesses made to business components represented by the nine blocks outlined in Figure 3.

Hence, over the course of six weeks, participants gain enough in-depth knowledge to decide if they want to proceed or not proceed toward business creation around their products.

Challenges

Although customer discovery using the Business Model Canvas is a best practice, it is also a challenge because of the amount of time required of I-Corps participants. Participants had to present their findings once a week in the course. When the I-Corps sessions were held during the academic year, some participating students and faculty on the teams faced challenges attending all of the sessions, meeting frequently with team members, utilizing the office hours of the teaching team, and, most importantly, completing all of their customer interviews and the testing of the full Business Model Canvas. Consistent exhortation from the teaching team was needed to guide participants away from trying to sell in their customer interviews. This led to them uncovering what their customers' problems and needs were instead, such that, at the end, most participants refrained from selling. Participants also were challenged with securing the requisite number of interviewees. This was partly circumvented by advising participants to ask a current interviewee if they could suggest others who might possibly have similar problems or needs. Interviewing telephonically or virtually

<table>
<tr><td rowspan="2">KEY PARTNERS</td><td>KEY ACTIVITIES</td><td rowspan="2">VALUE PROPOSITIONS</td><td>CUSTOMER RELATIONSHIPS</td><td rowspan="2">CUSTOMER SEGMENTS</td></tr>
<tr><td>KEY RESOURCES</td><td>CHANNELS</td></tr>
<tr><td colspan="2">COST STRUCTURE</td><td colspan="3">REVENUE STREAMS</td></tr>
</table>

Figure 3. The Business Model Canvas components.

in the era of a pandemic was also a challenge and an opportunity. Generally, it is more difficult to assess the behavioral cues of interviewees through the phone or on a screen, yet the normalization of virtual settings made both parties more accessible and comfortable and allowed for flexible scheduling of interview times. In addition, to ensure the interview questions were meaningful and directed towards the best potential customers, mandatory office hours allowed the teaching team to advise the participants in a more individualized setting. Office hours were also useful for encouraging participants in the event they had to pivot from what they initially thought about the value of their product, technology, or service. Ultimately, pressing participants to complete the Business Model Canvas was critical to their understanding of all aspects of a startup. This is because the Business Model Canvas informs I-Corps participants about nine blocks of business considerations (Figure 3) that must be addressed in making an informed decision regarding proceeding to the next step towards business creation.

Lessons Learned

Providing a small stipend (29) of up to $1,500 for customer discovery showed support for participants' efforts and fostered encouragement. In addition, offering a shorter session (2.5 weeks) mitigated some of the program's intensity while providing enough training to help participants decide if they wanted to take the more rigorous six-week course. The shorter session required less interviews while still helping participants design good interview questions and determine the viability of their products.

Outcomes

The pre- and post-workshop surveys consisted of the questions in Table 2. The Likert scale designated survey responses as 1) not at all, 2) somewhat, 3) neutral, 4) moderately, and 5) very.

Additional post-course survey questions were asked as outlined in Table 3. The Likert scale designated survey responses as 1) not at all, 2) somewhat, 3) neutral, 4) moderately, and 5) very.

The quantitative results of the pre- and post-surveys indicate substantial gains in participants' confidence due to the I-Corps activities provided by the project. Participants gained confidence in the ability to validate a business model, establish whether they have a good product-market fit, and understand the importance of networking in entrepreneurship. In addition, participants were satisfied with the coursework provided, the teaching team presentations, and the discussions during the I-Corps sessions. Participants felt the program was well-designed and that the delivery was both organized and, importantly, presented at the appropriate level. Participants strongly agreed that they would take a follow-up I-Corps course to further their overall development as entrepreneurs. Participants were satisfied overall with the learning experiences and the operations of the I-Corps course, including team presentations, office hours, and customer interview findings. The most notable success was that two teams from the project's Regional I-Corps courses advanced to the National I-Corps level, each winning $50,000 to continue moving their products toward commercialization.

Table 2. Evaluation Survey Results

Survey Item	Pre	Post
1-How confident are you that you can transition an idea to the marketplace?	2.2	3.40
2-What is your current desire/motivation to complete a STEM degree?	2.5	2.67
3-How much do you think networking plays a role in entrepreneurship?	3.8	4.60
4-How confident are you now that you have the skills to develop as an entrepreneur?	3.0	4.00
5-How confident are you now that any product you produce will have commercial success?	2.4	3.60
6-How confident are you now that your business can be validated in the marketplace?	3.1	4.20
7-How confident are you now that you can establish a good product-market fit?	2.6	4.00
8-How confident are you now to compete for and win a $50,000 I-Corps team grant?	2.2	3.60

Table 3. Evaluation Survey Results-Post Only

Survey Item	Post Only
1-How likely would you be to recommend this program to others?	5.00
2-How likely would you be to take a follow-up course to the I-Corps Project?	5.00
3-How helpful do you think the Teaching Team presentations were to your development?	4.80
4- How helpful do you think the Participant Team presentations were to your development?	4.20
5- How helpful do you think the office hours w/Teaching Team were to your development?	5.00
6- How helpful do you think the customer interview feedback was to your development?	4.75
7- How helpful do you think the business model canvas prep was to your development?	4.75
8- How helpful do you think the lessons learned in the presentation were to your development?	4.80

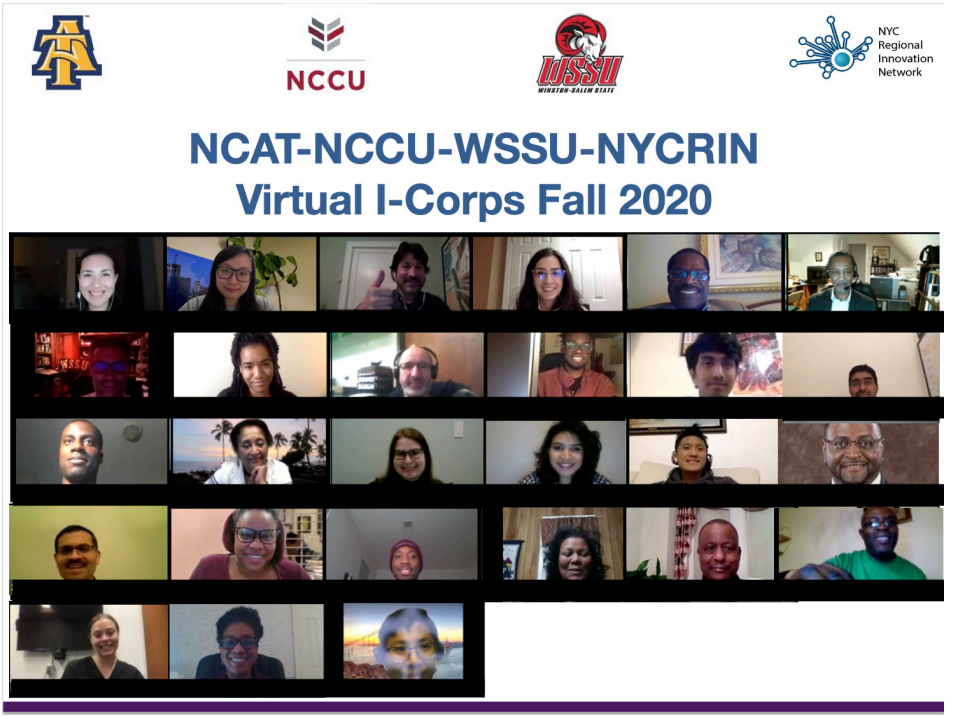

Figure 4. Earticipants of the six-week Fall 2020 cohort.

Figure 5. Participants of the six-week Summer 2021 cohort.

OUTCOMES

The following is a list of the noteworthy program outcomes:

1. Completion of two NSF I-Corps cohort training sessions — 21 participants
2. Completion of NSF Instructor Training Program — eight faculty members
3. Development of a thriving collaboration among the three participating North Carolina Universities and NYCRIN
4. Validation of the market potential of participants' ideas
5. Increased knowledge about technology entrepreneurship and commercialization, e.g., business model development, customer discovery, etc.
6. Increased probability of grant success, e.g., SBIR and National I-Corps
7. Expansion of participants' networks
8. Recognition of the importance of stipends for participants to support customer discovery, prototyping, etc.
9. Increased capacity of HBCU students and faculty to explore the transition of research into entrepreneurial ventures

CONCLUSIONS

Based on the outcomes of the two cohorts, it is concluded that the mentor-protégé approach described herein was very successful in achieving its main goal of training HBCU faculty to independently deliver the I-Corps curriculum to their students. Unanticipated positive outcomes include the creation of a new innovation ecosystem among HBCUs in Central NC along with novel institutional changes at each of the three universities. These results will likely serve as the template for future innovation ecosystem building efforts at similar minority-serving institutions classified as baccalaureate or master's colleges and universities.

ACKNOWLEDGMENTS

T.M. and J.A.B. acknowledge support from the NSF (2028508) and (1740622 and 1844298), respectively. The authors thank Kossi Agbeve, Mohd Anwar, Tanina Badley, Anthony Graham, Gail Hollowell, Darryl Scriven, Yao Sun, and Mulumebet "Millie" Worku for serving as additional faculty and mentors in the cohorts, and, most especially, Wendy Yan for serving as teaching assistant in the final cohort.

REFERENCES

1. Hofstra B, Kulkarni VV, Galvez SM-N, He B, Jurasky D, McFarland DA. The diversity-innovation paradox in science. Proc Natl Acad Sci. U.S.A. 2020;117(17):9284-9291.
2. Monterde S. The innovation imperative: why does innovation matter? [blog]. CISCO. [accessed 2021 Nov 5]. https://blogs.cisco.com/innovation/the-innovation-imperative-why-does-innovation-matter.
3. National Science Board. Science and engineering indicators 2020: the state of U.S. science and engineering. Alexandria (VA): National Science Board; 2020. [accessed 2022 Apr 10]. https://ncses.nsf.gov/pubs/nsb20201/.
4. National Research Council. Rising to the challenge: U.S. Innovation policy for global economy. Washington (DC): National Academies Press; 2012. [accessed 2022 Apr 10]. https://nap.nationalacademies.org/catalog/13386/rising-to-the-challenge-us-innovation-policy-for-the-global.
5. Grimaldi R, Kenney M, Siegel DS, Wright M. 30 years after Bayh–Dole: reassessing academic entrepreneurship. Res Policy. 2011;40(8):1045-1057.
6. Hamilton C. Increasing diversity among women entrepreneurs in high growth high tech using HBCU female academic entrepreneurs. Technology & Society Faculty Publications. 2020 [accessed 2022 Apr 10];27. https://commons.library.stonybrook.edu/techsoc-articles/27.
7. Nager A, Hart, DM, Ezell, SJ, Atkinson RD. The demographics of innovation in the United States. SSRN Electronic Journal. 2016 [accessed 2022 Apr 11]. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3066060.
8. Stone A, Rose S, Lal B, Shipp S. Measuring innovation and intangibles: a business perspective. Washington (DC): Institute for Defense Analysis, Science and Technology Policy Institute; 2008. [accessed 2022 Apr 10]. https://www.ida.org/-/media/feature/publications/m/me/measuring-innovation-and-intangibles-a-busi-

ness-perspective/ida-d-3704.ashx .
9. Keller S, Korkmaz G, Pires B, Shipp S. Measuring innovation and innovation activities using non-survey data sources. Washington (DC): Federal Committee on Statistical Methodology (FCSM) Research and Policy Conference; 2018. [accessed 2022 Apr 10]. https://nces.ed.gov/FCSM/2018_ResearchPolicyConference.asp.
10. National Research Council. Partnerships for emerging research institutions: report of a workshop. Washington (DC): The National Academies Press; 2009. [accessed 2022 Apr 10]. https://nap.nationalacademies.org/catalog/12577/partnerships-for-emerging-research-institutions-report-of-a-workshop.
11. US Department of Education. What is an HBCU? White House initiative on advancing educational equity, excellence, and economic opportunity through historically Black colleges and universities. Washington (DC): US Department of Education. [accessed 2022 Apr 10]. https://sites.ed.gov/whhbcu/one-hundred-and-five-historically-black-colleges-and-universities/
12. National Science Foundation. Women, minorities, and persons with disabilities in science and engineering. Arlington (VA): National Science Foundation; 2017. [accessed 2022 Apr 10]. www.nsf.gov/statistics/wmpd/.
13. National Science Foundation. Role of HBCUs as baccalaureate-origin institutions of Black S&E doctorate recipients. Arlington (VA): National Science Foundation; 2008. [accessed 2022 Apr 10]. https://files.eric.ed.gov/fulltext/ED502482.pdf.
14. Hurtado S, Cabrera NL, Lin MH, Arellano L, Espinosa LL. Diversifying science: underrepresented student experiences in structured research programs. Res High Educ. 2009;50:189–214.
15. National Center for Science and Engineering Statistics (NCSES). Higher education research and development: fiscal year 2019. Alexandria (VA): National Science Foundation; 2021. [accessed 2022 Apr 10]. https://ncses.nsf.gov/pubs/nsf21314.
16. Hamilton C. HBCU technology transfer supply chain networks sustainability budget resource planning tool development. Proceedings of the American Society for Engineering Management 2017 International Annual Conference. Ng EH, B. Nepal B, Schott E, editors. Red Hook (NY): Curran Associates, Inc.; 2018. p. 117-126.
17. Hamilton C. A Tool kit for building HBCU technology transfer supply chain networks using an advanced planning system [dissertation]. [Knoxville (TX)]: University of Tennessee; 2016. [accessed 2022 Apr 10]. http://trace.tennessee.edu/utk_graddiss/3922.
18. Blank S, Dorf B. The startup owner's manual: the step-by-step guide for building a great company. Pescadaro (CA): K & S Ranch Press; 2012.
19. National Science Foundation. Innovation Corps (I-Corps) Biennial Report. Washington (DC): National Science Foundation; 2021. [accessed 2022 Apr 10]. https://www.nsf.gov/news/special_reports/i-corps/pdf/NSFI-Corps2021BiennialReport.pdf.
20. National Science Foundation. NSF Innovation Corps Hubs. Washington (DC): National Science Foundation; [accessed 2022 Apr 10]. https://www.nsf.gov/news/special_reports/i-corps/hubs.jsp.
21. Orfaly RA, Frances JC, Campbell P, Whittemore B, Joly B, Koh H. Train-the-trainer as an educational model in public health preparedness. J Public Health Manag Pract. 2005;11(6) S123-S127.
22. Centers for Disease Control and Prevention. Understanding the training of trainers model. Division of Population Health, National Center for Chronic Disease Prevention and Health Promotion. Atlanta (GA): Centers for Disease Control and Prevention; [accessed 2022 Apr 10]. https://www.cdc.gov/healthyschools/tths/train_trainers_model.htm.
23. Bigelow JR, Johnson WB. Promoting mentor-protégé relationship formation in graduate school. Clin Superv. 2001;20(1):1-23..
24. Blank S. Why the Lean Start-Up changes everything. Harv Bus Rev. 2013 [accessed 2022 Apr 10]. https://hbr.org/2013/05/why-the-lean-start-up-changes-everything.
25. Colao JJ. Steve Blank introduces scientists to a new variable: customers. Forbes. 2012 [accessed 2022 Apr 10]. https://www.forbes.

com/sites/jjcolao/2012/08/01/steve-blank-introduces-scientists-to-a-new-variable-customers/?sh=5703185959b4.
26. Haines ST. The mentor-protégé relationship. Am J Pharm Educ. 2003;67(1/4):458.
27. Osterwalder A, Pigneur Y. Business model generation. New York (NY): John Wiley & Sons; 2010.
28. Ojasalo J, Ojasalo K. Service logic Business Model Canvas. J Res Mark Entrepreneurship. 2018;20(1):70-98.
29. Koffarnus MN, DeFulio A, Sigurdsson SO, Silverman K. Performance pay improves engagement, progress, and satisfaction in computer-based job skills training of low-income adults. J Appl Behav Anal. 2013;46:395-406.