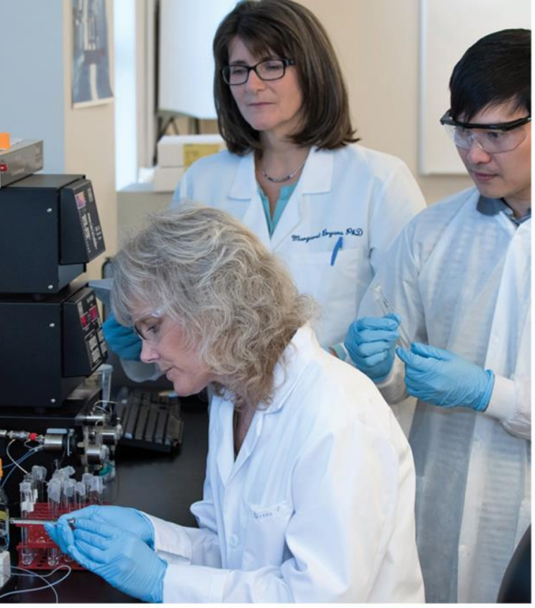
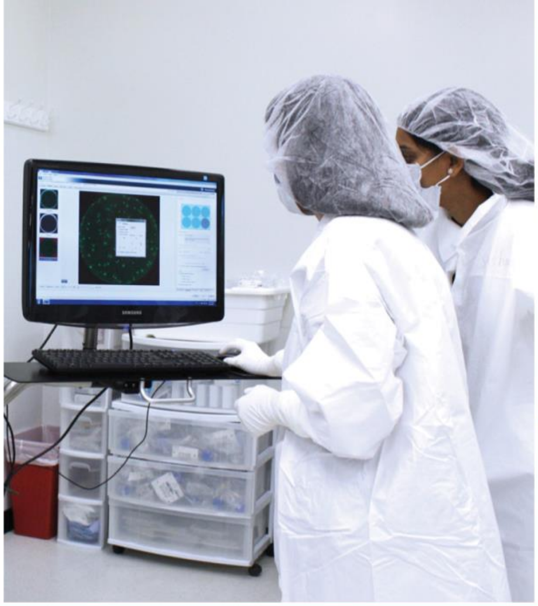


Evaluation of the Community College Consortium for Bioscience Credentials (c^{3}bc): Final Report

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Executive Summary

I. TAACCCT Program/Intervention Description and Activities

The Community College Consortium for Bioscience Credentials (c[3]bc) grant was designed to achieve four goals:

1. Bridge the gap between Trade Adjustment Act (TAA) and other displaced workers and their preparation for the workplace through expanded student recruitment, redesigned courses, and improved retention in bioscience programs;
2. Harmonize a set of core skills for biosciences that facilitate the creation of pathways and provision of training that lead to industry-recognized credentials;
3. Enhance training programs and accelerate certificate and credentialing processes in biosciences through prior learning assessment, focused support services, and the use of technology-enhanced instructional materials; and
4. Build community college capacity for education and training that meets employer needs through partnerships in which colleges work with employers in designing and delivering instruction, placing students into employment, and providing internships and other activities that prepare students for the workplace.

Forsyth Technical Community College (Forsyth Tech) served as the TAACCCT grantee for the consortium, and Abt Associates (Abt) conducted the third-party evaluation. The grant was organized using a hub structure that reflected the grant's focus on three subsectors of the bioscience industry—biomanufacturing, medical devices, and lab skills, and on modularized, more flexible approaches to learning—learning technologies. Each hub was comprised of a lead college and three partner colleges. While all hubs were involved in developing or expanding courses, programs, and or credentials, each hub had a special focus. The colleges that comprised each hub and the focus of each hub's activities were:

- **Biomanufacturing Hub**: Montgomery County (PA) Community College (MCCC) (Lead College) with Bucks County Community College (BCCC) and Los Angeles Valley Community College (LAVC)—revalidate biomanufacturing skill standards;
- **Lab Skills Hub**: City College of San Francisco (CCSF) (Lead College) with Austin Community College (ACC) and Madison Area Technical College (MATC)—update and revalidate bioscience lab skills standards;
- **Medical Devices Hub**: Ivy Tech Community College (Ivy Tech) (Lead College) with Salt Lake Community College (SLCC) and St. Petersburg College (SPC)—develop and validate new medical device skill standards; and
- **Learning Technologies Hub**: Forsyth Technical Community College (Forsyth Tech) (Lead College) with Alamance Community College and Rowan-Cabarrus Community College—develop contextualized and modularized online courses.

Through the hubs' work the c[3]bc colleges expanded courses, programs, and credentials in biomanufacturing, medical devices, and lab skills; developed new technology-based approaches to teaching introductory courses in biology, chemistry, and biotechnology; and developed a new structure and approach for teaching bioscience lab skills. In addition to the joint work among colleges within hubs, each c³bc college conducted activities to meet its specific goals for the grant. The colleges also engaged in cross-hub work in establishing a set of core skill standards for bioscience technicians that are derived from the individual hubs' development or revalidation of skill standards in the three bioscience subsectors that were the focus of the grant.

The c³bc grant served a diverse population of students across the seven colleges whose student data were analyzed in the evaluation. A total of 938 c³bc students participated in the evaluation. These students were equally male and female. Almost half of the students (47%) were ages 26-45; slightly more than one third (37%) were 25 years or younger; and 17 percent were 46 years or older. While slightly more than half (54%) of students were White, 18 percent were Black/African American; 12 percent were Hispanic; 10 percent were Asian; 3 percent were "other;" and 1 percent were American Indian/Alaskan Native.

The background characteristics of c³bc participants also illustrate the broad population served by the grant. At the time of enrollment in c³bc courses, slightly more than one-third (39%) of c³bc students had a high school diploma or less education; 19 percent had attended some post-high school training or college; and 36 percent had earned an AA/AS or higher degree. Half of the students (51%) were employed at enrollment. While a small percentage (2%) of c³bc students received Trade Adjustment Assistance (TAA) funding or had military experience (5% were Veterans; less than 1% were on active duty or in the Reserves; and 1% were eligible spouses), all seven colleges had TAA or Veterans' represented in their student populations.

II. Evaluation Design Summary

Abt's evaluation of the Community College Consortium for Bioscience Credentials was comprised of an implementation study, an impact study, and six outcome studies. Nine[1] of the 12 Consortium colleges conducted c³bc supported activities that involved developing new and enhancing existing bioscience courses, programs, and credentials. These colleges participated in the implementation study. Seven[2] of the colleges in the implementation study participated in the evaluation's impact and outcome studies. These colleges were able to collect individual-level student data that could be transferred to Abt for analysis. Two of the nine colleges in the implementation study were not able to transfer individual-level student data to Abt and thus did not participate in the impact or outcomes studies. Three[3] of the 12 colleges collaborated on the grant's activities but did not develop new courses or credentials, and were not part of the evaluation.

The impact and outcome studies were designed to assess student outcomes from activities the c³bc colleges implemented for the following two grant goals:

- Enhance training programs and accelerate certificate and credentialing processes in biosciences through prior learning assessment, focused support services, and the use of technology-enhanced instructional materials; and
- Build community college capacity for education and training that meets employer needs by designing and delivering instruction and placing students into employment.

[1] ACC, BCCC, CCSF, Forsyth Tech, Ivy Tech, LAVC, MCCC, SLCC, and SPC
[2] BCCC, Forsyth Tech, Ivy Tech, LAVC, MCCC, SLCC, and SPC
[3] Alamance Community College, Madison Area Technical College, and Rowan-Cabarrus Community College

Implementation Study

The following questions guided the c^{3}bc implementation study:

1. To what extent did the c^{3}bc colleges carry out the core activities of the c^{3}bc TAACCCT grant in terms of:

    a. Strategic Alignment through Partnerships:

        i. What types of private and public partnerships did c^{3}bc colleges develop?

        ii. What was the extent of partners’ involvement in c^{3}bc activities?

        iii. What were the effects of c^{3}bc’s partnerships on the project’s activities and outcomes?

    b. Course, Program, and Credential Development and Enhancement:

        i. What processes and content were used to develop new and/or enhance existing bioscience courses, programs, and credentials?

        ii. To what extent was prior learning assessment used to accelerate credential completion?

        iii. To what extent was the use of technology-enhanced instructional materials incorporated into the c^{3}bc–supported enhanced or new courses and programs?

    c. Student Recruitment, Assessment, and Advising:

        i. What recruitment strategies were used to attract students to enroll in the courses and programs developed under c^{3}bc?

        ii. What was the role of student assessment in screening and placing students into courses or programs?

        iii. To what extent were students provided with academic advising and career guidance?

    d. Preparation for Further Education and Employment: What strategies can facilitate students’ readiness to continue education and/or work in the bioscience industry?

    e. Harmonization of Standards: What processes did c^{3}bc use to harmonize a set of core skills for biosciences?

    f. c^{3}bc Design and Structure: What aspects of the design and structure of the Community College Consortium for Bioscience Credentials grant affected the implementation of c^{3}bc activities?

Data were collected through two site visits involving face-to-face interviews, observations of classes, and review of materials; review of colleges’ quarterly reports documenting their grant activities; documentation of presentations and discussions at the grant’s annual meetings, and reports from the colleges on the grant calls that Forsyth Tech conducted every three weeks. The implementation data were analyzed to identify common themes across topics and colleges concerning types of activities undertaken, factors that facilitated the activities, and challenges to conducting activities. Activities unique to a college or to a subset of the colleges were identified and reviewed to determine possible reasons for their uniqueness. Abt assessed the grant's capacity-building outcomes in terms of the number of newly developed or enhanced courses and credentials, and the types of business partnerships established during the grant.

Impact and Outcome Studies

Abt conducted a quasi-experimental impact evaluation at one college (Forsyth Technical Community College [Forsyth Tech]) and individual outcome studies at six colleges (Bucks County Community College [BCCC], Ivy Tech Community College [Ivy Tech], Los Angeles Valley College [LAVC], Montgomery County Community College [MCCC], Salt Lake Community College [SLCC], and St. Petersburg College [SPC]).

Impact Study

The impact study addressed the following research questions concerning the effects of Forsyth Tech's c3bc-enhanced Biology 111 and Chemistry 131 courses:

1. What is the impact of the c^{3}bc-enhanced Biology 111 course on students' course completion and grades, compared to students who enrolled in non-c^{3}bc enhanced versions Biology 111?

   1a. Do impacts of the c^{3}bc-enhanced Biology 111 course on course completion vary by student baseline characteristics?

   1b. Which characteristics of students are associated with greater likelihood of Biology 111 course completion?

2. What is the impact of the c^{3}bc-enhanced Chemistry 131 course on students' course completion and grades, compared to students who enrolled in non-c^{3}bc enhanced versions of Chemistry 131?

   2a. Do impacts of the c^{3}bc-enhanced Chemistry 131 course on course completion vary by student baseline characteristics?

   2b. Which characteristics of students are associated with greater likelihood of Chemistry 131 course completion?

The sample for the impact study was Forsyth Tech students. The treatment group was comprised of students who participated in c^{3}bc-enhanced Biology 111 courses and/or c^{3}bc-enhanced Chemistry 131 courses during academic years 2013-2104 or 2014-2015 or fall 2015. The comparison group was students enrolled in non-c^{3}bc enhanced Biology 111 courses and non-c^{3}bc enhanced Chemistry 131 courses at Forsyth Tech during the same time periods as the c^{3}bc courses were delivered. A total of 763 Forsyth Tech students participated in the impact study.

The data for the impact study consisted of student-level administrative data from Forsyth Tech that were stored in student transcripts and transferred data to Abt using Abt's secure online file transfer platform. A quasi-experimental design was used to compare outcomes of a sample of treatment group students who had enrolled in Forsyth Tech's c3bc-enhanced Biology 111 course during the period fall 2013 through fall 2015 to the outcomes of a propensity score-matched sample of comparison students who were similar to the treatment group students on demographic characteristics, prior education levels, and baseline measures of math, reading, and sentence skills, but who had enrolled in a Forsyth Tech non-c3bc-enhanced Biology 111 course during the same period. For each treatment student, one or more matched comparison students were identified using a propensity score matching approach. The same procedure was used for the Chemistry 131 course data. The impact analyses utilized a "doubly robust" approach in which the treatment impacts were estimated in linear regression models where observations were assigned weights based on the propensity scores.

Outcome Studies

Student outcome studies were conducted at six c^3bc colleges (MCCC, BCCC, LAVC, Ivy Tech, SLCC, and SPC) for which no comparison group was available. The studies assessed c^3bc students' course participation, course completion, attainment of college credentials, attainment of employment, and wage increase. The types of outcomes assessed were tailored to each college's courses and credentials developed under the c^3bc grant.

The research questions for the outcome studies at the six colleges were:

1. What were the course completion rates for each college's c^3bc-developed courses or programs?
2. What were the c^3bc-developed certificate completion rates for students who enrolled in the c^3bc- developed courses?
3. To what extent did students who participated in c^3bc-developed courses or credential programs obtain a job?
4. To what extent did students who participated in c^3bc-developed credential programs and obtained a job increase their hourly wages?

The sample was students who participated in the courses, programs, and credentials that the six colleges developed under c^3bc and for which students' administrative data were available and could be transferred to Abt. To ensure that the courses or credentials being evaluated were stable, only courses that had been pilot tested and revised were included in the evaluation. A total of 586 c^3bc students across six colleges participated in the outcome studies.

Data were collected for students who enrolled in c^3bc-developed or enhanced courses: demographic characteristics and background information; c^3bc course enrollment, grades, and number of credits earned (if credit-bearing course); credential attainment (name of certificate, degree; type of certificate, degree); and job attainment and wage data.

A pre-post design was used to assess students' outcomes from participation in c^3bc-developed or enhanced courses during the period fall 2013 through spring 2016. The descriptive analyses of student outcomes at each of the six colleges included frequency distributions of students': (1) demographic and background characteristics; (2) types and number of c^3bc-developed courses in which they (a) enrolled and (b) completed; (3) types of (a) certificates and (b) degrees they earned; (4) whether they obtained a job, and amount of hourly wage increase from pre-c^3bc program to post-c^3bc program. Separate analyses were conducted for each of the six colleges.

III. Implementation Findings

The key findings from the c^3bc grant's activities to increase the courses and credentials that are aligned with entry-level technician jobs in biomanufacturing, bioscience laboratory skills, and medical devices, and to specify core skill standards for entry-level bioscience technicians are the following:

Strategic Alignment through Partnerships

Key Findings:

- Employer and industry partnerships with community colleges are critical to the success of bioscience workforce education and can play an instrumental role in bioscience course and credential design, development, delivery, dissemination, and sustainability;
- Public workforce development partnerships can play important roles in promoting community college's bioscience programs, facilitating referral of students to colleges, providing sources of support for students' tuition, and linking colleges to other resources; and
- Partnership development is an ongoing effort that requires knowledgeable staff and sufficient time to engage, solidify, and sustain partnerships.

Course, Program, and Credential Development and Enhancement

Key Findings:

- Course development requires staff, time, and resources to coordinate with employer, industry, and workforce partners; align course content to meet college, state, and industry requirements; and implement pilot test and revision processes to ensure that the courses achieve their intended goals; and
- Cross-departmental relationships and support from community college administrators are critical to the development and approval of new bioscience curricula and credentials.

Student Recruitment, Assessment, and Advising

Key Findings:

- Conducting public awareness about bioscience occupations and the credentials needed to work in these occupations is a critical step in building understanding and support for bioscience education and recruiting potential students for bioscience programs; and
- Assessment and advising can help to ensure that students are prepared to meet course demands, develop an initial program plan, access academic assistance and other supports, and stay on track in carrying out their plan.

Preparation for Further Education and Employment

Key Findings:

- The organization of courses into an explicit career pathway and the development of credentials that can be stacked and latticed can potentially facilitate students' pursuit of further education; and
- The provision of internships that involve hands-on training in bioscience, and laboratory instruction that incorporates simulated work environments can provide students with industry experience that employers had identified as a priority in hiring.

Harmonization of Bioscience Skill Standards

Key Finding: Bioscience core skill standards provide a framework for curriculum development that specifies the academic skills and knowledge needed for industry positions, and can be customized to specific positions as part of the process of aligning workforce curricula with bioscience industry needs.

c^{3}bc Design and Structure

Key Findings:

- The organization of the c^{3}bc grant into a hub structure facilitated collaboration among colleges and provided centers of expertise that enabled the grant to carry out work in four separate but related areas; and
- Forsyth Tech's support for c^{3}bc college partners through communication and community-building activities and fiscal and management oversight provided an environment in which c^{3}bc partners conducted their grant work independently and also functioned as a collegial learning community.

Institutional Capacity Building

Key Finding: Under the c^{3}bc grant, the following course and credential outcomes were achieved:

- Developed new or updated 12 bioscience certificates;
- Developed one new associate's degree credential;
- Developed or updated more than 70 biosciences courses and related products;
- Updated and revalidated Bioscience Laboratory Skill Standards and Biomanufacturing Skill standards;
- Developed Medical Device Skill Standards; and
- Developed Core Skill Standards for Bioscience Technicians.

IV. Participant Impacts & Outcomes

Impact Study Results

Biology 111 Course

Students who participated in the c^{3}bc-enhanced Biology 111 course were less likely to complete the course ($p<.001$) and had lower average course grades ($p<.001$) than their matched comparison counterparts. Significant variation in the treatment effect on Biology 111 course completion was found for baseline education level ($p<0.05$). Treatment students who entered the c^{3}bc-enhanced Biology 111 course with associate degrees or higher and those who entered with less than a high school diploma were more likely than their comparison group counterparts to complete the course (Exhibit 1).

Some characteristics of students at the time they entered the Biology 111 course were associated with the likelihood of completing the course ($p<.05$). Students who were unemployed and those who were female were more likely to complete the Biology 111 course, while African American students were less likely to complete the course.

Exhibit 1. Impacts of c^{3}bc-Enhanced Biology 111 Course

Outcome	Unadjusted Mean or Percent Yes Treatment Group (n=218)	Adjusted Mean or Percent Yes Control Group [a] (n=340)	Impact Estimate [b]	Impact Standard Error	Impact p-value [c]
Bio 111 Course Completion	61.0%	79.3%	-18.3%	3.7%	<0.001
Bio 111 Course Grade	1.56	2.16	-0.60	0.11	<0.001

The adjusted mean or percent yes is calculated as the treatment group value minus the impact estimate.
[b] This is the doubly robust model-estimated average impact of the enhanced course on the outcome measure.
[c] Treatment effect p-value is for test of null hypothesis of no treatment impact, two-tailed test.

Chemistry 131 Course

Similar to the results for the Biology 111 course, students who enrolled in the c^{3}bc-enhanced Chemistry 131 course were less likely to complete the Chemistry 131 course and had lower average course grades than their counterparts in the matched comparison group (Exhibit 2). Fifty-four percent of treatment group students completed the course compared to 69 percent of comparison group students. The 15 percentage point difference between the groups was statistically significant at the $p<0.05$ level (Exhibit 2).

Exhibit 2. Impacts of c^{3}bc-Enhanced Chemistry 131 Course

Outcome	Unadjusted Mean or Percent Yes Treatment Group (n=97)	Adjusted Mean or Percent Yes Control Group [a] (n=107)	Impact Estimate [b]	Impact Standard Error	Impact p-value [c]
Chem 131 Course Completion	53.6%	69.0%	-15.4%	6.7%	0.024
Chem 131 Course Grade	1.43	1.95	-0.52	0.10	0.010

[a] The adjusted mean or percent yes is calculated as the treatment group value minus the impact estimate.
[b] This is the doubly robust model-estimated average impact of the enhanced course on the outcome measure.
[c] Treatment effect p-value is for test of null hypothesis of no treatment impact, two-tailed test.

Results from Outcome Studies

The results from the six outcome studies are summarized in Exhibit 3. For the five colleges (MCCC, BCCC, LAVC, SLCC, and SPC) with complete data on educational outcomes, 62.5 percent of students who participated in a program developed or enhanced under the c^{3}bc grant achieved an outcome—completed the program (LAVC); earned a certificate (MCCC, BCCC, SLCC, and SPC); or earned a degree (BCCC). Across all six programs, 60.5 percent of students achieved an outcome. The highest program completion rate (97.9 percent) was at LAVC, whose Biotech Bridge Training Academy used a rigorous screening process involving employers to place students in to the Bridge Academy. The three colleges that developed new courses and new certificates, MCCC, SLCC, and SPC had comparable completion rates for their certificate programs (MCCC—44.9 percent; SLCC—41.1 percent; and SPC—44.6 percent). BCCC, which developed new courses for the AS degree and enhanced the Biotechnology certificate, had a combined completion rate for both credentials of 84 percent.

The small samples of students, except for LAVC, and the large amount of missing employment and wage data suggest caution in interpreting the c^{3}bc results for employment and wage increases. However, the trends in the available data are promising. Further systematic data collection using a more rigorous evaluation design and the same methods across programs for collecting employment and wage data are warranted. Overall, 43 percent of students who participated in one or more courses developed under the c³bc grant were employed after they completed their program, certificate, degree, or courses. For the three colleges (LAVC, SLCC, and SPC) that were able to obtain data on students' pre-post program hourly wage increases, the median hourly wage increase for a sample of 75 students was 18.4 percent (Exhibit 3).

Exhibit 3. Summary of Outcomes from Six c³bc Community Colleges

Hub/College	Enrolled in 1 or More Certificate/ Degree Courses	Earned Certificate/ Degree		Employed After Program [a]		Amount of Hourly Wage Increase for Employed After Program [a]			
	#	#	%	#	%	# with Data	Mean	Median	% Change Median Hourly Wage
Biomanufacturing Hub									
Montgomery County CC	78	35	44.9	19[b]	24.4	NA	NA	NA	NA
Bucks County CC	19	16[c]	84.2	7[d]	36.8	NA	NA	NA	NA
Los Angeles Valley CC–Bridge Academy	188	184	97.9	143[e]	76.1	28	$3.23	$3.20	29.4
Medical Devices Hub									
Ivy Tech CC	64	11[f]	17.2	13[g]	20.3	NA	NA	NA	NA
Salt Lake City CC	73	30	41.1	21[h]	28.8	21	$1.92	$2.97	14.8
St. Petersburg College	130	58	44.6	34[i]	26.2	26	$1.23	$1.54	11.0
Total	552	334	60.5	237	42.9	75	$2.13	$2.57	18.4

NA = Not applicable
[a] Includes those who obtained a certificate/degree as well as those who enrolled in certificate/degree courses but did not earn a credential.
[b] Employment data missing for 59 students.
[c] Three students not earning certificate/degree were still enrolled at the end of the c³bc grant.
[d] Eight students were still enrolled in college and four were missing data at the end of the c³bc grant.
[e] Employment data missing for 4 students.
[f] Earned certificate/degree data missing for 53 students.
[g] Employment data missing for 51 students.
[h] Employment data missing for 52 students.
[i] Employment data missing for 96 students.

V. Conclusions

Lessons from c³bc Evaluation for Future Bioscience Education Capacity Building

The key lessons for community colleges' future work in bioscience education capacity building are:

- **Employer and industry partnerships** with community colleges are the linchpin for developing curricula and credentials that are aligned to employer needs and that provide explicit career pathways for students;
- **Partnerships within colleges** are critical to the development and approval of new curricula and credentials, recruitment of students, counseling of students, and retention and completion of students;
- **Partnerships between workforce agencies and community colleges** are important in recruiting and referring potential students to community colleges' new programs and in identifying employment opportunities for students;

- **The use of the Core Skill Standards for Bioscience Technicians** in developing curriculum for bioscience technicians can ensure that courses have a strong academic foundation and then can be customized to particular technician positions to reflect the needs of individual employers;
- **Pilot testing and revision** are important phases in the development or redesign of curricula to ensure that the courses operate as planned and are aligned to the academic standards and skill needs of employers; and
- **Public awareness and marketing** for new curricula and credentials should begin during curriculum development to build support from employers, workforce agencies, community agencies, and college departments.

Implications for Future Workforce and Education Research

Two important implications for research were identified from the evaluation of the c³bc grant:

- The timeline for TAACCCT grant was not long enough for the colleges to develop, pilot test, and revise new courses, and recruit students to fill the multiple cohorts of classes needed to generate a sufficient sample for the evaluation. For grant programs involving the development of courses beyond the introductory level, a period longer than three years is needed for the development and delivery of services that can be evaluated using a rigorous design; and
- The conduct of an experimental or quasi-experimental study requires the availability of an appropriate control group. In the case of the c³bc grant, the one college redesigning introductory-level science courses met the conditions for a quasi-experimental design. The other colleges designed courses that were unique to the local community and, in some cases, to bioscience, and thus 'business as usual" conditions were not available for these courses. For grants involving specialty courses for which an appropriate control group is not available, various approaches could be considered: One approach to a rigorous evaluation would be to test variations in supports to the courses, such as in advising or retention strategies, to assess the conditions under which the supports for a new course can be effective. Another approach would be to test different structures to internship programs or to mentoring, to assess the effectiveness of these programs in supporting the courses of interest or in facilitating students' attainment of employment.

Contents

Introduction

The U.S. bioscience industry continues to have strong prospects for growth. In 2012, bioscience companies employed 1.62 million personnel across more than 73,000 businesses. Since 2004, the economic output of the industry has expanded with a 17 percent growth rate, with nearly 111,000 new jobs being added to the bioscience employment base in the past decade. The industry also continues to create high-wage, family sustaining jobs with average wages that are 80 percent higher than the overall private sector (Battelle/BIO, 2014).

Among the critical factors to sustaining growth in the bioscience industry is the availability of education and workforce development programs that can provide the industry with a skilled workforce for the present and future. In response to this need, the Community College Consortium for Bioscience Credentials (c³bc) was formed. Led by Forsyth Technical Community College (Forsyth Tech), the Consortium was comprised of 12 colleges[4] in eight states. In fall 2012, the U.S. Department of Labor (DOL) awarded Forsyth Tech a Round Two Trade Adjustment Assistance Community College and Career Training (TAACCCT) grant for c³bc's activities. Forsyth Tech selected Abt Associates (Abt) as the third-party evaluator through a competitive procurement process. Abt began its evaluation activities in winter 2013.

The Consortium's TAACCCT grant was designed to build capacity at the:

- *National* level through the development of core skill standards for bioscience that reflect the knowledge, skills, and abilities that entry-level technicians need to succeed in employment in multiple bioscience subsectors. The core skill standards were intended to:
    - Guide educators in designing curricula and training programs for entry-level bioscience technicians working in biomanufacturing, lab skills, medical devices, and other bioscience industry subsectors; and
    - Assist bioscience industry employers in specifying job requirements and hiring entry-level technicians.
- *Local and regional* levels by expanding the availability of bioscience programs and credentials that are well aligned to the needs of industry employers.

The grant's approach was to encourage c³bc colleges to collaborate with industry employers in developing bioscience courses, programs, and credentials, and in developing, updating, and harmonizing skill standards for bioscience technicians. This approach was based on an extensive review of the state of bioscience in Science, Technology, Engineering, and Mathematics (STEM) education and of the future need for biotechnicians (NRC & NAE, 2012; Patton, 2008). The c³bc colleges' grant activities followed the TAACCCT core elements and other requirements specified in DOL's Solicitation for Grant Applications (SGA). The specific activities the community colleges conducted to meet the SGA requirements varied based on each college's existing bioscience capacity and regional and local industry needs.

[4] Alamance Community College, Austin Community College (ACC), Bucks County Community College (BCCC), City College of San Francisco (CCSF), Forsyth Technical Community College (Forsyth Tech), Ivy Tech Community College (Ivy Tech), Los Angeles Valley College (LAVC), Madison Area Technical College, Montgomery County (PA) Community College (MCCC), Rowan-Cabarrus Community College, Salt Lake Community College (SLCC), and St. Petersburg College (SPC)

Discussed in this final report are the results from Abt's implementation study and impact and outcome studies of the c³bc colleges' TAACCCT activities. Nine[5] of the 12 Consortium colleges conducted c³bc supported activities that involved developing new and enhancing existing bioscience courses, programs, and credentials. These colleges participated in the implementation study. Seven[6] of the colleges in the implementation study participated in the evaluation's impact and outcome studies. These colleges were able to collect individual-level student data that could be transferred to Abt for analysis. Two of the nine colleges in the implementation study were not able to transfer individual-level student data to Abt and thus did not participate in the impact or outcomes studies. Three[7] of the 12 colleges collaborated on the grant's activities but did not develop new courses or credentials, and were not part of the evaluation.

Appendix A contains brief case studies of the nine colleges that conducted course and curriculum development activities as part of the c³bc grant. Presented in Appendix B is information about the baseline equivalence of Forsyth Tech's c³bc treatment and comparison groups for the evaluation's impact study. Appendix C contains data tables on course completion by subgroups of students in the impact study. Tables with the demographic and background characteristics of c³bc participants from the seven colleges that participated in the evaluation's impact and outcomes studies are in Appendix D.

[5] ACC, BCCC, CCSF, Forsyth Tech, Ivy Tech, LAVC, MCCC, SLCC, and SPC
[6] BCCC, Forsyth Tech, Ivy Tech, LAVC, MCCC, SLCC, and SPC
[7] Alamance Community College, Madison Area Technical College, and Rowan-Cabarrus Community College

Description of c³bc Activities

The c³bc grant was designed to develop or enhance multiple interventions in bioscience education. Rather than create and implement one intervention across multiple colleges, the c³bc partners built from their colleges' prior and current bioscience work to leverage their expertise and resources to produce multiple interventions. These interventions, bioscience courses, programs, and credentials, contributed to capacity building in bioscience education.

As the lead college for the c³bc grant, Forsyth Tech used a distributed leadership approach in managing the grant. Forsyth Tech gave c³bc partners flexibility in developing and implementing their grant activities, provided ongoing opportunities for communication, and carefully tracked all grant activities. As a result, the partners carried out their grant activities through a variety of methods and strategies rather than using a standardized approach.

This section of the final report describes the key activities the nine[8] colleges in the evaluation's implementation study conducted as part of the c³bc grant. Because the grant involved multiple interventions of varying magnitude (one course versus an AAS degree), this section is organized according to the key activities that the colleges carried out in working on their interventions rather than by specific interventions. This section also describes how Forsyth Tech provided leadership to the colleges and managed the c³bc grant, and highlights the background characteristics of the c³bc student population that participation in this evaluation. The case studies in Appendix A provide information about the main interventions that each of the nine colleges developed or enhanced.

Goals and Structure

The c³bc grant was designed to achieve four goals:

1. Bridge the gap between Trade Adjustment Act (TAA) and other displaced workers and their preparation for the workplace through expanded student recruitment, redesigned courses, and improved retention in bioscience programs;
2. Harmonize a set of core skills for biosciences that facilitate the creation of pathways and provision of training that lead to industry-recognized credentials;
3. Enhance training programs and accelerate certificate and credentialing processes in biosciences through prior learning assessment, focused support services, and the use of technology-enhanced instructional materials; and
4. Build community college capacity for education and training that meets employer needs through partnerships in which colleges work with employers in designing and delivering instruction, placing students into employment, and providing internships and other activities that prepare students for the workplace.

The grant was organized using a hub structure that reflected the grant's focus on three subsectors of the bioscience industry—biomanufacturing, medical devices, and lab skills, and on modularized, more flexible approaches to learning—learning technologies. Each hub was comprised of a lead college and three partner colleges. While all hubs were involved in developing or expanding courses, programs, and

[8] ACC, BCCC, CCSF, Forsyth Tech, Ivy Tech, LAVC, MCCC, SLCC, and SPC

or credentials, each hub had a special focus. The colleges that comprised each hub and the focus of each hub's activities were:

- **Biomanufacturing Hub**: Montgomery County (PA) Community College (MCCC) (Lead College) with Bucks County Community College (BCCC) and Los Angeles Valley Community College (LAVC)—revalidate biomanufacturing skill standards;
- **Lab Skills Hub**: City College of San Francisco (CCSF) (Lead College) with Austin Community College (ACC) and Madison Area Technical College (MATC)—update and revalidate bioscience lab skills standards;
- **Medical Devices Hub**: Ivy Tech Community College (Ivy Tech) (Lead College) with Salt Lake Community College (SLCC) and St. Petersburg College (SPC)—develop and validate new medical device skill standards; and
- **Learning Technologies Hub**: Forsyth Technical Community College (Forsyth Tech) (Lead College) with Alamance Community College and Rowan-Cabarrus Community College—develop contextualized and modularized online courses.

Through the hubs' work the c³bc colleges expanded courses, programs, and credentials in biomanufacturing, medical devices, and lab skills; developed new technology-based approaches to teaching introductory courses in biology, chemistry, and biotechnology; and developed a new structure and approach for teaching bioscience lab skills. In addition to the joint work among colleges within hubs, each c³bc college conducted activities to meet its specific goals for the grant. The colleges also engaged in cross-hub work in establishing a set of core skill standards for bioscience technicians that are derived from the individual hubs' development or revalidation of skill standards in the three bioscience subsectors that were the focus of the grant. The key activities nine of the c³bc colleges conducted to achieve the grant's goals are discussed in this section.

Strategic Alignment through Partnerships

In preparing the c³bc TAACCCT application, Forsyth Tech and its hub college partners identified colleges' development and strengthening of partnerships with the private and public sectors as a priority for the grant's activities. The c³bc partners viewed the TAACCCT grant as an opportunity to build on their work together on previous Federal grants and address the need for core skill standards in biosciences that could be used as a framework for the development of industry-recognized credentials. Collaboration with bioscience industry associations and employers was central to this work as well as to the development of medical device skill standards and the revalidation of biomanufacturing and lab skills standards. The grant was to provide an infrastructure and resources to expand bioscience credentials and employers' roles in the design and delivery of bioscience workforce courses.

The colleges' c³bc grant staff (throughout this report c³bc "staff " refers to college faculty and non-faculty individuals who worked on the c³bc grant) varied in their backgrounds and prior experience in working with business, industry, public sector employers, and workforce development agencies. The c³bc staff were bioscience academic faculty, former industry employees, college workforce development staff, and individuals with training experience. The staff used different approaches to recruiting and working with partners based on their backgrounds, the colleges' history with private and public partnerships, the type of bioscience courses and credentials that were the focus of the colleges' c³bc work, and the local infrastructure for bioscience, such as state bioscience associations. The ways in which the c³bc colleges' private and public sector partners participated in the grant's activities were wide-ranging and included:

serving on colleges' c^{3}bc Advisory Councils; providing feedback on courses and credentials; developing, revising, and teaching courses; recruiting and screening students; serving as mentors; providing internships and other professionalization activities; interviewing students for jobs; and hiring students. The types of partnerships that c^{3}bc colleges forged and expanded are discussed in this section in the context of the activities that they conducted in course and credential development and delivery; student recruitment, assessment, advising, and career guidance; preparation for further education and employment; skill standards development and revalidation; and dissemination.

Course Development, Delivery, and Use of Technology-Enhanced Instruction

The c^{3}bc colleges were at different stages of bioscience program implementation at the inception of the grant. Among the three c^{3}bc colleges involved in course and credential development or enhancement, five colleges (CCSF, LAVC, MCCC, SLCC, and SPC) did substantial new credential design as part of c^{3}bc, and the other four colleges had existing courses and credentials that could serve as a foundation for their development work. Described are c^{3}bc's approaches to bioscience curriculum and credential development and delivery that include the involvement of private and public sector partners in working with the colleges. Displayed in Exhibit 1 are the departments in which the colleges' c^{3}bc grants were located, and the courses and credentials that the colleges developed or enhanced during the c^{3}bc grant.

Course Development and Delivery

The colleges in the three hubs focused on bioscience subsectors (biomanufacturing, lab skills, and medical devices) conducted analyses of local labor market needs in their subsectors to identify areas in which their bioscience courses or programs could be strengthened or where there was a need for new courses or programs. The colleges also worked with their industry advisory groups and with private and public sector employers to confirm what they had found in their labor market analyses and to obtain advice about course and credential development. For example, MCCC determined that the biomanufacturing program could develop a biotechnology and biomanufacturing certificate involving courses in which students would learn in a simulated industry environment using the same equipment and instruments required in technician jobs. At SLCC, c^{3}bc staff's outreach to industry employers helped them identify the course content for a Medical Device Manufacturing Processes and Practices Certificate that addressed employers' need for employee training in regulatory affairs and related topics. CCSF worked with the city's public utilities department to identify the skills and knowledge needed for courses in a new Environmental Monitoring, Sampling, and Analyses Program and Certificate. LAVC updated the courses for its Bridge Biotech Training Academy and worked closely with employers to determine the enhancements that should be made to course content. LAVC's employer partners (Baxalta-Shire and Grifols Biologicals, Inc.) requested that the Bridge Academy math course address topics such as ratios, proportions, decimals, rounding, word problems, and the metric system, and provide examples so that the course was contextualized to the workplace. These same employers assisted LAVC in specifying the content for the new Biotechnology Certificate courses that the college created under c^{3}bc.

In addition to helping specify topics for c^{3}bc courses, bioscience industry representatives assisted c^{3}bc staff in writing and reviewing courses, as well as in teaching courses. At SPC, a health care partner contributed to the development of the electronic instrumentation course, taught the course, and then refined it. Industry partners were major contributors to the courses developed for SLCC's Medical Device Manufacturing Processes and Practices Certificate. As employer representatives were hired to teach SLCC courses, they made suggestions for revisions and worked with SLCC's c^{3}bc staff in the revision process.

Exhibit 1. Colleges' Course and Credentials' Development or Enhancement

Hub/College	Division or Department Administering c³bc	Areas of Course Development or Enhancement	Credential Development or Enhancement
Biomanufacturing			
Montgomery County (PA) Community College (MCCC) (Lead)	Science, Technology, Engineering, and Math (STEM) Division	Developed 4 courses for certificate; Developed Downstream Processing Module	Developed Biotechnology & Biomanufacturing Certificate
Bucks County Community College (BCCC)	Science, Technology, Engineering, and Math (STEM) Division	Biomanufacturing course; Introduction to Biotechnology course	Updated Cell & Tissue Culture Certificate
Los Angeles Valley College (LAVC)	Workforce Department with Biology Department	Updated courses in Biotech Bridge Training Academy; New courses for certificate	Developed Biotechnology Certificate
Lab Skills			
City College of San Francisco (CCSF) (Lead)	Biotechnology Program in Engineering and Technology Department	Developed courses for the Environmental Monitoring, Sampling, and Analyses (EMSA) program; Enhanced courses in the Bridge to Biosciences program; Enhanced Mentoring for Success (MFS) program	Developed EMSA Certificate
Austin Community College (ACC)	Biotechnology Department	Modularized Biomanufacturing and 2 other courses; Developed Bioinformatics course; Updated Quality Assurance for the Biosciences course	Developed career pathway for biotechnology credentials
Medical Devices			
Ivy Tech Community College (Ivy Tech)	Biotechnology Department	Redesigned 5 Regulatory Affairs courses (online); Developed 3 Plastics courses; Developed "Course in a Box" for Quality Practices, Metrology, and Product Life Cycle	Updated Regulatory Affairs Concentration Certificate
Salt Lake Community College (SLCC)	Biotechnology Program & Continuing Education Division	Developed 4 core courses for certificate	Developed Medical Device Manufacturing Processes and Practices Certificate
St. Petersburg College (SPC)	Engineering Technology Department	Enhanced courses for Medical Quality Systems (MQS); Enhanced courses & developed new courses for Biomedical Equipment Technician Certificate (BMET) and AS degree	Enhanced MQS Certificate; Developed BMET; AS in Biomedical Engineering Technology
Learning Technologies			
Forsyth Technical Community College (Forsyth Tech)	Math, Science, & Technologies; Moved to Economic Workforce & Development Division	Developed online, modularized courses: Biology 111 & 112; Chemistry 131 & 132; Biotechnology 181; Anatomy & Physiology courses; Developed Science Skills Laboratory	

While all c^{3}bc colleges' bioscience programs had faculty with industry experience, the c^{3}bc course development work undertaken at ACC, LAVC, SLCC, and SPC considerably expanded the colleges' use of industry partners in teaching and refining courses. The grant's emphasis on aligning bioscience workforce courses with the skill demands of industry jobs encouraged c^{3}bc staff to increase outreach to industry partners, adapt courses to simulate the bioscience work environment, and work with industry partners to refine the courses.

Another type of collaboration supporting the c^{3}bc colleges' credential development and administration activities was between administrative units within the colleges. The c^{3}bc grant promoted new organizational relationships involving workforce, biology, and continuing education. LAVC's Workforce Department, in which the c^{3}bc grant was located, worked with the Biology Department in designing the courses for the college's new Biotechnology Certificate. At SLCC, the Biotechnology Program, which administered the grant, coordinated with the Continuing Education Division in offering the new Medical Device Manufacturing Processes and Practices Certificate. The courses for the certificate were non-credit and the Continuing Education Division had experience in recruiting students for workforce-focused credentials.

Industry and state standards also guided the content of c^{3}bc courses and credentials. The c^{3}bc colleges followed their state and institutional requirements concerning adherence to frameworks or standards. For example, SPC followed Florida's State Curriculum Framework for the Associate in Science in Biomedical Engineering Technology degree as well as other standards in developing the Associate Degree in Biomedical Engineering Technology. For SPC's Biomedical Equipment Technician (BMET) Certificate, the course designers referenced the National Core Standards for BMET, as well as the Core Competencies for the Biomedical Equipment Technician of the International Biomedical Equipment Technician Association. BCCC drew on standards from Texas and Washington and content from the c^{3}bc hubs to transform their Applied Biotechnology course to a Biomanufacturing course that included a lab component with equipment purchased under the grant. The new equipment was used for upstream and downstream processing, including bioreactors and liquid chromatography. BCC's Cell and Tissue Culture Certificate also was updated to include the Biomanufacturing course.

The c^{3}bc grant's work in revalidating Biomanufacturing and Lab Skills and developing new Medical Device Skill Standards (discussed below) also influenced the content of new and updated c^{3}bc courses. Because of the parallel timing in the c^{3}bc colleges' work on their own courses and the hub colleges' work on skill standards validation and development, some colleges aligned their new courses to the revalidated or new standards after the new courses were initially developed. Other colleges were able to use the new standards to guide their redesign of existing courses.

Approaches to Course Structure and Use of Technology-Enabled Instruction

The modularization of courses was a strategy that half of the c^{3}bc colleges used to provide students with more flexibility and self-pacing options, and to give instructors increased ability to adapt instructional materials. The design of modules varied among c^{3}bc colleges. Examples of modularized courses were ACC's Molecular Techniques and Instrumentation Courses, which are required for an AAS degree or the Advanced Technical Certificate. ACC also modularized the Biotechnology I and II courses, and experimented with accelerated and non-accelerated versions of these courses. Students' feedback on the accelerated version of the courses resulted in ACC's reconsideration of the accelerated structure of the course.

Forsyth Tech, the Learning Technologies Hub lead college, created a contextual and modularized learning program through their hub work. Forsyth Tech's instructional designers developed online, modularized courses to replace the traditional introductory courses in Biology, Chemistry, and Biotechnology, as well as Anatomy and Physiology courses. The designers also created a modularized Science Skills Laboratory course with online components that provided more flexibility for students to meet the lab requirements for science courses. The existing science courses were redesigned using North Carolina's course-level learning objectives, open-source materials, and new materials created by Subject Matter Experts. Each module consists of online assignments and an-in-person lab. Modules are comprised of combinations of "granules," which can include text, video, images, animation, audio, self-assessments, and practice activities. An underlying assumption of this design was that students' visualization of scientific processes will facilitate their learning. Forsyth Tech used a pilot test and revision process to ensure that the new modularized courses were functioning as expected, particularly given the potential variation in the composition of the modules.

MCCC developed a virtual training module on downstream processing, which was created in collaboration with vendors, subject matter experts, and local industry (GSK and Novartis). Students perform hands-on activities and processes on site and then use the virtual module to see how the processes were implemented in a large-scale manufacturing environment. The module, which includes visuals and text explanations of each stage of downstream processing, was used as a supplement to coursework.

Another form of course delivery was the adaptation of face-to-face courses for online access. Ivy Tech redesigned the college's Regulatory Affairs courses to align with the new Medical Device Skill Standards. The courses were revised to include additional medical device content and case study simulations in which students engage in hands-on exercises, explore the application of regulatory law, and respond to scenario questions. The courses were then offered online using the Quality Matters platform. Ivy Tech partnered with Anoka-Ramsey Community College in Minnesota to share their online Regulatory Affairs courses, which enabled both colleges to offer courses that they independently would not have been able to provide due to low student enrollment.

Student Recruitment, Assessment, Advising, and Career Guidance

The c³bc staffs' approach to recruiting students began with building awareness about their c³bc curricula and credentials with workforce development agencies and employers, and within their colleges. The colleges also used traditional forms of student recruitment such as the distribution of print materials and other activities to attract the anticipated c³bc student populations. Colleges varied in the types of assessment data that were used to determine students' readiness for c³bc courses, and two colleges explored prior learning assessment. The c³bc staff advised and provided career guidance to c³bc students, but the type of advising activities differed among the colleges.

Building Awareness and Student Recruitment

A priority for c³bc college staff as they began developing courses and credentials was to establish relationships with local workforce agencies to facilitate student recruitment and placement into employment. As part of the grant's activities, Forsyth Tech established a Workforce Committee with representation from the c³bc colleges. The committee provided information to the colleges about strategies for working with Workforce Investment Boards (WIBS) and One-Stop Centers, and facilitated colleges' sharing of their experiences in establishing workforce partners.

Prior to the c³bc grant, Forsyth Tech and LAVC c³bc staff had established working relationships with their Workforce Investment Boards (WIB), and the grant enabled them to expand their collaboration. Staffs from both colleges made presentations at their respective One-Stop Centers, met with One-Stop staff to discuss client referrals, and collaborated with WIB staff. For the other c³bc colleges, the grant was an opportunity to approach for the first time or reintroduce themselves to their WIBS and One-Stop Centers to discuss the bioscience labor market, the types of training and credentials that were being developed under the c³bc grant and potential target populations of clients who might be interested in bioscience careers. Among the colleges that established relationships with their WIBS were MCCC, BCCC, and SPC, which obtained Eligible Training Provider Status during the grant.

Through MCCC's partnership with PA CareerLink, the CareerLink staff advocated for MCCC's opportunities for displaced workers interested in biotechnology. The c³bc staff made presentations at CareerLink offices, shared information with staff about the Biotechnology Certificate, and left brochures about the program. The c³bc staff participated in CareerLink's Training Provider Day and Biotechnology Day events. CareerLink and MCCC staff also helped unemployed job seekers obtain Individual Training Account (ITA) funds to support their participation in the certificate program.

LAVC staff expanded their contacts and met with the representatives from the state's Employment Development Department to make them aware of the Biotech Bridge and Biotechnology certificate programs, and held workshops and information sessions at WorkSource and Rapid Response sites. LAVC also worked with the Southern California Biomedical Network (SoCal Bio) in expanding employer partnerships and in making presentations to WIBS and industry associations about the Biotech Bridge Academy and Biotechnology Certificate.

The c³bc staffs' work with employer partners also facilitated the identification of students for c³bc programs. SLCC's recruitment for the Medical Device Manufacturing Processes and Practices Certificate program depended heavily on endorsement from employers, who were able to help their employees understand why they should participate in the SLCC program. Two local employers offered their employees incentives for participation—BioFire Diagnostics strongly encouraged its entry-level employees to attend the courses to increase their promotion opportunities, while ATL Technology offered a 1% pay raise for each course its employees completed.

All colleges' c³bc recruitment activities included developing brochures and flyers, making presentations, and participating in open houses. These activities were to attract students from the community as well as from within a college. Ivy Tech's c³bc staff participated in the college's Biosciences Career Education Open House. SLCC's c³bc staff in the Biotechnology and Continuing Education Departments participated in various open houses, career fairs, and expos to advertise the program. They also used social media to recruit. Forsyth Tech worked with other departments in the college in which bioscience courses could help students meet their degree program's requirement. LAVC staff distributed informational brochures and flyers to local libraries, food banks, and non-profit organizations, and they conducted direct outreach to applicants who sought employment and training assistance through CalJobs.

Assessment

Two aspects of assessment were noteworthy in the c³bc grant. LAVC's student screening procedures for the Biotech Bridge Training Academy involved multiple types of assessment and extensive participation of employer partners. Potential students were invited to an orientation session that provided an overview of the logistics of Manufacturing Technician jobs, including salary, hours, working conditions, and primary functions. They also were required to complete the Reading and Math tests of the Comprehensive Adult Student Assessment Systems (CASAS) and to write a three-paragraph essay about their interest and commitment to enter the biotech field. Applicants who met the Bridge Academy requirements for these assessments were invited to attend a workshop on resume writing and basic interviewing skills, and to later participate in interviews with the partner employers. Interviewers screened applicants for past experience, ability to work on a team, and willingness to work in cold, wet environments.

The c^{3}bc staff at SPC and ACC explored the use of prior learning assessment. At SPC, c^{3}bc staff worked to establish processes for formal articulation of non-credit to credit courses through their development of the AS degree in Biomedical Engineering Technology. The process was under review for approval at the close of the c^{3}bc grant.

Advising and Career Guidance

The colleges' c^{3}bc staff were the main providers of advising and career guidance for students participating in c^{3}bc programs. Forsyth Tech appointed a workforce liaison who met with the college's students to help guide them into science courses, and worked with them to establish Individual Learning Plans. ACC had a designated staff member in the Biotechnology Department who interviewed students interested in enrolling in the Biotechnology program to help them determine their readiness for the program. SPC required pre-program enrollment advising for students, and they used *My Learning Plan* to complete an interest inventory, to keep track of required courses, and to register for courses. BCCC and MCCC staff provided guidance to students as they moved through their c^{3}bc courses. BCCC's change of policy that required all full-time and-part time students to meet with an advisor to plan their courses facilitated students' enrollment into the correct courses for the biotechnology program at the college.

Preparation for Further Education and Employment

The c^{3}bc colleges' activities in developing stackable and latticed credentials and providing student internships contributed to students' pathways to further education and employment. Prior to the c^{3}bc grant, many colleges had established articulation agreements with four-year colleges or universities to facilitate students' pursuit of further education. Examples are Forsyth Tech's agreement with Winston-Salem State University; BCCC's agreement with Thomas Jefferson University, and ACC's agreements with the University of Texas and Texas A & M University. Discussed in this section are c^{3}bc activities in preparing students for their next steps in education and work.

Stackable and Latticed Credentials

The role of stackable and latticed credentials was a key consideration in c^{3}bc colleges' course and credential development activities. ACC students in biotechnology could earn the Level-One Certificate, the Level-Two Certificate, the Advanced Technical Certificate, or the Associate of Applied Science degree. Prior to c^{3}bc, the various levels of study existed, but were not organized in a career pathway. With support from the grant, ACC developed stackable credentials that offer students multiple entry and exit points. Students who complete only one semester of courses can successfully earn the Level-One Certificate, at which time they may exit the program or continue.

In order for SPC to quickly launch the c^{3}bc supported Biomedical Equipment Technician (BMET) Certificate program while waiting for course and degree approvals from the college, c^{3}bc staff partnered with SPC's Workforce and Continuing Education Division. Through this arrangement, students began taking non-credit courses in the Corporate Training Department, with the understanding that students would be able to earn credits toward an AS degree for their participation. The courses offered through the college's Workforce Institute resulted in the non-credit Biomedical Equipment Technician I certificate, which is recognized as the acceptable credential for entry-level technicians.

SPC also aligned the BMET program with the CBET® (Certified Biomedical Equipment Technician). Upon completing the program's new BMET associate's degree, students are prepared to obtain the CBET and two other national industry certifications—the CAPM® (Certified Associate in Project Management) and the Comp TIA A+ for PC computer service technicians accredited by the ISO (International Organization for Standardization) and ANSI (American National Standards Institute).

Another example was MCCC, where the new Biotechnology and Biomanufacturing Certificate can stack onto an existing degree. At LAVC, students' completion of the Biotech Bridge Academy can facilitate their enrollment in the Biotechnology Certificate Program.

Internships

The c³bc colleges' student internship activities included external internships with bioscience employers, internal internships in the colleges' bioscience laboratories, and a program for training mentors who work with bioscience interns. Examples of the colleges' internship activities are described below.

At ACC, Biotechnology students pursuing the AAS or the Advanced Technical Certificate are required to complete an external internship as part of their program requirements. After earning the Level-Two Certificate, students can elect to complete an internal internship, which can provide them with additional training before seeking employment or an external internship.

ACC faculty and students also benefitted from the Biotechnology Department's participation at the Texas Life-Sciences Collaboration Center (TLCC), a local non-profit organization that seeks to recruit and retain biotechnology and life-sciences companies. The TLCC provides internships for students, classroom space for ACC courses, and opportunities for ACC life-sciences faculty to consult for companies working on projects there.

As part of its c³bc activities, CCSF developed the Mentoring For Success (MFS) program, which offered training for lab managers and post-doctoral students who were hosting student interns as part of the Bridge to Biosciences internship program. MFS was designed to ensure that the mentoring experience was mutually rewarding for both mentor and intern, with the goal that mentors and Bridge Internship coordinators would eventually serve as co-educators for the interns. MFS consisted of one introductory session and another six sessions during the internship. During the introductory session, potential mentors described why they wanted an intern, the kinds of projects or tasks the intern would undertake, the characteristics of the ideal intern candidate, and questions they would ask interns during interviews. Following this session, the mentors interviewed the interns.

Prior to the Bridge Internship, interns participated in a six-hour Internship for Success Boot Camp. The boot camp helped students/interns in resume writing and interviewing skills as well as understanding their role and expectations as interns. During the internship, while students attended the internship support course, mentors attended MFS sessions that addressed topics such as setting goals with interns, fostering interns' independence, helping interns work with diversity, approaching conflict, and handling successes and challenges. Mentors and interns completed surveys in the middle of the semester and at the end of the semester to assess progress toward meeting goals and expectations for the internship.

At MCCC, the Biotechnology Program obtained internal funding to support internships in the college. While BCCC does not require internships for its Biotechnology Associate's Degree, students in the program were able to obtain additional laboratory experience by assisting biotechnology faculty with special laboratory-based projects on campus.

Forsyth Tech's c³bc supported Capstone Experience provided internships to students from colleges in the c³bc grant. The Capstone was a five-day experience that was held at the BioNetwork Capstone Center in Raleigh, NC during 2014, 2015 and 2016. The 33 students who attended the Capstone participated in hands-on training in biotechnology and biomanufacturing in a simulated industry setting. The students reported the ways in which the internship had increased their understanding of the use of biomanufacturing processes.

Bioscience Skill Standards Activities

The c³bc grant's development and revalidation of bioscience skill standards were significant activities that the colleges' c³bc staff undertook to build capacity in the bioscience industry. The c³bc skill standards were to address workforce educators' need for better guidelines for designing curriculum and programs to prepare students for jobs in bioscience subsectors. The c³bc staff specified the core skills that all entry-level bioscience technicians need to succeed regardless of bioscience industry subsector, geographical location, or individual job description (Mowery & Carrese, 2016). These core skills relate to the Industry-Wide Technical Competencies found in the U.S. Department of Labor's Bioscience Competency Model (U.S. Department of Labor, 2008).

The c³bc grant, under the leadership of the c³bc hubs, conducted four activities related to core skill standards development:

- Revalidated biomanufacturing entry-level skill standards;
- Updated and revalidated entry-level bioscience lab skills standards;
- Developed and validated entry-level medical device skill standards; and
- Developed core skills for bioscience technicians.

Revalidation of Lab Skills and Biomanufacturing Skill Standards and Development of Medical Device Skill Standards

The c³bc Biomanufacturing and Bioscience Lab Skills Hubs updated existing skill standards that had been developed over a number of years by various entities. The hub staff validated the updates with employers and industry representatives to ensure that the standards reflected skill requirements for entry-level technician jobs.

The Medical Devices Hub developed and validated the first set of medical device skill standards for entry-level jobs within the medical devices industry. The hub staff facilitated five meetings during the period March 2013 to February 2016 with industry representatives, employers, staff from the other c³bc hubs, and representatives from five other community colleges doing work in medical devices. The process for developing the Medical Device skill standards and a list of the standards are found in the report *c³bc Medical Device Skill Standards*.[9]

Development of Core Skill Standards for Bioscience Technicians

The development of the core skill standards was led by a team of c³bc college faculty from each hub (the c³bc standards team) who worked with industry representatives and employers in carrying out this effort. The updated biomanufacturing and lab skills standards and the new medical device skill standards were the foundation for the core skill standards development. The processes used to specify the core standards and a list of the standards are found in *Core Skill Standards for Bioscience Technicians*.[10]

Industry Involvement in Core Skill Standards

Industry representatives and employers played a considerable role in the iterative process of skill standards development. In the selection of the core skill standards, consideration was given to industry expectations for entry-level technicians. This included an emphasis on quality and compliance to industry standards and regulations and on building a foundation of knowledge and skills that can lead to career advancement. In addition to the participation of industry representatives, the c³bc standards team convened a Skill Standards Core Team comprised of workforce educators with industry experience from each subsector to identify a preliminary set of core skills (Critical Work Functions). These skills were validated by industry through an online survey administered to industry representatives with experience supervising entry-level technicians and through face-to-face meetings.[11] Responses collected from the industry review process informed the final set of core skills that targeted areas of quality and compliance—documentation, safety, calculations, and communications (Exhibit 2).

Exhibit 2. Results from the Industry Review Process

Core Skill Standards: Critical Work Function	% of companies whose employees perform the Key Activities comprising the Critical Work Function
Maintain a safe and productive work environment	98.6
Provide routine facility support	91.5
Perform measurements/tests/assays	100
Comply with applicable regulations and standards	93.7
Manage and communicate information	100
Perform mathematical manipulations	100

Source: Mowery, J. & Carrese, J. (2016.) *Core skill standards for bioscience technicians.* Winston-Salem, N.C.: Forsyth Technical Community College. www.bio-link.org/home2/resource/bioscience-skill-standards

Skill Standards Format and Terminology

To maximize the use of the skill standards, the c³bc standards team followed a consistent format for the skill standards that includes the following elements: Critical Work Function (CWF), Key Activity (KA), Performance Indicator, Underlying Technical Knowledge, and Assessment**.** Each of the six CWFs has a list of KAs and performance indicators that provide concrete measures for mastery of the CWF. Each

[9] Community College Consortium for Bioscience Credentials. (2016). *c³bc medical device skill standards*. Winston-Salem, N.C.: Forsyth Technical Community College. www.bio-link.org/home2/resource/bioscience-skill-standards

[10] Mowery, J. & Carrese, J. (2016.) *Core skill standards for bioscience technicians.* Winston-Salem, NC: Forsyth Technical Community College. www.bio-link.org/home2/resource/bioscience-skill-standards

[11] Sources of industry feedback: c³bc National Advisory Council, two subject matter experts, 22 industry representatives across subsectors: biomanufacturing, bioscience lab skills, and medical devices.

activity is aligned to the underlying knowledge required to perform the KA. Finally, each KA offers suggested industry-specific, authentic assessments for educators and employers to evaluate technician mastery of the KA. Suggested assessments can be applied across the three subsectors; the exact task tested may vary by subsector. The c^{3}bc grant also launched an Assessment Library, an online collection of authentic assessments developed by c^{3}bc colleges that can be used in establishing a bioscience technician education program (Mowery & Carrese, 2016).

Dissemination

Dissemination of c^{3}bc information and products was an integral part of the grant's activities. From the c^{3}bc grant's inception, Forsyth Tech published announcements about the grant's award and planned activities, and the c^{3}bc Executive Director and c^{3}bc colleges' faculty and staff expanded their existing professional conference activities from related grants to include presentations about c^{3}bc activities. As the grant progressed, the c^{3}bc National Advisory Council (NAC) was convened to recommend dissemination activities that could facilitate knowledge transfer about the strategies c^{3}bc colleges used in working with business and industry to develop courses and credentials and facilitate students' job attainment. The NAC was comprised of 20 individuals representing bioscience employers; industry at the national, state, and regional levels; and public workforce development.

Key dissemination activities that Forsyth Tech and the c^{3}bc colleges conducted were:

- Annual publication of IMPACT magazine that highlighted c^{3}bc grant activities and accomplishments, including colleges' key course and credential development, creation of skill standards, and private and public partnership activities;
- Work with the National Association of Manufacturers' National Manufacturing Institute to develop and publish case studies of six of the c^{3}bc colleges' employer involvement activities. Case studies were made available at www.NAM.org and www.biotechworkforce.org;
- Presentations conducted by c^{3}bc partners and the external evaluator at professional conferences such as BIO's Community College Day, Hi-Tec, National Council for Workforce Education, and Medical Devices West; and
- Publication of two reports on c^{3}bc's skill standards development (Community College Consortium for Bioscience Credentials Development, 2016; Mowery & Carrese, 2016).

Leadership and Management of c^{3}bc

The organization of the c^{3}bc grant was complex with 12 colleges in eight states each implementing a customized set of c^{3}bc tasks and each working on hub-facilitated joint activities concerning skill standards. Forsyth Tech led and managed the c^{3}bc grant using strategies to ensure quality and accountability in meeting the TAACCCT grant's deliverables while fostering a sense of community and commitment to the grant among hub participants and key c^{3}bc stakeholders.

Quality Control

Quality control of the bioscience courses, programs, and credentials developed or enhanced under the c^{3}bc grant was implemented using three approaches. The nine c^{3}bc colleges developing new or enhancing existing bioscience materials and credentials each had review processes. Most of the colleges established c^{3}bc grant-related advisory groups with employer and industry representatives who assessed the content and methods of the colleges' planned c^{3}bc courses and often made recommendations for changes. As part of the course development and refinement processes, the c^{3}bc staff also used the standards developed or revalidated under the c^{3}bc grant as well as state standards to guide the content of the courses. A second approach to quality control was c^{3}bc staffs' pilot testing of new courses to ensure that the content and delivery processes worked as anticipated. Most colleges made revisions to initial versions of courses. A third approach was to implement an external review process of the courses and other products developed under the grant. Forsyth Tech asked the c^{3}bc National Advisory Council (NAC) to review selected c^{3}bc products. Forsyth Tech staff also reviewed key products developed by the c^{3}bc partner colleges.

Accountability Strategies

To manage the grant's work flow, Forsyth Tech developed a tracking form that delineated the 23 activities and 24 deliverables specified in the c^{3}bc grant's scope of work. Forsyth Tech used the tracking form to document the grant's progress and completion of deliverables and to communicate the breadth of the grant's activities with c^{3}bc college staff, the external evaluator, c^{3}bc grant advisors, bioscience industry representatives, and others who participated in c^{3}bc grant meetings. Each college also was given a customized list of its activities and deliverables that could be used for college-level tracking of the progress of the grant.

As part of accountability monitoring, the c^{3}bc Executive Director, Russel Read, and Forsyth Tech's Director of Foundation/Grants Accounting, Rebecca Keith, conducted multiple site visits to the colleges during the period of the grant. During the site visits, the Forsyth Tech team reviewed fiscal documentation, observed grant activities, and participated in special events related to the grant, such as program graduation ceremonies.

Communication and Community-Building Strategies

Forsyth Tech implemented a range of activities to promote communication and interest among c^{3}bc participants and stakeholders. The c^{3}bc Executive Director held grant teleconferences every three weeks that included the colleges' c^{3}bc grant and fiscal staff, Abt's evaluation staff, and external advisors to the c^{3}bc grant from bioscience associations and other entities. The teleconferences had a standing list of topics for discussion, including c^{3}bc hub and individual college reports on grant activities, Forsyth Tech's report on grant administration and progress on deliverables, Abt's report on evaluation activities, and upcoming project events and dissemination opportunities. The teleconferences also addressed topics of interest to the colleges, such as student recruitment for new c^{3}bc courses and relationship development with One-Stop Centers. The topics varied as colleges encountered issues they wanted to discuss.

Forsyth Tech convened annual c^{3}bc national meetings at the college's campus in Winston-Salem, NC, which were held in 2013, 2014, 2015 (2 meetings), and 2016 (in San Francisco in conjunction with the BIO industry conference). These meetings included colleges' updates on their activities, an evaluation update, external speakers on bioscience topics, and panel discussions on topics of interest including partnership development with local workforce development offices, employer engagement in c^{3}bc activities, progress on the development of core skill standards, development of Forsyth Tech's Science Skills Lab, and preparation of grant products for NTER and SkillsCommons. The c^{3}bc colleges also prepared posters that featured their grants' activities, outcomes, and products, which were updated annually and displayed at the c^{3}bc national meetings.

In addition to the all-college telephone conferences and national meetings, the c^{3}bc hub leaders also led regular telephone conferences with their hub colleges and others working on skill standards to discuss the progress of the hub's skill standards development (Medical Devices), standards update and revalidation (Bioscience Lab Skills), and standards revalidation (Biomanufacturing). These calls also were opportunities for the hub colleges to discuss their activities in course and credential development.

To ensure that all c³bc teleconference minutes and grant deliverables were available to c³bc staff, Forsyth Tech created a SharePoint site for the grant. The site was a central location for PowerPoint presentations from the national conferences, c³bc grant posters that each college developed and updated for the national meetings, and DOL quarterly reports. The c³bc staff were also asked to post key products on SharePoint, such as recruitment documents, to facilitate sharing among the colleges.

Population Served

The c³bc grant served a diverse population of students across the seven colleges whose student data were analyzed in the evaluation. A total of 938 c³bc students participated in the evaluation. These students were equally male and female. Almost half of the students (47%) were ages 26-45; slightly more than one third (37%) were 25 years or younger; and 17 percent were 46 years or older. While slightly more than half (54%) of students were White, 18 percent were Black/African American; 12 percent were Hispanic; 10 percent were Asian; 3 percent were "other;" and 1 percent were American Indian/Alaskan Native.

The background characteristics of c³bc participants also illustrate the broad population served by the grant. At the time of enrollment in c³bc courses, slightly more than one-third (39%) of c³bc students had a high school diploma or less education; 19 percent had attended some post-high school training or college; and 36 percent had earned an AA/AS or higher degree. Half of the students (51%) were employed at enrollment. While a small percentage (2%) of c³bc students received Trade Adjustment Assistance (TAA) funding or had military experience (5% were Veterans; less than 1% were on active duty or in the Reserves; and 1% were eligible spouses), all seven colleges had TAA or Veterans' represented in their student populations. Detailed exhibits with c³bc students' demographic and background data are found in Appendix D.

Evaluation Design

Abt's evaluation of the Community College Consortium for Bioscience Credentials was comprised of an implementation study, an impact study, and six outcome studies. As previously noted, nine of the 12 c³bc colleges participated in the implementation study because they developed new or enhanced existing bioscience courses, programs, and credentials. Seven of the nine colleges in the implementation study were able to access or collect individual-level student administrative data that could be transferred to Abt for analysis. These colleges participated in the evaluation's impact and outcomes studies. The designs for the evaluation's implementation, impact, and outcome studies are described in this section.

Goals of the Evaluation

The implementation study assessed (1) the extent to which nine c³bc colleges carried out activities to address the c³bc grant's four goals listed below, and (2) the factors that facilitated and posed barriers to the implementation of the grant's activities.

1. Bridge the gap between Trade Adjustment Act (TAA) and other displaced workers and their preparation for the workplace through expanded student recruitment, redesigned courses, and improved retention in bioscience programs;
2. Harmonize a set of core skills for biosciences that facilitate the creation of pathways and provision of training that lead to industry-recognized credentials;
3. Enhance training programs and accelerate certificate and credentialing processes in biosciences through prior learning assessment, focused support services, and the use of technology-enhanced instructional materials; and
4. Build community college capacity for education and training that meets employer needs through partnerships in which colleges work with employers in designing and delivering instruction, placing students into employment, and providing internships and other activities that prepare students for the workplace.

The impact and outcome studies were designed to assess student outcomes from activities the c³bc colleges implemented for the following two grant goals:

- Enhance training programs and accelerate certificate and credentialing processes in biosciences through prior learning assessment, focused support services, and the use of technology-enhanced instructional materials; and
- Build community college capacity for education and training that meets employer needs by designing and delivering instruction and placing students into employment.

Implementation Study Design

Research Questions

The following questions guided the c³bc implementation study:

1. To what extent did the c³bc colleges carry out the core activities of the c³bc TAACCCT grant in terms of:
    a. Strategic Alignment through Partnerships:

i. What types of private and public partnerships did c³bc colleges develop?

ii. What was the extent of partners' involvement in c³bc activities?

iii. What were the effects of c³bc's partnerships on the project's activities and outcomes?

b. Course, Program, and Credential Development and Enhancement:

i. What processes and content were used to develop new and/or enhance existing bioscience courses, programs, and credentials?

ii. To what extent was prior learning assessment used to accelerate credential completion?

iii. To what extent was the use of technology-enhanced instructional materials incorporated into the c³bc–supported enhanced or new courses and programs?

c. Student Recruitment, Assessment, and Advising:

i. What recruitment strategies were used to attract students to enroll in the courses and programs developed under c³bc?

ii. What was the role of student assessment in screening and placing students into courses or programs?

iii. To what extent were students provided with academic advising and career guidance?

d. Preparation for Further Education and Employment: What strategies can facilitate students' readiness to continue education and/or work in the bioscience industry?

e. Harmonization of Standards: What processes did c³bc use to harmonize a set of core skills for biosciences?

f. c³bc Design and Structure: What aspects of the design and structure of the Community College Consortium for Bioscience Credentials grant affected the implementation of c³bc activities?

2. What were the strengths and challenges of the colleges' implementation of each activity area examined in #1?

3. To what extent was institutional capacity for bioscience instruction and credentialing developed through the grant?

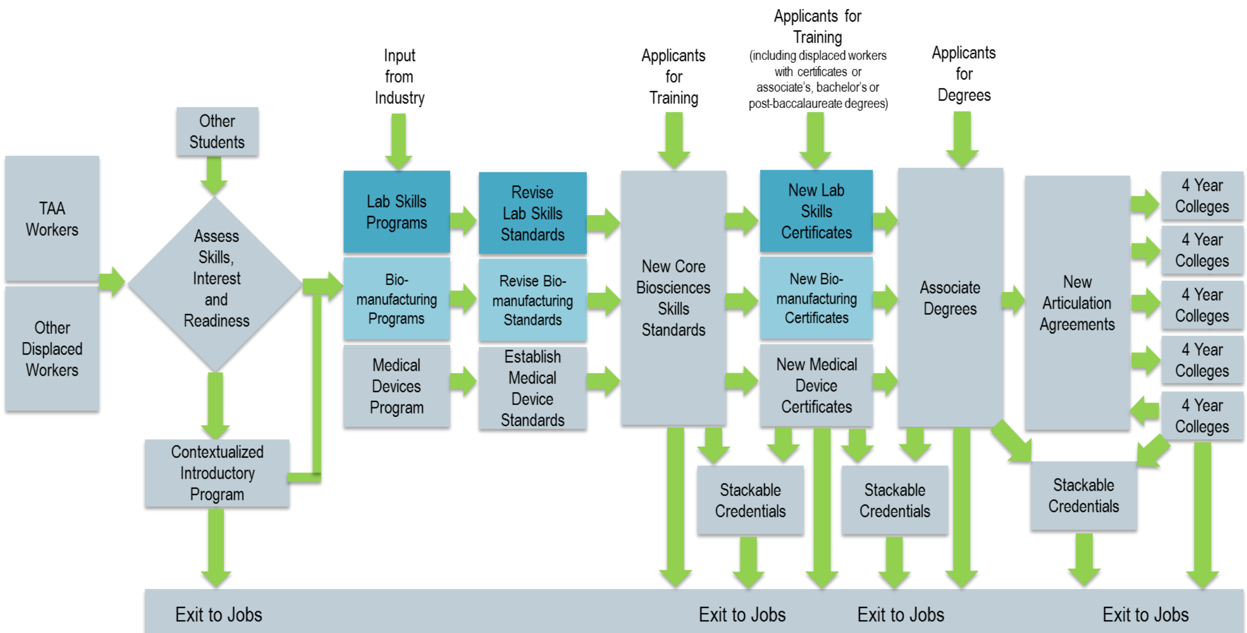
Conceptual Model

The c³bc college partners developed a conceptual model to guide the grant's activities, shown in Exhibit 3. As illustrated in the model, there was an assumption that diverse students would enroll in programs related to the three bioscience subsectors that were the focus of the grant—biomanufacturing, lab skills, and medical devices, and that c³bc partners would assess potential students' skills and interest to determine their readiness for their targeted bioscience program or for enrollment in other programs.

For the grant's work in refining existing and developing new bioscience programs, c³bc partners were expected to establish relationships with bioscience employers and industry representatives to identify the knowledge, skills, and abilities that employers require of employees working as entry-level bioscience technicians. The c³bc partners were to use this information and the expertise of industry representatives to develop new and revise existing bioscience courses, as well as to work on skill standards for the industry. The skill standards work was to update existing lab skills and biomanufacturing skill standards, and develop the first skill standards for medical devices. The skill standards refinement and development was expected to lead to the specification of new core bioscience skill standards for bioscience technicians, which the c³bc partners would use in developing new biomanufacturing, lab skills, and medical device certificate programs. The certificate programs were expected to attract a range of students, including those with education below the postsecondary level as well as students with postsecondary degrees who required further training to obtain employment in the bioscience industry. The new certificate programs also were expected to facilitate students' attainment of bioscience jobs and to serve as stackable credentials as part of a pathway to postsecondary degrees in bioscience. To support pathways from associate degrees to bachelor's degrees, c³bc partners were to develop new articulation agreements between community colleges and four-year colleges or universities.

The c³bc conceptual model guided the design of the implementation study data collection in terms of the topics that were investigated during the study's data collection activities and the relationships among the activities examined during the data analysis phase of the study.

Exhibit 3. c³bc Model: Bioscience Career Pathways with Multiple Entry and Exit Points



Implementation Study Methods and Data

Abt's implementation study involved the following data collection methods:

- Conduct of two site visits to six of the colleges and one site visit with follow-up telephone interview to three of the colleges in the implementation study. The colleges that participated in one site visit were those in which c³bc activities changed minimally during the period after the first site visit. The site visits involved: (1) individual interviews with each college's c³bc leadership, college administrators, faculty teaching c³bc and non-c³bc enhanced courses, college staff working on the c³bc grant, employer partners, One-Stop Center staff, and other individuals participating in the college's grant activities, (2) observation of c^{3}bc course classes and grant advisory meetings, and (3) review of c^{3}bc curricula materials and other grant documents. Abt's researchers used a standardized interview protocol to conduct the face-to-face interviews and a documentation form for the class observations. While the interview protocol had standardized topics, the topics were customized to reflect the college's bioscience subsectors, c^{3}bc goals, and other college-specific activities;

- Conduct of telephone interviews with the colleges' c^{3}bc coordinators in between the site visits. These telephone interviews were customized for each college to document the key activities that were underway at the sites;
- Documentation of colleges' c^{3}bc activities reported during the c^{3}bc grant teleconferences that Forsyth Tech led every three weeks during the grant period;
- Collection of c^{3}bc quarterly reporting forms from colleges in which the c^{3}bc staff described their activities in each key area of the grant's work. Abt created a standardized activities' documentation form that each of the colleges submitted quarterly to Forsyth Tech and to Abt;
- Documentation of colleges' presentations about activities at the c^{3}bc annual national meetings, c^{3}bc hub meetings, and core skill standards' meetings in which Abt participated; and
- Review of Forsyth Tech's quarterly and annual c^{3}bc reports submitted to DOL.

The information Abt's researchers collected during the face-to-face and telephone interviews, and from the review of quarterly reporting forms addressed the topics in Exhibit 4.

Exhibit 4. Topics Investigated in Interviews and Quarterly Report Reviews

Categories of Information	Topics
College Background and Local Economy	College's STEM & bioscience background, bioscience regional economy
Strategic Alignments	Private and public partnerships, activities with One-Stop Center, Workforce Investment Board, state associations, industry advisory groups
Instructional Development, Enhancement, and Delivery	Bioscience course, program, and credential development, enhancement; delivery of courses
Student Recruitment and Supports	Recruitment, assessment, advising, career guidance
Acceleration of Degree Attainment	Use of experiential learning
Employment Placement	Colleges' activities in facilitating students' job placement
Skill Standards	Development, updating, and specification of standards
c^{3}bc Dissemination	Professional meetings, conferences
Grant-Related Collaboration	Activities with other TAACCCT or related grants
Assessment of Grant Activities	Benefits and challenges to implementing grant activities

Data Analysis

A qualitative database was developed for each of the nine colleges that contained descriptive information about c^{3}bc activities collected during the site visit interviews and observations, telephone interviews, colleges' quarterly activities documentation forms, and other documentation of c^{3}bc activities. The database was organized according to the topics in the site visit interview protocol (Exhibit 4), and was updated each time new information became available. As part of the process of updating the database, Abt's researchers checked to determine whether the new information was consistent with existing information. Any inconsistencies were clarified with c³bc college staff.

Information in the colleges' qualitative databases was analyzed to identify common themes across topics and colleges concerning types of activities undertaken, factors that facilitated the activities, and challenges to conducting activities. Activities unique to a college or to a subset of the colleges were identified and reviewed to determine possible reasons for their uniqueness. Abt assessed the grant's capacity-building outcomes in terms of the number of newly developed or enhanced courses and credentials, and the types of business partnerships established during the grant. Analyses of the colleges' qualitative databases were used to prepare the description of the c³bc activities discussed in the previous section of this report, the implementation study's findings, and the individual college case studies in Appendix A.

Design of Impact and Outcome Studies

Abt conducted a quasi-experimental impact evaluation at one college (Forsyth Technical Community College [Forsyth Tech]) and individual outcome studies at six colleges (Bucks County Community College [BCCC], Ivy Tech Community College [Ivy Tech], Los Angeles Valley College [LAVC], Montgomery County Community College [MCCC], Salt Lake Community College [SLCC], and St. Petersburg College [SPC]).

Forsyth Tech was the only college with c³bc-enhanced courses that could be evaluated through an impact study with a quasi-experimental design. Outcome studies were conducted at each of the six other colleges. These colleges designed new courses or credentials for which there was no precedent at the college, or there was no appropriate comparison college with the same types of courses in the region.

Impact Study

The impact study examined the effects of c³bc-enhanced courses on Forsyth Tech students' course completion and grades. The two introductory-level courses examined in the impact study, Biology 111 and Chemistry131, were significantly revised under the grant to increase student access and completion. These revisions included development of an online delivery mode for the courses and modularization of course content incorporating text, video, images, animation, audio, self-assessments, and practice activities. Because these courses were not expected to result in students' receipt of credentials or job attainment, these outcomes were not examined in the impact study.

Research Questions

The research questions for the quasi-experimental study at Forsyth Tech were:

1. What is the impact of the c³bc-enhanced Biology 111 course on students' course completion and grades, compared to the same course outcomes for similar Forsyth Tech students who enrolled in non-c³bc enhanced versions Biology 111?

   1a. Do impacts of the c³bc-enhanced Biology 111 course on course completion vary by student baseline characteristics?

   1b.Which characteristics of students are associated with greater likelihood of Biology 111 course completion?

2. What is the impact of the c³bc-enhanced Chemistry131 course on students' course completion and grades, compared to the same course outcomes for similar Forsyth Tech students who enrolled in non-c³bc enhanced versions of Chemistry131?

   2a. Do impacts of the c³bc-enhanced Chemistry131 course on course completion vary by student baseline characteristics?

   2b.Which characteristics of students are associated with greater likelihood of Chemistry131 course completion?

Sample

The sample for the impact study was Forsyth Tech students. The treatment group was comprised of students who participated in c³bc-enhanced Biology 111 courses and/or c³bc-enhanced Chemistry 131 courses during academic years 2013-2104 or 2014-2015 or fall 2015. The comparison group was students enrolled in non-c³bc enhanced Biology 111 courses and non-c³bc enhanced Chemistry 131 courses at Forsyth Tech during the same time periods as the c³bc courses were delivered. A total of 763 Forsyth Tech students participated in the impact study.

Data Collection

The data for the impact study consisted of student-level administrative data from Forsyth Tech that were stored in student transcripts. The college's Institutional Effectiveness office transferred data to Abt using Abt's secure online file transfer platform. All student data were de-identified; that is, directly identifying information such as name, address, social security number were not provided to Abt.

The types of student data that were transferred to Abt were:

- Demographic and background characteristics of Forsyth Tech students enrolled in c³bc courses and of a matched comparison group; and
- Treatment and comparison students' enrollment and grades in Biology 111 and Chemistry 131courses (c³bc-enhanced and non-c³bc enhanced courses).

Impact Study Methods

To address research questions 1a and 1b, a quasi-experimental design was used to compare outcomes of a sample of treatment group students who had enrolled in Forsyth Tech's c3bc-enhanced Biology 111 course during the period fall 2013 through fall 2015 to the outcomes of a propensity score-matched sample of comparison students who were similar to the treatment group students on demographic characteristics, prior education levels, and baseline measures of math, reading, and sentence skills, but who had enrolled in a Forsyth Tech non-c3bc-enhanced Biology 111 course during the same period. For each treatment student, one or more matched comparison students were identified using a propensity score matching approach.[12] The resulting matched sample included 218 treatment students and 340

[12] Propensity score analysis is a matching technique wherein participants in a course are matched to non-participants on the basis of their "propensity score." This technique uses pre-treatment characteristics to estimate the probability (the propensity score) that a student is in the treated group. After propensity scores are estimated for each individual student, one or more comparison students that have propensity scores are sufficiently close to the propensity score of a treatment group student are assigned as matched comparisons for the treatment student. The criterion used for "sufficiently close" was 0.01 units on a probit scale. Stata's "psmatch2" procedure was used to select the 340 students who were most closely matched to students in the treatment group from a larger pool of 1,078 students who had taken the non-c3bc enhanced course.

matched comparison students. Appendix B tables show that the matching process identified a comparison group of students who were very similar to the treatment group students on baseline characteristics.

Impacts of the c3bc-enhanced Biology 111 were estimated for the following student outcomes:

Outcome Measure	**Coding / Description**
Bio 111 Course Completion	=1 if completed the biology 111 course with a grade of D or higher;[13] =0 otherwise
Bio 111 Course Grade	= 4, 3, 2, 1 or 0 corresponding to course grade of A, B, C, D, or F (Both F and course withdrawal were coded as zero for analysis)

The methods used to address questions 2a and 2b were the same as those described above, but utilized a treatment sample of 97 students who had enrolled in Forsyth Tech's c3bc-enhanced Chemistry 131 course during academic years 2013-14, 2014-15, or fall 2015, and a matched comparison group of 107 students who had enrolled in non-c3bc-enhanced Chemistry 131 courses in the same years. The outcomes for these analyses were:

Outcome Measure	**Coding / Description**
Chem 131 Course Completion	=1 if completed the chemistry 131 course with a grade of D or higher; =0 otherwise
Chem 131 Course Grade	= 4, 3, 2, 1 or 0 corresponding to course grade of A, B, C, D, or F (Both F and course withdrawal were coded as zero for analysis)

There was a small amount of overlap of students between the two studies of the impacts of the c3bc-enhanced Biology 111 and Chemistry 131 courses. A total of 15 students were included in both studies including eight students who were in the treatment group in both studies, four who were in the comparison groups in both studies, and three who were in the treatment group in one study and in the comparison group in the other.

Data Analysis

Abt's impact analyses utilized a "doubly robust" approach (Stuart, 2010) in which the treatment impacts were estimated in linear regression models where observations were assigned weights based on the propensity scores.[14] These analyses included a treatment group indicator as an independent variable and baseline covariates that were used as statistical controls to further adjust for any residual covariate imbalance between the groups.[15] For the outcomes measured on a binary (1=yes, 0=no) scale (*Bio 111 Course Completion*), the impact estimate was expressed as a percentage point difference between the successful course completion in the treatment and comparison groups. For the outcome measured on

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[13] At Forsyth Tech, a grade of D is a passing grade worth 1 quality point per grade hour.

[14] The weights were calculated as $w_i = T_i + (1 - T_i)\frac{\hat{p}_i}{1-\hat{p}_i}$, where T_i is 1 if individual i is in the treatment group, and = 0 if individual i is in the comparision group, and $\hat{p}_i$ is the estimated propensity for individual i. With this weight, treated individuals receive a weight of 1 and comparison group individuals are weighted up to the treated group. In this way both groups are weighted to represent the treatment group and the impact estimates are estimates of the average effect of treatment on the treated (ATT) (Stuart, 2010).

[15] The baseline covariates used as statistical controls are the same variables displayed in the baseline balance results displayed in Appendix B.

ordinal scale (*Bio 111 Course Grade*, range 0-4), the impact estimate was expressed as treatment-control difference in the mean of the numerically coded course grade.

To address the question of whether impacts varied by baseline student characteristics (education level, employment status, gender, race/ethnicity, age, and placement test performance), a series of models were fit to the data where the main impact model described above was modified to include a term (or terms) for the interaction between the treatment group indicator and the baseline characteristic being examined. These models produced a test of whether the impact of the c3bc-enhanced version of the course varied across the level of the subgroup variable (e.g. different impacts for students with different baseline education levels). When the F-test for the treatment by subgroup interaction met the criterion for statistical significance ($p<0.05$), there was evidence that the treatment effect varied among the levels of the subgroup, and the results of tests of whether there were significant impacts within each of the subgroups were reported.

To assess whether there were associations between student baseline characteristics and the likelihood of completing the Biology 111 course, weighted linear regression models similar to those described above were fit to the data that included a treatment indicator and a variable defining subgroups based on student baseline characteristics as the independent variables. For example, to test whether males or females were more likely to complete the course, an indicator variable for "female" was entered as an independent variable in the model, which produced a test of whether either subgroup was more likely to complete the course. Test results with p-values less than 0.05 were interpreted as statistically significant associations.

The same analyses were used to examine student impacts from participation in Chemistry 131.

Outcome Studies

Student outcome studies were conducted at six c³bc colleges (MCCC, BCCC, LAVC, Ivy Tech, SLCC, and SPC) for which no comparison group was available. The studies assessed c³bc students' course participation, course completion, attainment of college credentials, attainment of employment, and wage increase. The types of outcomes assessed were tailored to each college's courses and credentials developed under the c³bc grant.

Research Questions

The research questions for the outcome studies at the six colleges were:

1. What were the course completion rates for each college's c³bc-developed courses or programs?
2. What were the c³bc-developed certificate completion rates for students who enrolled in the c³bc-developed courses?
3. To what extent did students who participated in c³bc-developed courses or credential programs obtain a job?
4. To what extent did students who participated in c³bc-developed credential programs and obtained a job increase their hourly wages?

Sample

The sample was students who participated in the courses, programs, and credentials that the six colleges developed under c³bc and for which students' administrative data were available and could be transferred to Abt. To ensure that the courses or credentials being evaluated were stable, only courses that had been pilot tested and revised were included in the evaluation. A total of 586 c^{3}bc students across six colleges participated in the outcome studies.

Data Collection

The following data were collected for students who enrolled in c^{3}bc-developed or enhanced courses:

- Demographic characteristics and background information;
- c^{3}bc course enrollment, grades, and number of credits earned (if credit-bearing course);
- Credential attainment (name of certificate, degree; type of certificate, degree); and
- Job attainment and wage data.

The c^{3}bc student demographic and background characteristics were stored in databases maintained by each college's c^{3}bc grant coordinator. The coordinators collected these data using the grant's c^{3}bc student intake form that contained the background characteristics needed for TAACCCT reporting, such as TAA and Veteran status. Coordinators obtained data on students' course participation, grades, credits' earned, and credential attainment from the colleges' student records and entered the information into the c^{3}bc student databases. The coordinators at five of the colleges obtained students' job attainment and wage data by conducting telephone and email follow up with students after they earned a credential or completed courses. Data for students at SLCC were obtained from the state's Unemployment Insurance (UI) data match. The grant coordinators transferred the student administrative data to Abt using Abt's secure online file transfer platform.

Outcome Studies' Methods and Analysis

A pre-post design was used to assess students' outcomes from participation in c^{3}bc-developed or enhanced courses during the period fall 2013 through spring 2016. The descriptive analyses of student outcomes at each of the six colleges included frequency distributions of students': (1) demographic and background characteristics; (2) types and number of c^{3}bc-developed courses in which they (a) enrolled and (b) completed; (3) types of (a) certificates and (b) degrees they earned; (4) whether they obtained a job, and amount of hourly wage increase from pre-c^{3}bc program to post-c^{3}bc program. Separate analyses were conducted for each of the six colleges. The results were then aggregated across the six colleges in the evaluation.

Implementation Study Results

The c³bc implementation study was guided by the following questions:

1. To what extent did the c³bc colleges carry out the activities of the TAACCCT grant in terms of:
    a. Strategic alignment through partnerships;
    b. Course, program, and credential development and enhancement;
    c. Student recruitment, assessment, and advising;
    d. Preparation for further education and employment;
    e. Harmonization of standards; and
    f. c³bc design and structure?
2. What were the strengths and challenges of the colleges' implementation of each activity area in #1?
3. To what extent was the institutional capacity for bioscience instruction and credentialing developed through the grant?

Discussed in this section are the key findings from the c³bc grant's activities to increase the courses and credentials that are aligned with entry-level technician jobs in biomanufacturing, bioscience laboratory skills, and medical devices, and to specify core skill standards for entry-level bioscience technicians. The support for the findings and the factors that facilitated the grant's activities in producing these findings are described.

Strategic Alignment through Partnerships

Key Findings:

- Employer and industry partnerships with community colleges are critical to the success of bioscience workforce education and can play an instrumental role in bioscience course and credential design, development, delivery, dissemination, and sustainability;
- Public workforce development partnerships can play important roles in promoting community college's bioscience programs, facilitating referral of students to colleges, providing sources of support for students' tuition, and linking colleges to other resources; and
- Partnership development is an ongoing effort that requires knowledgeable staff and sufficient time to engage, solidify, and sustain partnerships.

The involvement of bioscience employer and industry partners was a core design element of the c³bc grant. These partners had substantial roles in the c³bc grant's college-wide activities as well as in college-specific activities related to the design and delivery of bioscience courses and credentials. The college-wide activities involved developing, revalidating, and harmonizing bioscience skill standards and carrying out the work of the c³bc National Advisory Council (NAC). Employers and industry partners participated in the meetings that the c³bc Medical Device hub convened to identify the skill standards for the medical devices subsector, in discussions with the biomanufacturing and lab skills hubs to revalidate the skills standards for these subsectors, and in the survey, discussions, and meetings regarding the specification of core skill standards for bioscience technicians. The c^{3}bc NAC was composed of national and state industry representatives, employers, and public workforce agency representatives. The NAC members reviewed key products including the core skill standards, made suggestions about the direction of the colleges' c^{3}bc activities, and assisted the grant leaders in planning national dissemination activities particularly for the core skill standards. The NAC members were very supportive of the grant's activities and participated in the grant's telephone conferences and meetings as well as in NAC-specific meetings and telephone calls.

Factors that facilitated the grant's involvement of bioscience partners in these activities were Forsyth Tech's experience in working with the bioscience industry, the grant's executive director's bioscience industry contacts at the national, state, and regional levels, and the contacts of the colleges' c^{3}bc grant leaders, and key advisors to the grant, such as the SoCal Bio representative. The c^{3}bc college leaders also were able to leverage their current and prior work on other federal grants to expand their partnerships with bioscience partners in carrying out the skill standards work. Once partners agreed to support the grants' college-wide activities, the c^{3}bc college leaders listed to and acted on their partners' suggestions as part of the process of reinforcing the partnership. For example, the NAC members assisted in planning the grant's dissemination activities to ensure that the colleges' bioscience expansion approaches would be documented and shared nationally.

The grant's college-specific course, program, and credential development activities also involved bioscience employers and industry representatives. The colleges varied in the extent to which bioscience partners were involved in the course design, development, delivery, and revision phases of the work. Three of the colleges (LAVC, SLCC, and SPC) that conducted extensive development activities involved their bioscience employer partners extensively throughout the grant. The c^{3}bc grant coordinators at these colleges led these activities. Because the coordinators were working primarily on the c^{3}bc grant they had flexibility in their schedules and activities, and could be proactive in doing outreach with employers. This flexibility enabled the coordinators to develop new employer partners and work with them to understand the skills needed in their workplaces and how the college courses could be contextualized to include these skills. Among the factors facilitating these colleges' work with bioscience partners were prior experience with employer partners (LAVC), coordination with the Continuing Education Division to leverage that division's work with employers (SLCC), and experience in training and coordination of curriculum and materials development (SPC).

The c^{3}bc colleges' partnerships with the Workforce Investment Boards (WIBS) and One-Stop Centers were slower to develop than employer partnerships. One factor affecting the pace of development was these partners' interest in bioscience jobs as options for workforce clients. While bioscience was a growing occupation in the colleges' labor markets, it was a small market in some areas and workforce staff generally gave priority to occupations on the region's Demand Occupations List. Another factor was the One-Stop Center's staff's lack of familiarity with the bioscience industry. The colleges' c^{3}bc coordinators conducted outreach to the WIBS and One-Stop Centers and provided information about bioscience jobs and the colleges' programs to assist workers in transition to prepare for these jobs. Through their persistence, three of the colleges' (MCCC, BCCC, and SPC) were able to obtain Eligible Provider Status for their bioscience programs. The c^{3}bc coordinators also worked with the One-Stop Centers to facilitate clients' access to ITA funds.

The examples of the c^{3}bc college staffs' activities in pursuing new partnerships and persisting in establishing them illustrate the process of developing partnerships. This process requires sufficient time to develop a relationship, and a clear understanding of the benefits that one has to offer a partner and what is expected in return so that a balanced relationship can be formed (Alampese, 2009). In the colleges where c^{3}bc coordinators established successful partnerships with employers, both the coordinators and the partners could explain the mutual benefits of working together. For example, medical device company representatives who assisted c^{3}bc staff in medical device course development and delivery indicated that they enjoyed teaching the courses because it gave them an opportunity to share their knowledge and experience about the work of a biomedical equipment technician. The c^{3}bc staff found that these instructors brought authentic examples from the medical device workplace that enabled students to understand the types of issues a technician was likely to encounter, which was motivating to students. For the college bioscience programs that worked with WIBs and One-Stop Centers and were granted Eligible Provider Status, the balance in the partnership came when the workforce partners realized the extent of the marketplace for the bioscience credentials and bioscience students were able to obtain jobs.

The colleges' development and engagement of partners took time and persistence. The c^{3}bc staff and faculty with experience in working with employers and workforce partners were able to move forward with these partnerships at a faster pace and with more success. This was particularly the case in the college departments where c^{3}bc staff and faculty had existing partnerships at the time the c^{3}bc grant began. For the colleges that had c^{3}bc coordinators who were new to the colleges, it took time for them to establish a relationship with the grant's employer advisory group and identify potential employer partners' needs and potential payoffs to working with the bioscience programs. The c^{3}bc staff who were able to establish a balanced relationship with partners were more likely to sustain partnerships with employers throughout the period of the grant.

Course, Program, and Credential Development and Enhancement

Key Findings:

- Course development requires staff, time, and resources to coordinate with employer, industry, and workforce partners; align course content to meet college, state, and industry requirements; and implement pilot test and revision processes to ensure that the courses achieve their intended goals; and
- Cross-departmental relationships and support from community college administrators are critical to the development and approval of new bioscience curricula and credentials.

Course Development

The c^{3}bc staffs' experiences in course development illustrate the amount of time and expertise needed for colleges to work collaboratively with employers, industry partners, and others in creating courses that meet colleges' and states' requirements and are aligned to industry needs. For all colleges, the c^{3}bc course development process took more than the grant's projected timeframe of six months.

The c^{3}bc staff's collaborative work with other departments within the colleges as well as with employers required staff who could initiate partnerships and follow through on activities to reinforce the benefits of collaboration to partners. For the c^{3}bc colleges that focused on developing new partners, staff spent considerable time identifying the appropriate people to contact, working with potential partners to determine the benefits from working with the bioscience program, and specifying the types of activities in which partners would participate. While c^{3}bc staff could move ahead with the technical details of developing courses, the process of engaging employer and industry partners in course development added a dimension that was difficult to control in term of timeline and level of staff's effort.

The c^{3}bc staff's work to ensure that partners had an active role in all stages of course creation and initial delivery involved multiple discussions with partners and planning. The staff took steps to ensure that the new and enhanced c^{3}bc courses reflected the most current information about content and instructional design, and involved applications from the targeted bioscience occupations. Employers assisted c^{3}bc staff in identifying the focus of new courses and in developing and revising courses by providing suggestions about how courses could be better aligned with industry needs. At ACC, Ivy Tech, SLCC, and SPC, employees from employer partners also taught the new or refined courses and provided feedback to c^{3}bc staff. The collaboration between c^{3}bc staff and employers in course development required extensive communication that went beyond the typical involvement of a college's employer advisory group.

Other aspects of course development contributed to the amount of time, staff, and resources for this phase of the grant. Most of the c^{3}bc colleges procured equipment and instruments for the new c^{3}bc courses, and faculty had to wait for the arrival of equipment before teaching the new courses. As part of the course development process, most colleges incorporated a pilot test to determine whether the courses were operating as planned or needed modifications. While a pilot test helped staff to assess whether aspects of course redesign were effective, this process also extended the course development time. Overall, the colleges' learned that standards-based course development involving collaboration with industry partners and the use of good design procedures requires significantly more time than six months to create finished products.

Course Approval

The c^{3}bc staff identified the processes that can support course development and the approval of colleges' new courses and credentials. The c^{3}bc staff at three colleges found that working across college departments facilitated their activities. At LAVC the Workforce Department collaborated with the Biology Department in developing the new courses for the Biotechnology Certificate. This collaboration strengthened the quality of the course and generated cross-departmental support for the certificate program. At SLCC the c^{3}bc staff in the Biotechnology Program worked with the Continuing Education Division in developing and delivering the courses for the Medical Device Manufacturing Processes and Practices Certificate. This collaboration was formed after it was determined that the initial target audience for the certificate program was incumbent workers who could use the certificate as a means of upward mobility in their companies The Continuing Education Division's experience brought new employer contacts and a structure for managing non-credit certificate programs that enabled the certificate program to move forward. To support SPC's simultaneous development of the Biomedical Equipment Technician (BMET) Certificate and the AS degree in Biomedical Engineering Technology, SPC's c^{3}bc coordinator worked with the college's Workforce and Continuing Education Division. Through this collaboration, students could take non-credit courses for the BMET certificate while the course and degree approvals from the college were underway, with the understanding that they would be able to earn credits toward the AS degree for their participation in the BMET certificate.

Another aspect of the course and credential approval process is the need for college administrative support, particularly in the development of new degree programs. At SPC there was a lengthy process of committee, college, and state approvals that required support from the dean to enable the new degree program to meet the requirements at each level of review.

Student Recruitment, Assessment, and Advising

Key Findings:

- Conducting public awareness about bioscience occupations and the credentials needed to work in these occupations is a critical step in building understanding and support for bioscience education and recruiting potential students for bioscience programs; and
- Assessment and advising can help to ensure that students are prepared to meet course demands, develop an initial program plan, access academic assistance and other supports, and stay on track in carrying out their plans.

Student Recruitment

The c^{3}bc staff found it challenging to recruit students for the new courses and credentials developed under the grant. Except for Forsyth Tech and LAVC, the enrollments in the c^{3}bc courses were small during the first three years of the grant but began to increase during the last year. The strategies that c^{3}bc staff used to increase stakeholders' awareness about bioscience education and address the challenge of recruiting students are described in this section.

While bioscience is a growing industry in the labor markets served by the c^{3}bc colleges, the colleges' bioscience programs were relatively small compared to other science programs in the colleges and varied in their visibility in their communities. Because of the size of existing bioscience programs, there was a limited pipeline of students ready to move into the newly developed programs. In order to reach potential students, the c^{3}bc staff had to conduct extensive awareness and outreach with both community and college stakeholders.

The c^{3}bc staff reported that their marketing of the c^{3}bc courses and credentials in their communities eventually resulted in student referrals from community organizations and an understanding among staff in these organizations about bioscience opportunities. While c^{3}bc staff did not measure the relative effectiveness of their marketing strategies, they indicated that the relationship building through marketing activities made it easier to work with community agencies and to obtain their cooperation in referring potential students. These marketing activities included the distribution of print media such as brochures, posters, and handouts, and meetings with key community stakeholders at the One-Stop Centers, Veterans' and social service agencies, employers, secondary and other postsecondary institutions, and other agencies. The messages communicated through these activities concerned the opportunities in the bioscience industry as well as the availability of the new bioscience programs established under the c^{3}bc grant. The special features highlighted in the marketing materials varied depending on colleges' bioscience programs. For example, MCCC and ACC emphasized the opportunity to work in a simulated industry environment, and CCSF and other colleges noted the opportunities available for internships outside of and within colleges.

The c^{3}bc staff also worked within their colleges to build support and visibility for the new bioscience courses and credentials. Through meetings with academic departments, workforce education, continuing education, and advising and counseling offices, c^{3}bc staff explained the further education and employment opportunities for students who were enrolled in bioscience courses. These efforts gradually resulted in increased cooperation between c^{3}bc staff and staff in other departments and more referrals from advising and counseling offices.

Assessment and Advising

The grant's assessment activities were focused on determining students' readiness for bioscience courses. Of the c³bc colleges, LAVC conducted the most comprehensive assessment process, motivated by their employer partners' involvement in selecting Biotech Bridge Training Academy participants. LAVC's assessment included the administration of three basic skills assessments and individual interviews with staff and employer partners. One result from the careful selection of Bridge Academy participants was that almost all (98 percent) of Bridge participants completed the program.

The c³bc colleges used a combination of formal and informal advising of students to facilitate their placement in bioscience courses. Some colleges (Forsyth Tech, SPC) asked students to complete learning plans to help them think about their long-term participation in college and understand the types of courses that they would have to complete to attain a credential. At the other colleges, c³bc staff or a designated bioscience program staff member met with prospective students to discuss their background and goals and to determine their fit with the particular bioscience program. Through both formal and informal advising processes, staff referred students to college resources when it was apparent that students needed additional assistance to prepare for courses. While it was not possible to conduct a systematic analysis of the effects of students' completion of formal learning plans on their retention, c³bc staff reported that they thought the completion of learning plans enabled students to have a more realistic understanding of what was required for them to participate in a particular program and was a first step to encouraging retention.

Preparation for Further Education and Employment

Key Findings:

- The organization of courses into an explicit career pathway and the development of credentials that can be stacked and latticed can potentially facilitate students' pursuit of further education; and
- The provision of internships that involve hands-on training in bioscience, and laboratory instruction that incorporates simulated work environments can provide students with industry experience that employers have identified as a priority in hiring.

The c³bc staff carried out activities to strengthen career pathways in their bioscience programs and to implement meaningful internships with bioscience employers. These activities were intended to build the capacity of the bioscience programs during the period of the c³bc grant, with the expectation that over time these activities would result in students' increased bioscience credential attainment and placement in industry jobs. Given the stage of the capacity building, the c³bc evaluation did not assess the effects of these activities on student outcomes.

The colleges that used the grant to better align their bioscience credentials, such as ACC's biotechnology certificates and LAVC's Biotech Academy and Biotech Certificate, indicated that the alignment also enabled them to show students specific pathways and to recruit students using the pathways as an incentive. ACC found that having pathways maps enabled students to have a better understanding of options for future credential attainment.

The c³bc colleges expanded and refined their internship programs, as previously described in this report. The internships were considered to be particularly important for students with no experience in the bioscience industry, since employers' feedback to c³bc staff emphasized their priority in hiring individuals with some exposure to bioscience workplaces. While some research on internships has linked participation in internships to employment, the c³bc colleges' work on developing different types of internship models is an opportunity for deeper study of the varied ways in which internship programs can be structured (Silva, Costa, Sebra, et al., 2016). CCSF's work in developing training for mentors is another way in which the grant contributed to understating processes for implementing successful internships.

Harmonization of Bioscience Skill Standards

Key Finding: Bioscience core skill standards provide a framework for curriculum development that specifies the academic skills and knowledge needed for industry positions, and can be customized to specific positions as part of the process of aligning workforce curricula with bioscience industry needs.

The c³bc grant's work in specifying core skill standards for bioscience technicians in collaboration with employers and bioscience industry representatives resulted in a framework for curriculum development and reinforced career pathways for bioscience technician education. During the grant period, some colleges (Forsyth Tech, ACC) used the skill standards to design entry-level courses in the biosciences. Other colleges (MCCC, SPC) used the new core skill standards to review the bioscience courses they had developed earlier in the grant and make necessary changes so that the new courses reflected the industry-identified core skills.

The publication of the core skill standards provides a resource for educators and employers. Educators can design new bioscience courses or curricula based on a uniform set of core skills that can include customization to the relevant bioscience subsector. The use of the core skills should help to ensure that the fundamental skills and knowledge needed for technician positions are being taught along with the applications to specific industry positions.

Employers can use the core skills framework to better evaluate community college training programs and assess potential employees' skill levels. The skill standards can also guide employers in developing or enhancing their internal training programs and internship opportunities.

Forsyth Tech, in coordination with the grant's NAC, began national dissemination of the core skill standards report during the final months of the grant, and planned to continue this outreach after the grant concluded.

c³bc Design and Structure

Key Findings:

- The organization of the c³bc grant into a hub structure facilitated collaboration among colleges and provided centers of expertise that enabled the grant to carry out work in four separate but related areas; and
- Forsyth Tech's support for c³bc college partners through communication and community-building activities and fiscal and management oversight provided an environment in which c³bc partners conducted their grant work independently and also functioned as a collegial learning community.

The hub structure of the c³bc grant facilitated cross-college staff working together on several grant tasks during the same time period. This structure also enabled one college in each hub to have responsibility for the completion of tasks while working collaboratively with the other colleges in the hub. Given the number and breadth of the deliverables required for the c^{3}bc grant, the hub structure was an efficient mechanism for involving a range of professionals representing three subsectors in the bioscience industry who could work within colleges and across colleges to meet the grant's goals.

The c^{3}bc college leaders were a well-networked group of bioscience professionals. The c^{3}bc grant, through Forsyth Tech's communication and community-building activities, provided an opportunity for the college staff who were new to the c^{3}bc group to become integrated into this professional network. Over the course of the grant, new professional relationships were formed and c^{3}bc staff shared information and grant opportunities. This professional networking was an example of the bioscience education capacity building that resulted from the grant.

Institutional Capacity Building

Key Finding: Under the c^{3}bc grant, the following course and credential outcomes were achieved:

- Developed new or updated 12 bioscience certificates;
- Developed one new associate's degree credential;
- Developed or updated more than 70 biosciences courses and related products;
- Updated and revalidated Bioscience Laboratory Skill Standards and Biomanufacturing Skill standards;
- Developed Medical Device Skill Standards; and
- Developed Core Skill Standards for Bioscience Technicians.

In addition to the examples discussed in this section about staff's capacity building through the c^{3}bc grant's activities, the grant produced a number of new or enhanced credentials and course, which are listed above. Materials related to these "products" have been posted on NTER and SkillsCommons are available for public use. The number of course and credentials from the grant represents significant capacity build in biomanufacturing, bioscience laboratory skills, and medical devices.

Results from Impact and Outcome Studies

Impact Study Results

The impact study addressed the following research questions concerning the effects of Forsyth Tech's c3bc-enhanced Biology 111 and Chemistry 131 courses:

1. What is the impact of the c³bc-enhanced Biology 111 course on students' course completion and grades, compared to students who enrolled in non-c³bc enhanced versions Biology 111?

   1a. Do impacts of the c³bc-enhanced Biology 111 course on course completion vary by student baseline characteristics?

   1b. Which characteristics of students are associated with greater likelihood of Biology 111 course completion?

2. What is the impact of the c³bc-enhanced Chemistry 131 course on students' course completion and grades, compared to students who enrolled in non-c³bc enhanced versions of Chemistry 131?

   2a. Do impacts of the c³bc-enhanced Chemistry 131 course on course completion vary by student baseline characteristics?

   2b. Which characteristics of students are associated with greater likelihood of Chemistry 131 course completion?

Impacts of Biology 111 Course

The results of the impact analysis indicated that students who enrolled in the c3bc-enhanced Biology111 course were less likely to complete the Biology 111 course and had lower average course grades than their matched comparison group counterparts (Exhibit 5). Sixty-one percent of the treatment group students completed the course compared to 79.3 percent of comparison group students. The 18.3 percentage point difference between the groups was statistically significant at the $p<0.001$ level.

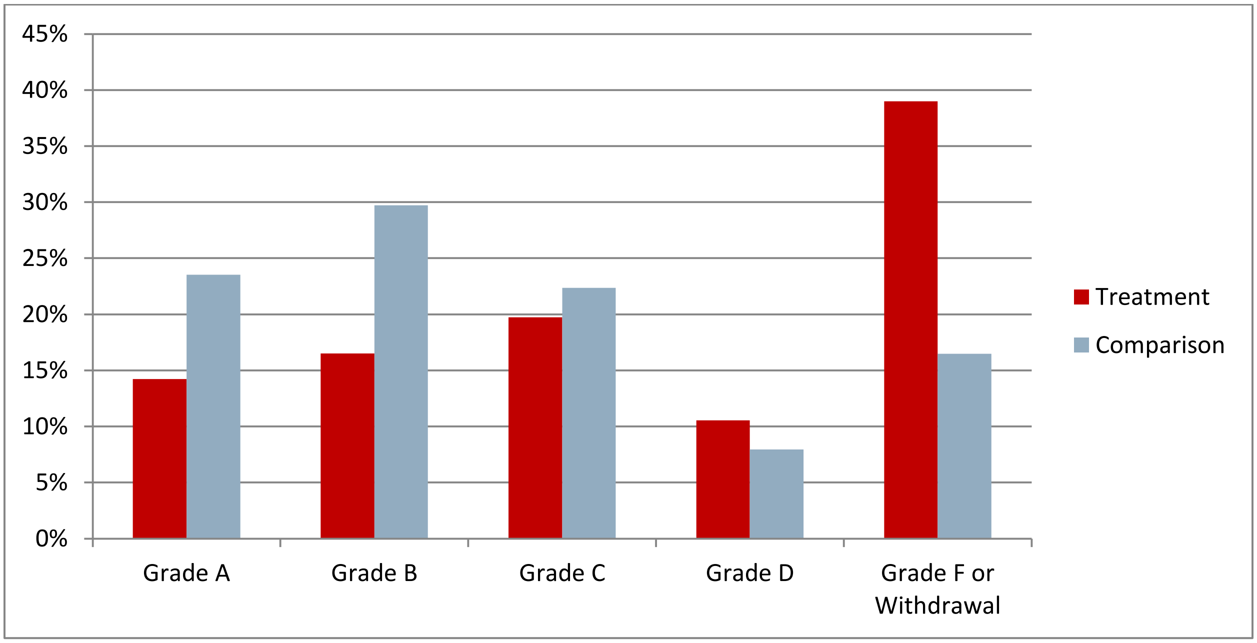
The mean course grade for students in the c3bc-enhanced course was1.56 (approximately mid-way between C and D grades), which was a little over half a grade point lower than the mean course grade for the comparison group (impact estimate = -0.60 grade points, $p<0.001$). The distributions of grades for the two groups are displayed in Exhibit 6. Among the subgroups of students who received grades of D or higher, treatment group students were less likely to get A's and B's and more likely to C's and D's than their comparison group counterparts (Exhibit 7).

Exhibit 5. Impacts of c³bc-Enhanced Biology 111 Course

Outcome	Unadjusted Mean or Percent Yes Treatment Group (n=218)	Adjusted Mean or Percent Yes Control Group [a] (n=340)	Impact Estimate [b]	Impact Standard Error	Impact p-value [c]
Bio 111 Course Completion	61.0%	79.3%	-18.3%	3.7%	<0.001
Bio 111 Course Grade	1.56	2.16	-0.60	0.11	<0.001

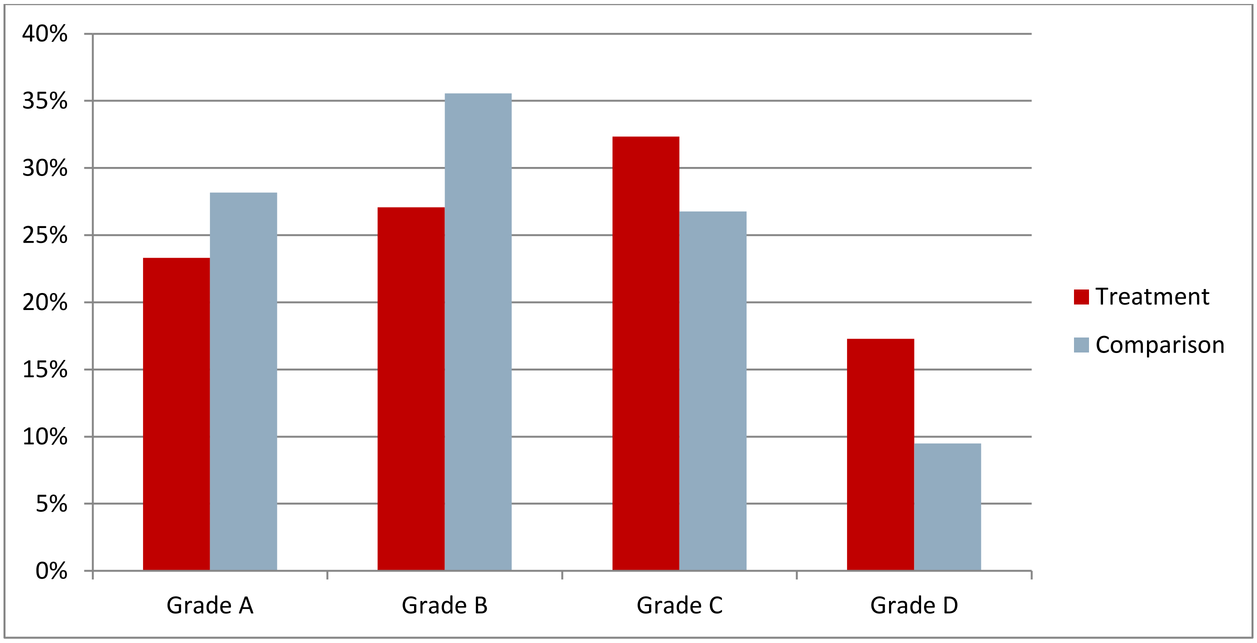
[a] The adjusted mean or percent yes is calculated as the treatment group value minus the impact estimate.
[b] This is the doubly robust model-estimated average impact of the enhanced course on the outcome measure.
[c] Treatment effect p-value is for test of null hypothesis of no treatment impact, two-tailed test.

Exhibit 6. Distribution of Biology 111 Course Grades By Treatment Group



Note: Distribution of grades for 218 treatment group and 340 comparison group students.

Exhibit 7. Distribution of Biology 111 Course Grades By Treatment Group for the Subset of Students with Grades of D or Higher

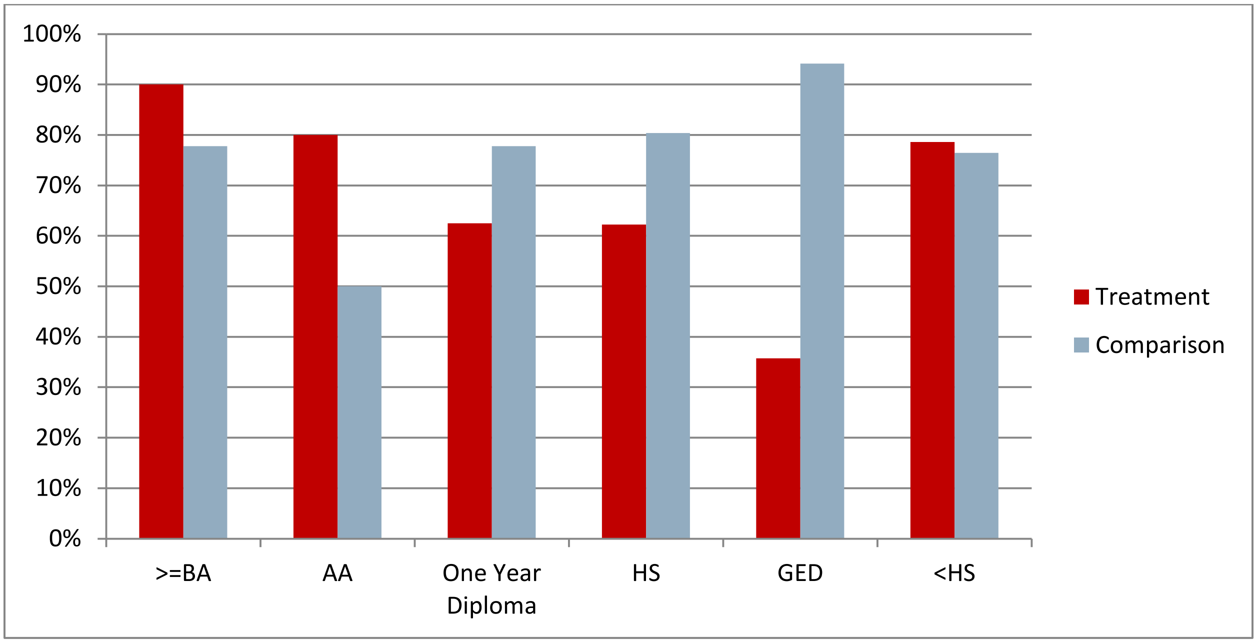


Notes: Distribution of grades for subsets of 133 treatment group and 284 comparison group students who received grades of D or higher in the Biology 111 course.

Variation in Impacts of Biology 111 by Student Characteristics

Student baseline characteristics (education level, employment status, gender, race/ethnicity, age, and placement test performance) were examined to determine variation in treatment effects on Biology 111 course completion. Significant variation in the treatment effect on Biology 111 course completion was found for baseline education level ($p<0.05$). Specifically, among higher educated students (students with associate's degrees, or bachelor's degree and higher) and among students with the lowest baseline education (less than high school), greater percentages of students in the treatment than the comparison group completed the Biology 111 course. The sample sizes in these educational subgroups were relatively small (fewer than14 percent of the total sample had an associate's degree or higher and 13 percent had less than a high school diploma), and the treatment effects were not statistically significantly different than zero in those education level subgroups (Exhibit 8). Bar graphs showing the percentages of treatment and comparison group members completing the Biology 111 class by other baseline characteristics are shown in Appendix C.

Exhibit 8. Percent Completing Biology 111 by Baseline Education Level and Treatment Group



Notes: About two-thirds of students had a high school diploma, and about 14 percent had less than high school diploma. The percentages of students in each of the other categories ranged from around 4 to 7 percent. See Table B.1 for details.

Student Characteristics Associated with Biology 111 Course Completion

As described in the previous sections and Appendix B, the treatment effects did not vary by baseline employment status, gender, race/ethnicity, age, or placement test performance. Some of these baseline characteristics, however, were associated with students' likelihood of completing the course. The following statistically significant ($p<0.05$) relationships were found:

- Unemployed students were more likely to complete the course than full-time and part-time workers;
- Females were more likely to complete the course than males; and
- African American students were less likely to complete the course than other students.

Student age, placement test taking, and placement test performance were not associated with the likelihood of completing the course.

Impacts of Chemistry 131 Course

Similar to the previous results, students who enrolled in the c³bc-enhanced Chemistry 131 course were less likely to complete the Chemistry 131 course and had lower average course grades than their counterparts in the matched comparison group (Exhibit 9). Fifty-four percent of treatment group students completed the course compared to 69 percent of comparison group students. The 15 percentage point difference between the groups was statistically significant at the $p<0.05$ level.

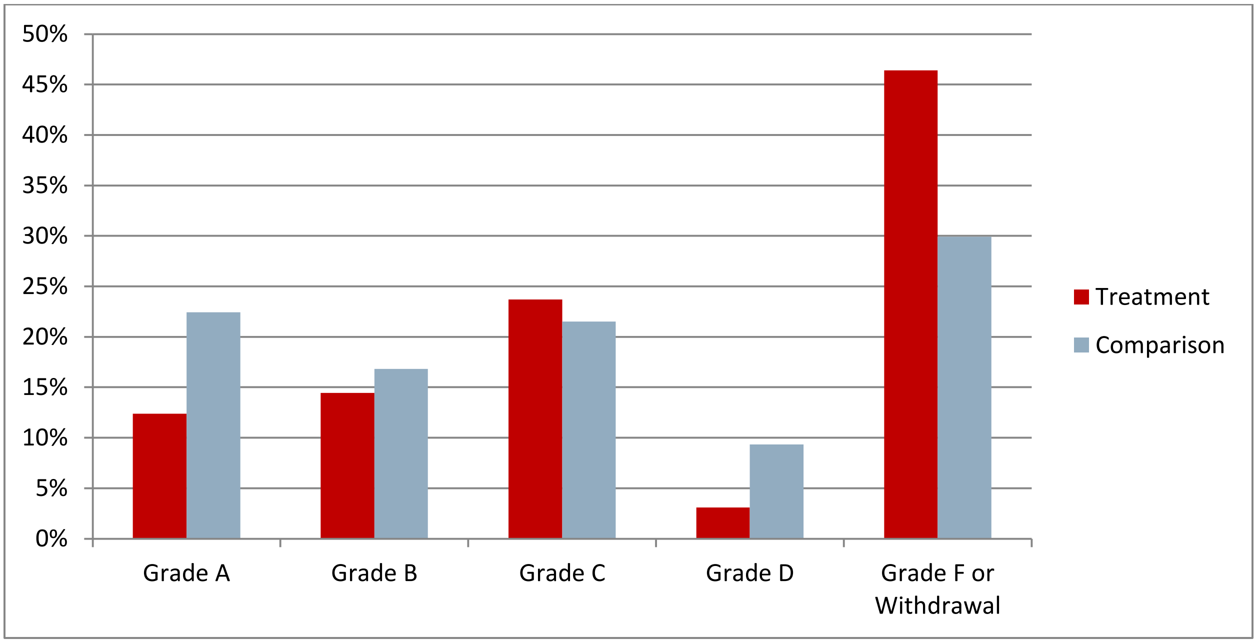
Distributions of course grades are shown in Exhibit 10 and Exhibit 11. Treatment group students were more likely to fail or withdraw, but among those who completed the course, treatment group students more often received B's and C's and less often received A's and D's than students in the comparison group.

Exhibit 9. Impacts of c³bc-Enhanced Chemistry 131 Course

Outcome	Unadjusted Mean or Percent Yes Treatment Group (n=97)	Adjusted Mean or Percent Yes Control Group [a] (n=107)	Impact Estimate [b]	Impact Standard Error	Impact p-value [c]
Chem 131 Course Completion	53.6%	69.0%	-15.4%	6.7%	0.024
Chem 131 Course Grade	1.43	1.95	-0.52	0.10	0.010

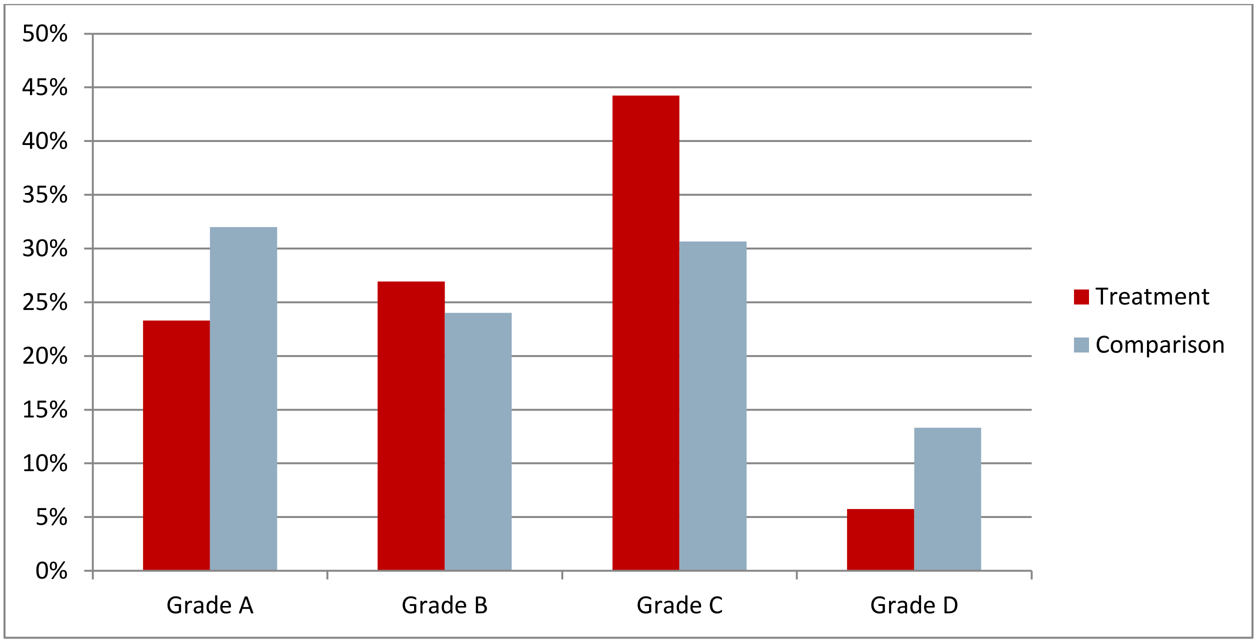
[a] The adjusted mean or percent yes is calculated as the treatment group value minus the impact estimate.
[b] This is the doubly robust model-estimated average impact of the enhanced course on the outcome measure.
[c] Treatment effect p-value is for test of null hypothesis of no treatment impact, two-tailed test.

Exhibit 10. Distribution of Chemistry 131 Course Grades By Treatment Group



Notes: Distribution of grades for 97 treatment group and 107 comparison group students.

Exhibit 11. Distribution of Chemistry 131 Course Grades By Treatment Group for Subset of Students with Grades of D or Higher



Notes: Distribution of grades for subsets of 52 treatment group and 75 comparison group students who received grades of D or higher in the Biology 111 course.

Variation in Impacts of Chemistry 131 by Student Characteristics

There was no significant variation in the treatment effects of the c³bc-enhanced Chemistry 131 course on course completion for any of the baseline characteristics examined (education level, employment status, gender, race/ethnicity, age, and placement test performance).

Student Characteristics Associated with Chemistry 131 Course Completion

Students with higher education levels at baseline were more likely to complete the course. Other baseline characteristics (employment status, gender, race/ethnicity, age, and placement test performance) did not have significant associations with the likelihood of completing the Chemistry131course.

Summary of Impact Results

Biology 111 Course

Students who participated in the c³bc-enhanced Biology 111 course were less likely to complete the course ($p<.001$) and had lower average course grades ($p<.001$) than their matched comparison counterparts. Significant variation in the treatment effect on Biology 111 course completion was found for baseline education level ($p<0.05$). Treatment students who entered the c³bc-enhanced Biology 111 course with associate degrees or higher and those who entered with less than a high school diploma were more likely than their comparison group counterparts to complete the course.

Some characteristics of students at the time they entered the Biology 111 course were associated with the likelihood of completing the course ($p<.05$). Students who were unemployed and those who were female were more likely to complete the Biology 111 course, while African American students were less likely to complete the course.

Chemistry 131 Course

Students who participated in the c^{3}bc-enhanced Chemistry 131 course were less likely to complete the course and had lower average course grades than their matched comparison counterparts. There was no significant variation in the treatment effects of the c^{3}bc-enhanced Chemistry 131 course on course completion for any of the baseline characteristics examined. The only student characteristic associated with completion of the Chemistry 131 course was students' education level at entry into the course. Students with higher education levels were more likely to complete the course.

Outcome Studies' Results

Descriptive studies of student outcomes for each of the six colleges' (MCCC, BCCC, LAVC, Ivy Tech, SLCC, and SPC) that developed c^{3}bc courses and credentials were conducted. The studies addressed the following questions about students' educational participation, educational attainment, and employment outcomes:

1. What were the course completion rates for each college's c^{3}bc-developed courses or programs?
2. What were the c^{3}bc-developed certificate completion rates for students who enrolled in the c^{3}bc -developed courses?
3. To what extent did students who participated in c^{3}bc-developed courses or credential programs obtain a job?
4. To what extent did students who participated in c^{3}bc-developed credential programs and obtained a job increase their hourly wages?

The results from the outcome studies are described below. Data were collected on students who participated in c^{3}bc-developed or enhanced courses during the period fall 2013 through spring 2016. Courses were evaluated after they had been pilot tested and revised. All of the colleges except SLCC conducted their own student follow-up data collection to obtain job attainment and wage data. SLCC accessed job attainment and wage data from the state's Unemployment Insurance data match records. Because of the follow-up method used to obtain students' employment and wage outcomes, there was considerable missing data for these two outcomes, which limits the interpretation of the results. Students' demographic and background data referenced in the findings are found in Appendix D.

Biomanufacturing Hub

Montgomery County (PA) Community College (MCCC)

The MCCC study examined the outcomes from students' enrollment in courses for the Biotechnology and Biomanufacturing Certificate and their attainment of the certificate. The target population for the certificate was nontraditional students who were displaced, seeking a career transition, or reentering the workforce. Almost half (49 percent) of MCCC students had an associate's degree or higher when they entered the program.

MCCC's course completion data show that 41 percent of the students who enrolled in the certificate courses obtained a certificate during the time of the grant (Exhibit 12). Of the students who enrolled in the courses, three-quarters (75 percent) obtained a grade of "C" or better. MCCC was able to obtain employment data on 24 percent of the students enrolled in courses, all of whom obtained a job after the program ended. Of the students reporting a job, 84 percent had earned a certificate.

Exhibit 12. MCCC Course Completion and Job Attainment

Number of Courses Taken Toward Certificate	Students Enrolled in Certificate Courses		Students Completed Certificate Courses ("C" or better)[a]		Students Obtained a Job after Program	
	#	%	#	%	#	%
4 courses / Earned Biotech Certificate	35	44.9	34/32[b]	43.6/41.0	16	20.5
3 courses	3	3.8	2	2.6	0	0.0
2 courses	13	16.7	8	10.3	1	1.3
1 course	27	34.6	14	17.9	2	2.6
Did not complete (with "C" or better)			20	25.6		
Missing	0	0.0	0	0.0	59	75.6
Total	78	100.0	78	100.0	78	100.0

[a] Of the students, who did not complete all courses with a "C" or better, 13 were enrolled in 1 course, 5 were enrolled in 2 courses, 1 was enrolled in 3 courses, and 1 was enrolled in 4 courses. Six students withdrew from all or their courses, and thus had no reported grades.

[b] Two students who completed 4 courses did not receive a certificate because they did not take the 4 core curriculum courses for the certificate, instead taking other courses offered by MCCC.

Bucks County Community College (BCCC)

The BCCC study examined students' attainment of an Associate's Degree in Biotechnology and of the Biotechnology Cell and Tissue Culture Certificate. The target population for these credentials was recent high school graduates or students with limited science background. Almost two-thirds (63 percent) of the students for whom data were available were age 25 or younger when they entered the biotechnology program.

Of the students participating in BCCC's biotechnology degree and certificate programs, half (52 percent) earned an Associate of Science degree and one third (32 percent) earned the Biotechnology Cell and Tissue Culture Certificate (Exhibit 13). After completing the program, slightly more than one-third (37 percent) of students were employed and the remaining students for whom data were available were still attending college (Exhibit 14).

Exhibit 13. BCCC Credential Attainment

Type of Credential	#	%
Biotechnology Associate of Science (AS)	10	52.6
Biotechnology Cell and Tissue Culture Cert.	6	31.6
Not applicable–Still in program	3	15.8
Missing	0	0.0
Total	19	100.0

Exhibit 14. BCCC Post-Program Employment Status

Post-Program Employment Status	#	%
Employed full-time	7	36.8
Not applicable–Still in program	3	15.8
Transferred to another school	5	26.3
Missing	4	21.1
Total	19	100.0

Los Angeles Valley College (LAVC)

The LAVC study examined students' completion of the Biotech Bridge Training Academy and their attainment of the Biotech Certificate, which was developed during the second half of the c³bc grant. The target population for the Bridge Academy was displaced workers (including TAA recipients), Veterans, and workers with relevant degrees who had difficulty finding employment. Three-quarters (76 percent) of the students who participated in the Bridge Academy were unemployed at the time of their enrollment, and almost half (49 percent) had an AA degree or higher. Bridge Academy applicants participated in a rigorous screening process that included the administration of math, reading, and writing assessments and interviews with Academy staff and with the program's employer partners. Applicants had to be approved by the staff and the employers to be accepted into the program (see the LAVC case study in Appendix A). Students who completed the Bridge Academy program were guaranteed an interview for a Technician I position with an employer partner. As shown in Exhibit 15, almost all (98 percent) Bridge Academy participants completed the program.

The target population for the Biotech Certificate was TAA workers, graduates of the Bridge Academy, and current employees of regional bioscience companies. Almost two-thirds (62 percent) of Biotech Certificate students were unemployed at the time of their enrollment in the program and the same percentage had an associate's degree or higher. At the end of the c³bc grant, approximately one quarter (24 percent) of students in the Biotech Certificate program had earned a certificate (Exhibit 15).

Exhibit 15. LAVC Credential Attainment

Program	Students Enrolled	Graduates	
	#	#	%
Biotech Bridge Training Academy	188	184	97.9
Biotech Certificate	34	8	23.5
Total	222		

Data were analyzed for Bridge Academy graduates' post-program employment and wages. Over half (56 percent) of Bridge Academy participants who were unemployed when they began the program became employed after they completed the program. Another 20 percent of students were employed both when they entered the program and after they completed the program. Twenty-two percent of students who participated in the program were unemployed at follow up (Exhibit 16).

Pre-Post program wage data were available for 28 Bridge Academy participants. The median hourly wage increase for Bridge Academy graduates was 29.4 percent. Graduates' hourly wage increased to $16.50 from $10.90 rate (Exhibit 17).

Exhibit 16. LAVC Bridge Academy Graduates' Post-Program Employment Status

Post-Program Employment Status	#	%
Employed at baseline and employed at follow up	38	20.2
Unemployed at baseline and employed at follow up	105	55.8
Employed at baseline and unemployed at follow up	8	4.3
Unemployed at baseline and unemployed at follow up	33	17.6
Missing	4	2.1
Total	188	100.0

Exhibit 17. LAVC Bridge Academy Graduates' Employment Hourly Wage Data				
Employment Wage[a]	Mean	Median	Std Dev	% change
Baseline hourly wage (n=28)	$12.19	$10.90	$3.48	
Post-program hourly wage (n=28)	$15.43	$16.50	$2.94	
Hourly wage change	$3.23	$3.20	$4.17	29.4

[a] Data missing for 115 students employed at follow-up.

Medical Devices Hub

Ivy Tech Community College (Ivy Tech)

The Ivy Tech study examined students' participation in the Biotechnology Associate's degree program. While demographic and background data were available for all students examined in the study (Appendix D), follow-up data on students' credential attainment and post-employment wages were available for 20 percent of the students. Of the total students enrolled in the Associate's degree program, almost two-thirds (64 percent) were ages 26-45 when they entered the program, and 11 percent were employed. As shown in Exhibits 18 and 19, all of the students who obtained an Associate's degree were employed after they earned their degree.

Exhibit 18. Ivy Tech Credential Attainment		
Type of Credential	#	%
Biotechnology Associate's Degree	11	17.2
Missing	53	82.8
Total	64	100.0

Exhibit 19. Ivy Tech Post-Program Employment Status		
Post-Program Employment Status	#	%
Employed	13	20.3
Missing	51	79.7
Total	64	100.0

Salt Lake Community College (SLCC)

The SLCC study examined students' attainment of the Medical Device Manufacturing Processes and Practices Certificate. The target population for this credential was bioscience industry employees and individuals wishing to enter the medical device field. At the time of their enrollment in the certificate program, half (53 percent) of the students were ages 26-45, and approximately half (49 percent) had an associate's degree or higher. Almost all (92 percent) of the students were employed when they began the certificate program.

Students had to complete four courses to attain the certificate. Forty-one percent of the students who enrolled in the program had earned the certificate by the end of the c³bc grant. One-third of the students completed only one course (Exhibit 20).

Pre-post hourly wage data were available for 29 percent of the students. Students who earned a certificate had a higher median hourly wage increase than students who took courses but did not earn the certificate. The median hourly wage change from pre- to post-program employment for students with a certificate was 17.7 percent, while the hourly wage change for students who took courses but did not earn a certificate was 10.7 percent. The percent of change in hourly rate for all students was 14.8 percent (Exhibit 21).

Exhibit 20. SLCC Course Completion and Certificate Attainment

Number of Courses Taken Toward Medical Device Manufacturing Processes and Practices Certificate	Student Course Completion and Certificate Attainment	
	#	%
4 courses / Earned certificate	30	41.1
3 courses	6	8.2
2 courses	13	17.8
1 course	24	32.9
Total	73	100.0

Exhibit 21. SLCC Employment Wage Data[a]

	Baseline Hourly Wage			Post-Program Hourly Wage			Wage Change			
	Mean	Median	Std Dev	Mean	Median	Std Dev	Mean	Median	Std Dev	% Median Hourly Wage Increase
Students with certificate (n=9)	$21.71	$20.00	7.57	$24.55	$23.04	7.86	$2.85	$3.54	7.51	17.7
Students without certificate (n=12)	$29.53	$20.30	30.31	$30.75	$27.40	20.18	$1.22	$2.22	15.98	10.7
All students (n=21)	$26.17	$20.00	23.33	$28.09	$25.51	16.09	$1.92	$2.97	12.80	14.8

[a] Data missing for 52 students.

St. Petersburg College (SPC)

The SPC study examined students' attainment of the Biomedical Equipment Technician (BMET) Certificate that was developed under the c³bc grant and the Medical Quality Systems (MQS) Certificate that was refined as part of the grant's activities. The target population for these certificates included individuals wishing to enter the medical devices industry and those who wanted to advance within the industry. The certificate programs attracted a broad range of students. At the time of entry into one of the certificate programs, over half (57 percent) of the students were ages 26-45, and a quarter (25 percent) were below age 25. Almost a third of the students had a high school diploma or less at entry; a quarter (26 percent) had attended post-high training or college; and 41 percent entered the certificate program with an associate's degree or higher. Almost three-quarters (72 percent) of students were employed at entry into the program.

Almost half (45 percent) attained the BMET, MSQ, or another related certificate offered by SPC. More students (28 percent) completed the BMET certificate than completed the MQS certificate (15 percent) (Exhibit 22).

Exhibit 22. SPC Credential Attainment		
Type of Credential	**#**	**%**
BMET	36	27.7
MQS	19	14.6
Other certificate	3	2.3
Enrolled in courses, no credential	72	55.4
Total	130	100.0

Based on the available data, a quarter (26 percent) of the students was employed after they participated in one of the SPC programs (Exhibit 23). The post-program wage data obtained for 20 percent of the students showed that at entry into the program, the median hourly wage ($14.75) for students who earned a certificate was higher than the median hourly wage ($13.13) for students who did not earn a certificate. By the end of students' participation in the program, the median hourly wage ($16.00) of students who did not earn a certificate was close to the median hourly wage ($16.54) of students who earned a certificate. While both groups' hourly wages had increased after they left the program, the students who did not earn a certificate had a slightly higher median increase (13.3 percent) than students who earned certificates (8.7 percent). The median hourly rate increase for all students who took at least one course was 11 percent (Exhibit 24).

Exhibit 23. SPC Post-Program Employment Status		
Post-Program Employment Status	**#**	**%**
Employed	34	26.2
Missing	96	73.8
Total	130	100.0

Exhibit 24. SPC Employment Wage Data[a]

	Baseline Hourly Wage			Post-Program Hourly Wage			Wage Change			
	Mean	**Median**	**Std Dev**	**Mean**	**Median**	**Std Dev**	**Mean**	**Median**	**Std Dev**	**% Median Hourly Rate Increase**
Students with certificate (n=20)	$15.34	$14.75	$5.36	$16.50	$16.54	$5.72	$1.06	$1.29	$7.71	8.7
BMET (n=13)	$15.58	$15.00	$4.74	$17.67	$17.00	$6.52	$2.08	$1.00	$7.55	
MQS (n=5)	$14.40	$13.40	$8.17	$13.42	$13.30	$2.88	($0.97)	$3.30	$9.93	
Other (n=2)	$16.15	$16.15	$2.66	$16.61	$16.61	$3.70	$0.46	$0.46	$2.07	
Students without certificate (n=6)	$12.54	$13.13	$3.64	$14.34	$16.00	$4.08	$1.80	$1.75	$1.40	13.3
All students (n=26)	$14.70	$13.95	$5.09	$16.00	$16.54	$5.39	$1.23	$1.54	$6.76	11.0

[a] Data missing for 104 students.

Summary of Results from Outcome Studies

The results from the six outcome studies are summarized in Exhibit 25. For the five colleges (MCCC, BCCC, LAVC, SLCC, and SPC) with complete data on educational outcomes, 62.5 percent of students who participated in a program developed or enhanced under the c³bc grant achieved an outcome—completed the program (LAVC); earned a certificate (MCCC, BCCC, SLCC, and SPC); or earned a degree (BCCC). Across all six programs, 60.5 percent of students achieved an outcome. The highest program completion rate (97.9 percent) was at LAVC, whose Biotech Bridge Training Academy used a rigorous screening process involving employers to place students in to the Bridge Academy. The three colleges that developed new courses and new certificates, MCCC, SLCC, and SPC had comparable completion rates for their certificate programs (MCCC—44.9 percent; SLCC—41.1 percent; and SPC—44.6 percent). BCCC, which developed new courses for the AS degree and enhanced the Biotechnology certificate, had a combined completion rate for both credentials of 84 percent.

The small samples of students, except for LAVC, and the large amount of missing employment and wage suggest caution in interpreting the c^{3}bc results for employment and wage increases. However, the trends in the available data are promising. Further systematic data collection using a more rigorous evaluation design and the same methods across programs for collecting employment and wage data are warranted. Overall, 43 percent of students who participated in one or more courses developed under the c^{3}bc grant were employed after they completed their program, certificate, degree, or courses. For the three colleges (LAVC, SLCC, and SPC) that were able to obtain data on students' pre-post program hourly wage increases, the median hourly wage increase for a sample of 75 students was 18.4 percent (Exhibit 25).

Exhibit 25. Summary of Outcomes from Six c^{3}bc Community Colleges

Hub/College	Enrolled in 1 or More Certificate/ Degree Courses	Earned Certificate/ Degree		Employed After Program [a]		Amount of Hourly Wage Increase for Employed After Program [a]			
	#	#	%	#	%	# with Data	Mean	Median	% Change Median Hourly Wage
Biomanufacturing Hub									
Montgomery County CC	78	35	44.9	19[b]	24.4	NA	NA	NA	NA
Bucks County CC	19	16[c]	84.2	7[d]	36.8	NA	NA	NA	NA
Los Angeles Valley CC–Bridge Academy	188	184	97.9	143[e]	76.1	28	$3.23	$3.20	29.4
Medical Devices Hub									
Ivy Tech CC	64	11[f]	17.2	13[g]	20.3	NA	NA	NA	NA
Salt Lake City CC	73	30	41.1	21[h]	28.8	21	$1.92	$2.97	14.8
St. Petersburg College	130	58	44.6	34[i]	26.2	26	$1.23	$1.54	11.0
Total	552	334	60.5	237	42.9	75	$2.13	$2.57	18.4

NA = Not applicable
[a] Includes those who obtained a certificate/degree as well as those who enrolled in certificate/degree courses but did not earn a credential.
[b] Employment data missing for 59 students.
[c] Three students not earning certificate/degree were still enrolled at the end of the c^{3}bc grant.
[d] Eight students were still enrolled in college and four were missing data at the end of the c^{3}bc grant.
[e] Employment data missing for 4 students.
[f] Earned certificate/degree data missing for 53 students.
[g] Employment data missing for 51 students.
[h] Employment data missing for 52 students.
[i] Employment data missing for 96 students.

Conclusions

The findings from Abt's evaluation of the Community College Consortium for Bioscience Credentials provide lessons for community colleges interested in working with employer and industry partners to developing curricula and credentials that are aligned with employer needs and that can result in career pathways for students. The c³bc evaluation also has implications for future workforce and education research.

Lessons from c³bc Evaluation for Future Bioscience Education Capacity Building

The key lessons for community colleges' future work in bioscience education capacity building are:

- **Employer and industry partnerships** with community colleges are the linchpin for developing curricula and credentials that are aligned to employer needs and that provide explicit career pathways for students. Employers and industry representatives should be engaged in the initial planning for the capacity building activity and in all phases of implementation, including specification of areas of curriculum development, design of courses, pilot testing and revision of courses, student recruitment, delivery of courses, development of internships and mentoring programs, and placement of students in employment.
- **Partnerships within colleges** are critical to the development and approval of new curricula and credentials, recruitment of students, counseling of students, and retention and completion of students. The college should be viewed as one institution in which departments work together in support of student completion. College department developing new courses may need to work with other departments in designing courses, identifying employer partners to collaborate in course design and delivery, and in recruiting students. Other college departments may play a role in academic advising and identification of supportive services for students and in developing and approving new credentials, such as offering non-credit and credit courses as part of the credential development process;
- **Partnerships between workforce agencies and community colleges** are important in recruiting and referring potential students to community colleges' new programs and in identifying employment opportunities for students. Of particular importance is colleges' work with Workforce Investment Boards to obtain Eligible Training Provider Status so that students can access Individual Training Account funds for college tuition.
- **The use of the Core Skill Standards for Bioscience Technicians** in developing curriculum for bioscience technicians can ensure that courses have a strong academic foundation and then can be customized to particular technician positions to reflect the needs of individual employers;
- **Pilot testing and revision** are important phases in the development or redesign of curricula. A pilot test phase helps to ensure that the courses operate as planned and are aligned to the academic standards and skill needs of employers. As the complexity of course design increases with co-development with employers and other partners and the incorporation of technology-enabled instruction, multiple iterations of new courses may be needed; and

- **Public awareness and marketing** for new curricula and credentials should begin during curriculum development to build support from employers, workforce agencies, community agencies, and college departments. This support will be critical for recruiting students for new courses and programs and for transitioning students to further education and employment;

Implications for Future Workforce and Education Research

Two important implications for research were identified from the evaluation of the c³bc grant:

- The timeline for TAACCCT grant was not long enough for the colleges to develop, pilot test, and revise new courses, and recruit students to fill the multiple cohorts of classes needed to generate a sufficient sample for the evaluation. For grant programs involving the development of courses beyond the introductory level, a period longer than three years is needed for the development and delivery of services that can be evaluated using a rigorous design; and
- The conduct of an experimental or quasi-experimental study requires the availability of an appropriate control group. In the case of the c³bc grant, the one college redesigning introductory-level science courses met the conditions for a quasi-experimental design. The other colleges designed courses that were unique to the local community and, in some cases, to bioscience, and thus 'business as usual" conditions were not available for these courses. For grants involving specialty courses for which an appropriate control group is not available, various approaches could be considered: One approach to a rigorous evaluation would be to test variations in supports to the courses, such as in advising or retention strategies, to assess the conditions under which the supports for a new course can be effective. Another approach would be to test different structures to internship programs or to mentoring, to assess the effectiveness of these programs in supporting the courses of interest or in facilitating students' attainment of employment.

References

Alamprese, Judith A. (2009). *Shared goals, common ground: State and local coordination and planning to strengthen adult basic education services*. Bethesda, MD: Abt Associates. http://www.abtassociates.com/reports/Alamprese_Shared_Goals_Common_Ground_June_2009.pdf

Battelle/BIO. (June 2014). *State bioscience jobs, investments, and innovation*. Author. http://www.bio.org

Community College Consortium for Bioscience Credentials. (2016). *c³bc medical device skill standards*. Winston-Salem, N.C.: Forsyth Technical Community College. www.bio-link.org/home2/resource/bioscience-skill-standards

Mowery, J. & Carrese, J. (2016). *Core skill standards for bioscience technicians.* Winston-Salem, NC: Forsyth Technical Community College. www.bio-link.org/home2/resource/bioscience-skill-standards

National Research Council (NRC) and National Academy of Engineering (NAE. (2012). Community colleges in the evolving STEM education landscape: Summary of a summit. S. Olson and J.B. Labov, Rapporteurs. Planning Committee on Evolving Relationships and Dynamics between Two- and Four-Year Colleges, and Universities. Board on Higher Education and Workforce, Division on Policy and Global Affairs. Board on Life Sciences, Division on Earth and Life Studies. Board on Science Education, Teacher Advisory Council, Division of Behavioral and Social Sciences and Education. Engineering Education Program Office, National Academy of Engineering. Washington, DC: The National Academies Press. https://www.nap.edu/download/13399

Patton, Madeline. (2008). *Educating biotechnicians for future industry needs*. Washington, DC: Community College Press. http://files.eric.ed.gov/fulltext/ED509574.pdf

Silva, P., Lopes, B., Costa, M., Seabra, D., Melo, A., Brito, E., & Dias, G.P. (December 2016). Stairway to employment? Internships in higher education. *Higher Education*, 72 (6): 703-721. http://hdl.voced.edu.au/10707/420780.

Stuart, E. A. (February 2010). Matching methods for causal inference: A review and a look forward. *Stat Sci*. 25(1): 1–21.

U.S. Department of Labor. (2008). *Bioscience competency model*. www.careeronestop.org/competency model/competency-models/bioscience.aspx

Appendix A: Community College Case Studies

Biomanufacturing Hub

Montgomery County Community College (Blue Bell, Pennsylvania)

Overview of the College

Montgomery County Community College (MCCC), the lead college for the c³bc Biomanufacturing Hub, offers five associate's degrees (Associate of Arts, Associate of Science, Associate of Applied Science, Associate of Fine Art, and Associate of General Studies) and several certificate programs. The college serves students on two campuses and through e-learning opportunities. Nearly 60% of the students are women, and slightly more than one-quarter are ethnic/racial minorities. Nearly two-thirds of credit students are enrolled part time, and 83% live in Montgomery County. The c³bc grant was administered in the college's Science, Technology, Engineering, and Math (STEM) Division.

Regional Needs and Goals for Participating in c³bc

The main goal of MCCC's c³bc grant was to offer hands-on experience with industry-relevant equipment and provide a certificate in Biotechnology and Biomanufacturing to nontraditional students who were displaced, in a career transition, or reentering the workforce to prepare them for high-demand jobs relating to healthcare and biotechnology. The c³bc grant enabled the Biotechnology Program to implement necessary updates to the curriculum, to purchase state-of-the-art lab equipment, to recruit displaced workers, and to expand the program to serve post-baccalaureate students in addition to entry-level students.

In 2011, the Montgomery County and Bucks County regions were home to 10,095 bioscience jobs, and an additional 2,282 were expected by 2021. In 2014, Pennsylvania's concentration of bioscience employment was 10% greater than the national average.[16] As of September 2016, Biological Technician and Medical and Chemical Laboratory Technician remain on the state's list of high-priority occupations.[17] Big Pharma is a large regional industry but has laid off workers in recent years. In the wake of this downsizing, several small and specialized contract research organizations have been created. Many of them seek skilled employees.

Partnerships to Design and Implement Activities to Achieve Goals

MCCC's implementation of the c³bc grant was supported through several partnerships. Staff built on prior relationships to collaborate closely with the c³bc staff at Bucks County Community College (BCCC). Both c³bc teams held a shared vision for the grant, and they jointly developed the equipment list, standard operating procedures, and skill standards for their respective Biotechnology Programs. They also coordinated their job placement activities and their efforts to secure "preferred provider" status from their local Workforce Investment Boards so that more students could obtain funding for Individual Training Accounts (ITAs) from the local CareerLink offices. To obtain preferred provider status, the colleges prepared an application for each course to demonstrate how it related to a high-priority occupation in both counties.

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16 https://www.bio.org/sites/default/files/SP_Pennsylvania.pdf

17 Data retrieved from: http://www.workstats.dli.pa.gov/Products/HPOs/Pages/default.aspx

The c^{3}bc grant staff developed a strong relationship with the local CareerLink office and identified staff at the CareerLink who understood and advocated for MCCC's opportunities for displaced workers interested in biotechnology. As a result of their connection to CareerLink, c^{3}bc staff were invited to present at CareerLink offices, to share information with staff about the Biotechnology certificate, and to leave brochures about the program. CareerLink added the certificate program to its database, and c^{3}bc staff participated in CareerLink's Training Provider Day and Biotechnology Day events. CareerLink and MCCC staff worked closely to help unemployed job seekers obtain ITA funds to support their participation in the certificate program. During the period of the c^{3}bc program, 10 individuals received Workforce Investment Act (WIA) or Trade Readjustment Act (TRA) funding to participate in the certificate program.

MCCC and BCCC jointly hosted several roundtable events that brought together staff of three local CareerLink offices, as well as the deans and other TAACCCT grant staff from each college, industry representatives, and representatives of state and local trade organizations. The curriculum and content of the Biotechnology Programs was shared as well as local workforce needs and procedures for optimizing CareerLink involvement.

Course Development

Content and Process for Development

The c^{3}bc grant funds enabled MCCC to develop the 16-credit Biotechnology and Biomanufacturing Certificate of Completion and to convert three existing biotechnology courses from 3-credit to 4-credit lab/lecture courses. Students can earn the Biotechnology certificate upon successful completion of these three courses—Introduction to Biotechnology, Techniques and Instrumentation for Biotechnology, Biomanufacturing, and the 4-credit Biotechnology Research course. The courses for the Biotechnology certificate were reviewed and approved by the college's Curriculum Committee, a 15-person panel of faculty and administrators, and the Board of Trustees. The certificate was approved by the college, but not by the state since state-approved certificate program must be greater than 30 credits.

The Biotechnology certificate is "stackable," in that students can use the certificate to expand their skills and stack the new credential onto an existing degree. Alternatively, students can build on the 16-credit certificate to earn the 64-credit AAS degree. MCCC also partnered with several 4-year colleges in the region to develop articulation agreements for the AAS degree.

Each core biotechnology course is offered as a classroom-based lab/lecture, where each class session includes a lecture and a hands-on lab activity. The Techniques and Instrumentation for Biotechnology course incorporates several Core Skill Standards for Bioscience Technicians, such as quality, documentation, safety, lab math, pipetting, and solution preparation. Through hands-on lab experience, students are exposed to current good laboratory practices and a variety of techniques. MCCC used c^{3}bc grant funds to acquire state-of-the-art equipment, including an AKTA pure chromatography system, a plate reader, an inverted microscope, two bioreactors, a high performance liquid chromatography system, two tangential flow filtration systems, a NanoDrop spectrophotometer, a GelDoc-imaging system, a top-loading autoclave, a carbon dioxide incubator, and laptops. The c^{3}bc instructor used this equipment to transform the Biomanufacturing course to incorporate activities for students that simulate an industrial environment with Good Manufacturing practices where they can conduct sophisticated experiments and practice developing products in teams.

MCCC developed a virtual training module on downstream processing, which was created in collaboration with vendors, subject matter experts, and local industry (GSK and Novartis). Students performed hands-on activities and processes on site and then used the virtual module to see how the processes were implemented in a large-scale manufacturing environment. The module, which included visuals and text explanations of each stage of downstream processing, supplemented their coursework.

Role of Internships

MCCC's c^{3}bc program staff reached out to local companies to arrange internships that could serve as a bridge from the certificate program to permanent employment. They found greater success developing relationships with smaller companies than with larger ones. However, MCCC's Biotechnology Program Coordinator was able to secure internal grants to support three summer interns at local biotechnology companies Rockland Immunochemicals and Shenandoah Biotechnology. These students, who were mentored by the Program Coordinator and by company scientists, began industry-relevant projects in the college lab and completed their projects in the company labs. The students presented their research at a National Science Foundation Principal Investigator meeting and were later hired by MCCC.

Student Population and Recruitment

Targeted Student Population

The target population for MCCC's Biotechnology certificate was nontraditional students who were displaced, seeking a career transition, or reentering the workforce. Many of the students had bachelor's or master's degrees prior to entering the program, and some had prior work experience. Certificate students had to take Biology and Chemistry as part of the program unless they had successfully completed the courses within the last five years.

Recruitment Activities

MCCC's c^{3}bc marketing materials, which consisted of posters, flyers, and brochures, included references to industry-relevant skills and equipment, as well as information about potential jobs completers of the biotechnology certificate might hold. These materials were disseminated on campus, to the local CareerLink offices, and through professional organizations such as Pennsylvania Bio. The c^{3}bc staff helped host college-wide open houses as well as career transition workshops on campus. They also recruited program applicants through local activities held for displaced workers, for example, by the state Commerce Department and CareerLink.

Student Supports

Advising and Counseling

Each applicant interested in the Biotechnology certificate met with the Biotechnology Program Coordinator, Career Coach, and Project Director to assess his or her prior education and work experience, as well as future educational and career goals. Prospective students received information about program expectations and available funding opportunities. The c^{3}bc staff reported that this advising, which also consisted of developing individualized learning plans and assisting students with enrollment and registration, was important because the student pathways into the program were nontraditional. Students also received career coaching and resume counseling, and were invited to attend biweekly meetings with the Career Coach and office hours with the Program Coordinator to receive guidance and support.

Professionalization Activities

The Biotechnology certification courses included field visits and guest speakers, which taught students about specific aspects of companies and the work they do. Students also participated in a career-readiness workshop, in which local recruiters presented on resume building, the local job market, and how to prepare for job opportunities in the field. Some students also attended the Pennsylvania Bio conference.

Links to Employment

In addition to being advised by c³bc staff, students were encouraged to use the college's Student Success Center services. Students were also informed of job search services offered by CareerLink. MCCC hosted a Biotechnology and Biomanufacturing Career Fair, which was attended by hiring managers of local biotechnology and pharmaceutical companies who met with current and past c³bc program students. The c³bc staff established a LinkedIn group to share biweekly information on job opportunities and interest stories related to biotechnology. MCCC also partnered with Lab Support, a hiring agency that recruits for temporary, permanent, and temp-to-hire positions for a variety of companies. Students were invited for interviews after entering their information into a database, and Lab Support hired three.

Leveraged Activities and Resources

MCCC and BCCC continue to collaborate in developing new Biomanufacturing curriculum. In October 2015, MCCC was awarded renewed funding from the NSF for the NBC2 Advanced Technology Education regional center. Some of the best practices used in the c³bc were included in this proposal. The collaborative round table events will continue on a semiannual basis and the career fair for program graduates and alumni will continue on an annual basis at each of the colleges.

Sustainability

The industry partnerships forged during the c³bc project are continuing and strengthening. New cutting edge curriculum is being created using the state of the art equipment purchased with c³bc funds. This curriculum will continue to be shared with other colleges via the NBC2 website.

Bucks County Community College (Newtown, Pennsylvania)

Overview of the College

Bucks County Community College (BCCC) offers nearly 80 programs of study that lead to an associate's degree or certificate at three campuses and through a Virtual Campus. Each year, the college serves approximately 9,000 credit-seeking students and 70,000 students in non-credit programs. Nearly 60% of the students attend part-time. The study body is predominantly White, with small percentages of Hispanic, African-American, and Asian students. BCCC was a member of the c³bc Biomanufacturing Hub, and the c³bc grant was administered by the college's Science, Technology, Engineering & Mathematics (STEM) Department.

Regional Needs and Goals for Participating in c³bc

The region surrounding BCCC is home to several pharmaceutical and medical and diagnostic testing companies and research institutions. Biotechnology is one of the fastest growing industries in the county, and the Pennsylvania Department of Workforce Development has designated Biological Technician as one of the state's "high priority occupations." In 2011, the Bucks County and Montgomery County regions were home to 10,095 bioscience jobs, and an additional 2,282 were expected by 2021. In 2014, Pennsylvania's concentration of bioscience employment was 10% greater than the national average.[18] As of September 2016, Biological Technician and Medical and Chemical Laboratory Technician remain on the state's list of high-priority occupations.[19]

The Biotechnology Program at BCCC launched in 2008, partly in response to requests that industry partners made to community colleges to help upgrade the skills of lab technicians. BCCC's objective for participating in c³bc was to increase enrollment in its Biotechnology Program and refine its courses with relevant curriculum and updated lab equipment.

Partnerships to Design and Implement Activities to Achieve Goals

Under c³bc, staff at BCCC expanded the Biotechnology Program's 10-member advisory board to include additional regional companies. Board members meet annually at BCCC to provide feedback on course content, course requirements, and curriculum. Members represent some of the region's large pharmaceutical companies, small biotech companies, local universities, and a forensic testing lab. Throughout the grant period, c³bc staff met with leaders and hiring managers to discuss regional employment and internship opportunities, as well as employer needs.

The c³bc staff worked with the college's Center for Workforce Development to facilitate outreach to local biotechnology employers in order to assess the local biopharmaceutical industry's need for biopharmaceutical training courses and the use of BCCC biomanufacturing equipment and laboratory facilities. The center supported efforts of c³bc staff to obtain approval as a preferred provider for training from the Bucks County CareerLink Center.

Once BCCC secured "preferred provider" status from the CareerLink Center, students were able to qualify for Individual Training Account (ITA) funding. BCCC staff held information sessions for CareerLink staff to learn about its Biotechnology Cell and Tissue Culture Certificate. During the early implementation phases of c³bc, BCCC launched a partnership with the CareerLink Center to identify strategies for recruiting Trade Adjustment Assistance and displaced workers and for identifying local bioscience employers that could be connected to job seekers with relevant skills. Jointly, c³bc and CareerLink staff assessed candidates' eligibility for the certificate program.

BCCC partnered with Montgomery Community College, a fellow member of the c³bc Biomanufacturing Hub, to organize roundtable meetings of local education, industry, and workforce groups to discuss a regional partnership to address employment and training needs of local bioscience companies.

Course Development and Certificate Enhancement

Content and Process for Development

BCCC offers an occupational degree (AS) in biotechnology, in which students complete 61–63 credits. It also offers a Biotechnology Cell and Tissue Culture Certificate, a 16-credit occupational certificate students earn after completing four courses: Chemistry I, Biotechnology Methods and Techniques, Cell and Tissue Culture, and Biomanufacturing. All courses are offered in traditional classroom settings.

Prior to c³bc, BCCC offered an Applied Biotechnology course, which focused on research skills, but the college did not have adequate equipment to ensure the course was industry relevant. With the support of

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18 https://www.bio.org/sites/default/files/SP_Pennsylvania.pdf

19 Data retrieved from: http://www.workstats.dli.pa.gov/Products/HPOs/Pages/default.aspx

the c³bc grant, the course was transformed to include a lab component where students use grant-purchased lab equipment for upstream and downstream processing, including bioreactors and liquid chromatography systems. Faculty drew on published skill standards from Texas and Washington as well as content from the c³bc Hubs, to update their courses. The college's curriculum committee reviewed and approved the newly named Biomanufacturing course. The Cell and Tissue Culture Certificate was updated to include the Biomanufacturing course. The c³bc grant funds also facilitated the revision of the Introduction to Biotechnology course, which is not part of the four-course certification sequence.

BCCC's c³bc -supported faculty infused industry-relevant developments, concepts, and techniques into their courses. For example, the laboratory manager from a local laboratory company assisted c³bc staff in aligning the Biomanufacturing course curriculum with industry best practices, and scientists from the same company provided technical assistance to the college's faculty as they developed a course module on small-scale production of monoclonal antibodies from hybridoma cell lines. As part of the course, students visit the company to see the production of hybridoma cells in a larger-scale industry setting. Content of the Cell and Tissue Culture course draws on current industry standards and practices.

The Biomanufacturing course was developed in coordination with c³bc staff at Montgomery County Community College.

Articulation Agreements

BCCC and Thomas Jefferson University in Philadelphia established an articulation agreement to allow BCCC students to transfer bioscience credits there and pursue either a 4-year degree or a combined BS/MS degree in the biotechnology field.

Student Population and Recruitment

Targeted Student Population

BCCC's AS in Biotechnology degree is intended for recent high school graduates, or students with limited science background. Most students in the program often have some work experience in non-scientific areas and the typical age of students in the degree program is 23–25. Students with bachelor's degrees and or some previous lab experience typically enroll in the Biotechnology Cell and Tissue Culture Certificate program.

To complete the Biotechnology certificate and degree programs, students must complete four core biotechnology courses. These core courses have college algebra as a pre-requisite or a score of at least 7 on the math section of the Accuplacer placement test. The Accuplacer test is an admission requirement for all BCCC students. In addition, students referred through the CareerLink Center are required to score at least "Silver" on the WorkKeys® exam and show an aptitude for working in a laboratory setting.

The c³bc staff reported these prerequisites presented challenges to some students interested in studying biotechnology and have found that often students without previous background in the sciences have to enroll in developmental math courses in order to fulfill the college algebra prerequisite and complete the biotechnology core courses. To assist students with these challenges, the college provided access to a free science learning center and tutoring services on campus to provide supplemental instruction and academic support to students.

Recruitment Activities

The c³bc staff engaged in multiple student recruitment efforts, many of which were in partnership with other college departments. The c³bc staff attended New Student Orientation, hosted a Biotechnology Open

House and laboratory tours, and collaborated with the BCCC's Office of Admissions to reach out to local high schools. They also provided its Academic Advising Office and the call center with information about the Biotechnology Program that could be shared with current and prospective students. The program also updated the college website to provide prospective students and employers with up-to-date information on the contents of the AS degree and Biotechnology Cell and Tissue Culture Certificate.

Student Supports

Advising and Counseling

BCCC now requires all students, including part-time students, to meet with advisors to register for courses. Since this requirement was updated to include part-time students, c^{3}bc staff reported they were better able to advise students about their sequence of courses. The c^{3}bc staff created a map for each major in the department to help students plan their program of study.

Links to Employment

BCCC's Biotechnology Program's AS degree and certificate do not require internships. During the grant period a few students were able to get additional laboratory experience by assisting biotechnology faculty with special laboratory-based projects on campus. The c^{3}bc staff also provided its students with one-on-one career coaching support. As students completed the degree and certification programs, staff met with them to share job searching tools, advise them on how to tailor their resumes to relevant job postings, and conducted mock interviews. Staff also partnered with the college's Career Services Office to recruit bioscience employers to participate in the BCCC annual Career Fair.

Leveraged Activities and Resources

The Northeast Biomanufacturing Center and Collaborative (NBC2) received another 3-year NSF-ATE grant, NBC3. The c^{3}bc partnership was a strong synergistic effort with the NBC2 and allowed members of the Biomanufacturing Hub to leverage curriculum for its NSF grant. The biotechnology programs were also supported by BCCC's Carl D. Perkins Funds for Career Technical Education. Perkins funds were used to purchase additional upstream processing and bioanalytical equipment.

Los Angeles Valley College (Los Angeles, California)

Overview of the College

Los Angeles Valley College (LAVC), a member of the c^{3}bc Biomanufacturing Hub, is a 2-year college that serves nearly 20,000 students. The college offers more than 140 associate's degree programs and certificates, including Associates of Arts, Associates of Science, and Skills Certificates, and many courses are available online or in hybrid formats. The college is a Hispanic-serving institution, meaning the largest percentage of students is Hispanic, followed by White. Approximately 70% of LAVC students attend part-time, and it enrolls more women than men (57% and 43%, respectively).

The college's Workforce Department led the c^{3}bc-supported Biotech Bridge Training Academy, while the Biotech Certificate program was co-led by the Biology Department and the Workforce Department. The c^{3}bc grant was administered by the Workforce Department, which also administers two other nationally recognized programs—the LA Fellows and METRO Training.

Regional Needs and Goals for Participating in c^{3}bc

The Los Angeles area has an extensive biomanufacturing industry and many medical device companies. In 2011, the area had 12,012 bioscience jobs, and an additional 4,225 were expected by 2021. It also had the third largest national market for lab skills employment at the time. The state experienced a 5% increase in bioscience employment from 2007 to 2012.[20] In December 2014, Los Angeles County projected the number of workers employed as Medical and Clinical Laboratory Technicians and as Environmental Science and Protection Technicians (Including Health) would increase by nearly 30% over 2012–2022, while the number employed as Biological Technicians and as Chemical Technicians would increase by 15% and 6%, respectively, over that same period.[21]

The college's 6-week Biotech Bridge Training Academy was designed in 2009 to help students learn core skills and competencies to fill manufacturing technology positions in the bioscience industry. LAVC, with encouragement from the local workforce investment board, used the c³bc grant for two initiatives: (1) expand the existing Bridge Academy to better meet local employers' needs and (2) develop a two-semester Biotech Certificate program to provide experienced workers with specific biomanufacturing skills.

Partnerships to Design and Implement Activities to Achieve Goals

The Biotech Bridge Training Academy was highly customized to the needs of local companies, and LAVC staff reported they created it by first understanding those employer needs and then working backward to develop training modules to meet them. Two local employers, Baxalta (now Baxalta-Shire Shire) and Grifols Biologicals Inc., partnered with LAVC to screen Academy applicants. The two also interviewed students once they successfully completed the Academy.

In addition to employer engagement, LAVC developed new and leveraged existing relationships with local workforce development partners to expand the Biotech Bridge Training Academy. The local Workforce Investment Board and One-Stop Centers referred unemployment applicants; Community Career Development, a non-profit that operates local WorkSource Centers and One-Stop Centers, helped enroll students and tracked their progress and placement after they completed the Academy. LAVC staff visited the WorkSource Centers to share information about the Biotech Bridge Training Academy. The state's Employment Development Department also partnered with LAVC by referring Trade Adjustment Assistance (TAA) recipients to the college and the Academy.

The Southern California Biomedical Council (SoCal Bio), a non-profit, member-supported trade association, operates an industry advisory board and assists with program outreach to employers and potential Bridge Academy participants. SoCal Bio was instrumental in involving LAVC in the cob grant, and it has been an advisor throughout the grant period.

Course Refinement and Development

The Biotech Bridge Training Academy is a 6-week program that includes several non-credit courses, each of which lasts 3–4 days. Under cob, all courses were designed with employer input and were geared toward the workplace. The Bridge Academy targets skills and operations needed for Manufacturing Technician 1 positions, and it added emphasis on basic math and science skills based on feedback from students and employers. At the request of employer partners, the Math course covered topics such as ratios, proportions, decimals, rounding, word problems, and the metric system, each grounded within examples and contextualized to the workplace. Under the c³bc-supported Academy, students also

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20 https://www.bio.org/sites/default/files/SP_California.pdf

21 Data retrieved from: http://www.labormarketinfo.edd.ca.gov/data/employment-projections.html

participated in Blood Basics and Fractionation courses and were required to participate in a lab component designed to help them get comfortable there and provide hands-on experience to apply theories learned in course lectures.

In addition to content-focused courses, the Biotech Bridge Training Academy included an Employability and Attitude course. The material for this course was slightly tailored to each student cohort, but was generally consistent across cohorts. In this course, students were taught to research the companies they were applying to and to think about why they would want to work at each one. Instructors discussed professional dress and body language, as well as workplace communication and conflict. Emotional intelligence and team-building skills were also covered. Students also received supports in resume writing, personal branding, and interviewing.

The Biotech Certificate program requires students to take five credit-bearing courses, which can typically be completed in two semesters. They are Fundamentals of Biomanufacturing and Biotechnology; Biomanufacturing 1; Biomanufacturing 2 or 3; Environmental Control and Support Processes; and Quality Control and Validation. Like the Bridge Academy courses, the courses for the Certificate program were designed with employers in mind, but they are also applicable to other degree programs offered by the college and by other colleges in California. The courses within the Certificate program were approved by LAVC's faculty senate for transfer to California State University schools. Developed under c^3bc, the courses included a combination of lectures and hands-on activities, each with an emphasis on relatable, everyday information and examples from the workplace. With the support of the c^3bc, course materials and training procedures were developed to incorporate the newly acquired equipment, including biochemistry analyzer, autoclave, liquid chromatography, air sampler, centrifuge, and incubator, into the curriculum.

Student Population and Recruitment

Targeted Student Population

The Biotech Bridge Training Academy targeted displaced workers (including TAA recipients), Veterans, and workers with relevant degrees who had difficulty finding employment. Local employers such as Baxalta and Grifols advertised the Biotech Certificate opportunity to current employees. Additionally, program graduates who were hired out of the Biotech Bridge Training Academy at Baxalta returned for Employment Training Panel (ETP) training during facility shutdowns to upgrade their skills with for credit classes and workshops contextualized for the industry. Some LAVC students enrolled in other programs at the college also participated in the Academy.

LAVC staff and representatives from local employers jointly participated in screening applicants to each Academy cohort. Potential students were invited to an orientation session that provided an overview of the logistics of Manufacturing Technician jobs, including salary, hours, working conditions, and primary functions. They also were required to complete the Reading and Math sections of the Comprehensive Adult Student Assessment Systems (CASAS) and to write a three-paragraph essay about their interest and commitment to enter the biotech field. Applicants who passed the CASAS and essay were invited to attend a workshop on resume writing and basic interviewing skills, and to later participate in interviews with the partner employers. Interviewers screened for past experience, ability to work on a team, and willingness to work in cold, wet environments.

The Biotech Certificate program recruited TAA workers as well as graduates of the Bridge Academy. Current employees of regional companies were also targeted.

Recruitment Activities

LAVC used several recruitment strategies for the Biotech Bridge Training Academy and Biotech Certificate program, including outreach to local employers, workforce development agencies, and universities. Staff met with the representatives from the state's Employment Development Department to make it aware of the programs, and they held workshops and information sessions at WorkSource, America's Job Centers, and Rapid Response sites. They also distributed informational brochures and flyers to local libraries, food banks, and non-profit organizations, and they conducted direct outreach to applicants who sought employment and training assistance through CalJobs. Staff visited LAVC Biology classes and they updated the Bridge Academy Twitter account daily to generate interest in the program. Staff also participated in recruitment efforts at local events held for Veterans.

Student Supports

Advising and Counseling

The Bridge Academy coursework provides students with counseling on job search and interviewing skills, and LAVC staff meet informally with students, including to help them prepare for job interviews. The staff work closely with students throughout the Bridge Academy to support their completing the program and to prepare them to transition to employment in the biotechnology field.

As students complete the Bridge Academy, they are counseled as to whether they should consider continuing their education in the Biotechnology Certificate program and the potential value of earning the credential.

Links to Employment

LAVC has worked closely with local employers since before the c^3bc grant award, and employers have been actively involved during the grant period. As noted above, Baxalta and Grifols in particular have worked closely with the program and its staff. At the Bridge Academy graduation ceremony for each cohort, Baxalta and Grifols representatives have been speakers to signal to students their support for the program.

Leveraged Activities and Resources

Based on the demonstrated success of LAVC's Bridge Academy and the work accomplished through the c^3bc grant, LAVC was awarded grant funding to continue offering the Biotech Bridge through the use of National Emergency Grant (NEG) funds through June 2017. The purpose of this grant award is to provide industry-focused workforce services, including training and placement to the long-term unemployed, recipients of unemployment insurance and returning veterans. Additionally, the c^3bc project director was also designated by the Workforce Development Board as a sector strategist for the bioscience and biotechnical industry. The goal of this grant is to bring all the local workforce development boards together to pull information for a regional plan to serve local businesses and provide pipelines of job-ready candidates.

Lab Skills Hub

City College of San Francisco (San Francisco, California)

Overview of the College

The City College of San Francisco (CCSF), a member of the c^3bc Lab Skills Hub, is a 2-year community college that serves more than 85,000 students (credit and non-credit) at the main campus and nine centers.

Students can earn AA or AS degrees or certificates in more than 50 academic programs and 100 occupational disciplines. Nearly one-third of CCSF students are Asian, and Hispanic and White students each make up one-fifth of the student population. The college has a Metro Academy that supports cohorts of students to work toward transferring to 4-year institutions, and many students also pursue a certificate as they earn credits toward their degrees.

The c³bc grant was administered by staff in the college's Biotechnology Program, which is housed within the Engineering and Technology Department.

Regional Needs and Goals for Participating in c³bc

The Bay Area is home to a large number of biotechnology companies, and University of California–San Francisco is the largest local employer in biotechnology. In 2011, the Bay Area housed 6,672 bioscience positions, and an additional 2,385 were anticipated by 2021. The area also had the fifth largest national market for lab skills employment at the time. The state experienced a 5% increase in bioscience employment from 2007 to 2012. In December 2014, the number of jobs in the San Francisco area as a Biological Technician was projected to increase by 31% over 2012–2022; Medical and Clinical Laboratory Technician and Environmental Science and Protection Technician (Including Health) jobs were projected to increase by 23% and 22%, respectively; and Chemical Technician by 18% during that same time.

After a long history of administering a BioLink Center grant from the National Science Foundation (NSF), CCSF applied for c³bc grant funding to refine and develop courses and programs within the Biotechnology Program. The primary goal of its c³bc project was to develop the Environmental Monitoring, Sampling, and Analysis (EMSA) program. EMSA courses prepare students to enter the environmental field in positions such as Water Quality Technician, Environmental Technician, or Water Operator in public or private companies or government agencies. Graduates will earn an EMSA Certificate, once approved.

The c³bc grant also supported enhancements to the college's Bridge to Biosciences, originally launched by SFWorks, before the program was transferred to CCSF in 2007. The Bridge to Biosciences program was funded through various Carl Perkins and NSF grants for several years. It includes courses and an internship to provide hands-on training in research laboratories, leading to a Biotech Lab Assistant Certificate.

Partnerships to Design and Implement Activities to Achieve Goals

CCSF's Biotechnology Program had an Advisory Committee that provided guidance on the development of the EMSA program and on the enhancements to Bridge to Biosciences. The committee included local industry representatives as well as a representative from Region 9 of the U.S. Environmental Protection Agency (EPA). The committee provided feedback on courses and what types of jobs might be appropriate for students in Biotechnology and EMSA.

Each summer, faculty from the Biotechnology Program worked with faculty in CCSF's Biology and Chemistry Departments to update or add new content to the courses that comprised Bridge to Biosciences.

Course Development

Monitoring, Sampling, and Analysis (EMSA)

The EMSA program included four courses that give a foundation to environmental science as well as to teach students to use professional-grade, EPA-certified instruments to evaluate, test, and analyze water, soil, and air for contaminants. A short course included a speaker series where professionals from industry, public utilities and governmental agencies presented their jobs, their career paths, and educational requirements. Skills covered in the program included those used by public utility employees as well as technicians at other small businesses in the Bay Area.

The courses that students in the EMSA program must complete were Introduction to Environmental Science; Foundations in Environmental Instrumentation, Sampling, and Monitoring; Environmental Microbiology Methods; Introduction to Geographic Information Systems (GIS); and Environmental Speaker Series. The c³bc funds supported the development of the Foundations in monitoring course, the environmental microbiology course as well as the environmental speaker series. An environmental monitoring specific unit was included in the GIS course. The grant also supported the development of an Environmental Toxicology course. Courses within the EMSA program focused on developing transferrable skills, as opposed to preparing students for a specific job or job type. The Foundations course covered sampling methods that align with EPA standards, calibration of field instruments, and documentation, including chain of custody for samples, and its credits were transferrable to California State University schools. The Environmental Microbiology Methods course taught several skills that align with the methods used by the EPA, including serial dilutions and calculations and detection and enumerations of microbes; its credits were transferable to University of California schools as well as California State University schools. A Water Quality Analysis and Anion-Based Chromatography course used the program's ion chromatography machine according to EPA methods. In the Sustainability and the Environment speaker series, which was offered as an elective course, students learned about career and education paths from hydrologists, lab analysts, chemists, and engineers.

Students participating in the c³bc-supported EMSA courses had the opportunity to support small-scale environmental monitoring projects undertaken by local community-based organizations (CBOs). In collaboration with CBOs, students learned to write project and sampling plans. Included in those plans were objectives to monitoring, how and what to sample, analytical methods used as well as results to the analysis. These project-based learning opportunities gave students real-world objectives and monitoring experience. Additionally, their work was part of the larger scope of EPA's volunteer monitoring programs as well as citizen science. The Biotechnology Program secured approval for the EMSA Certificate.

Bridge to Biosciences

The Bridge to Biosciences program provided training and support to students to develop careers in the life sciences. The program was offered in two phases. The first phase included classroom training; an internship and job preparation followed in the second phase. All Bridge courses were taken for credit and transferrable to the AS degree and as elective credits to the state's 4-year colleges.

The c³bc grant supported enhancements to its Career Exploration in Science course, which taught students how to find out more about local job opportunities and apply for internships. During the semester, students learned about various science careers through informational interviews and guest speakers. At a student-run science conference held at the end of each semester, the Bridge's BioSymposium, students network with scientist and others already working in the field while presenting posters on areas-of-interest they researched, listening to panel discussions, and participating in mock interviews.

The CCSF Bridge to Biosciences program included a 180-hour internship and a concurrent internship support class designed to prepare students to enter careers in laboratory science. Students were required to interview with internship sites, which included research and development labs, government agencies, and local companies working in regulatory affairs. Some students were hired by employers after they successfully completed their internships.

Students concurrently enrolled in a Biotechnology Internship Experience course while they completed their internships. In this course, students learned about the expectations for completing their internship and how to maximize what they got out of the experience. Throughout the semester, students discussed their internship experiences and prepared a scientific poster to present at the Bridge's BioSymposium. They also contributed to weekly blogs to practice writing about what they were doing and learning. Guest speakers and former students were invited to speak to students enrolled in the class, and students also had opportunities to discuss job searches and resumes with staff from a local employer. As an additional support to interns, the instructor for this class conducted site visits with mentors and interns to discuss and assess the intern's learning objectives.

Mentoring For Success

CCSF used c³bc grant funds to develop the Mentoring For Success (MFS) program, which offered training geared toward lab managers and post-doctoral students who were hosting student interns as part of the Bridge to Biosciences internship program. MFS was designed to ensure the mentoring experience was mutually rewarding for both mentor and intern, with the goal that mentors and Bridge Internship coordinators eventually serve as co-educators for the interns. MFS consisted of one introductory session and another six sessions during the internship. During the introductory session, potential mentors engaged in activities to describe why they wanted an intern, the kinds of projects or tasks the intern would work on, the characteristics of the ideal intern candidate, and questions they would ask interns during interviews. Following this session, the mentors interviewed the interns.

Prior to the internship, interns participated in a 6-hour Internship for Success Boot Camp. The boot camp helped students/interns in resume writing and interviewing skills as well as understanding their role and expectations as interns. During the internship, while students attended the internship support course, mentors attended MFS sessions that covered topics such as setting goals with interns, fostering their independence, helping interns work with diversity, approaching conflict, and handling successes and challenges. Mentors and interns completed surveys in the middle of the semester and again at the end of the semester to assess progress toward meeting goals and expectations for the internship.

Student Population and Recruitment

Recruitment Activities

To recruit students, CCSF prepared flyers, handouts, and presentations for local organizations, such as Veterans Affairs, Goodwill, and the Jewish Community Center. Open House and Open Lab events were also used to attract students to the Biotechnology Program, and staff participated in 1-day orientations where students completed placement tests, orientation, and meetings with counselors. Biotechnology staff also offered a workshop at Frisco Day, an annual event for local high school students.

Because local public utility unions offered training courses for Environmental Technicians, CCSF encountered some difficulties recruiting students for its EMSA program. The college formerly recruited through the state's Employment Development Department and through partnerships with local community-based organizations, but it found many of those they served were seeking immediate employment, not training.

Student Supports

Students at CCSF took a placement test and spoke with a counselor when they applied to the college, and they were invited to attend orientation sessions. There was no official application for the Bridge to Biosciences program, which meant students often signed up for courses without having spoken to program staff.

Once in the Bridge program, students often met with the Biotechnology Program's counselor, who was trained to help them navigate the financial aid process. When given the opportunity, the counselor asked students about their backgrounds and their current life circumstances in order to help them choose the course of study that made the most sense for them.

Sustainability

Among the things that would facilitate the institutionalization of EMSA at CCSF are: (1) faculty member to continue the program under career technical education, who would keep up with labor market indexes, hold annual advisory board meetings, have continuous outreach and recruiting, and obtain funding for supplies and reagents and the upkeep of instruments; (2) Inclusion of the program in a collaborative so that students can find courses in the environmental science and sustainability easier; and (3) Continued outreach to industry partners, industry trade group organizations, and non-profit organizations so that students are able to network and find internships or jobs with those organizations.

Most of the improvements made to the Bridge to Biosciences program over the course of the c³bc grant have been fully integrated into the program structure and will continue to be implemented.

The Mentoring For Success program is an exciting new expansion of the Bridge to Biosciences program; it will help the Bridge staff work together more closely with industry professionals to understand what is needed to train entry-level workers successfully and should significantly improve workplace learning for students. CCSF will continue to develop this initiative with the guidance and support of the Bio-Link Center.

Austin Community College (Austin, Texas)

Overview of the College

Austin Community College (ACC), a member of the c³bc Lab Skills Hub, is a 2-year college that serves approximately 53,000 credit and non-credit students per year on its 11 campuses. ACC offers more than 100 fields of study and it awards Associate of Science, Associate of Arts in Teaching, and Associate of Applied Science degrees, as well as Associate of Applied Science degrees and numerous certificates in workforce programs. Approximately 21% of the students are enrolled full-time, and more females than males (55% and 45%, respectively) attend ACC. White and Hispanic students make up the largest majority of students (45% and 30%, respectively). ACC's c³bc grant was administered by the college's Biotechnology Department, which offers workforce programs.

Regional Needs and Goals for Participating in c³bc

Texas's bioscience industry grew nearly 7% from 2007 to 2014.[22] In 2011, Austin had 2,085 jobs in the biosciences, with an estimated 1,137 more openings predicted by 2021. Labor projections for the Capital Area estimated the number of workers employed as Medical and Clinical Laboratory Technicians would

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[22] https://www.bio.org/sites/default/files/SP_Texas.pdf

increase by 35% over 2012–2022, while the number employed as Chemical Technicians, as Environmental Science and Protection Technicians (Including Health), and as Biological Technicians would increase by 27%, 26%, and 21% respectively.[23]

Given Austin's small, but steadily growing biotechnology industry, ACC saw an opportunity to contribute to the growing workforce through the c3cbc grant by offering courses to provide lab skills and medical device training for entry- and mid-level technicians. In addition to c³bc, ACC was awarded two other DOL TAACCCT grants, supporting the college's simultaneous expansion into additional fields in health sciences and information technology. The c³bc grant provided resources to develop courses in biomanufacturing and medical devices, while also providing opportunities for students to master content knowledge along with lab skills and "soft" skills valued by employers. ACC's c³bc -supported program provided students with opportunities to pursue various career options as they earned stackable credentials.

Partnerships to Design and Implement Activities to Achieve Goals

ACC's c³bc program implementation depended on several collaborative partnerships. Staff reported cross-collaboration between the Biology, Chemistry, Physics, and Biotechnology Departments to develop course content and connections to industry partners for various certificate programs offered by the college. ACC faculty and students also benefitted from participation at the Texas Life-Sciences Collaboration Center (TLCC), a local non-profit organization that seeks to recruit and retain biotechnology and life-sciences companies. The TLCC provides internships for students, classroom space for ACC courses, and opportunities for ACC life-sciences faculty to consult for companies working on projects there.

ACC's c³bc grant activities were supported by the Biotechnology Department's advisory group composed of representatives from 15–20 biotechnology and medical device companies in the Austin area. The advisory group met twice per year to provide advice on curriculum and relevance of courses offered through c³bc. Several participating companies hosted tours for ACC students and expressed willingness to offer internship opportunities.

The college's c³bc staff met with the Executive Director of Texas Workforce Solutions (WFS) to seek preferred provider status for the college's biotechnology programs. However, they were unable to obtain the designation because biotechnology is recognized as a growing industry, but not one that has enough demand to justify WFS expending resources on biotechnology placements for job seekers. ACC staff also presented information to WFS job seekers to make them aware of what the college and local biotechnology industry offer individuals seeking employment or additional training.

Course Development

Course Content, Development, and Certificates

ACC students in biotechnology can earn the Level-One Certificate, the Level-Two Certificate, the Advanced Technical Certificate, or the Associate of Applied Science degree. Prior to c³bc, the various levels of study existed, but were not organized in a career pathway. With support from the grant, ACC developed stackable credentials that offer students multiple entry and exit points. Students who complete only one semester of courses can successfully earn the Level-One Certificate, at which time they may exit the program or continue.

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[23] Data retrieved from: http://www.tracer2.com/publication.asp?PUBLICATIONID=830

The Level-One Certificate provides students with skills to prepare them for jobs such as basic cleaning, organizing, sample intake, and setting up samples. After completing Introduction to Biotechnology I and II and Quality Assurance for the Biosciences, students earn the Level-One Certificate. The Level-Two Certificate prepares students to become a technician, which is a step above a filling job, and to possibly work in development or quality control positions. The Advanced Technical Certificate is designed for students who have a 4-year degree but want to obtain a research technician position.

Under the c^{3}bc grant, ACC modularized the Biotechnology I and II courses (required of all biotechnology students) and experimented with offering both accelerated and non-accelerated versions of the courses. The modules were designed to build on one another, and students were required to pass a test after each module before advancing to the next. The introductory courses incorporate algebraic concepts, so students no longer need to complete Algebra as a prerequisite for Biotechnology I. Biotechnology I was revised to be more workforce focused, and it now includes more speakers, industry tours, and career exploration activities. Biotechnology II focuses on conducting assays and writing regulatory paperwork and standard operating procedures (SOPs), and it includes opportunities for students to practice "soft" skills required for the workplace, such as working together, communicating, meeting deadlines, and showing up on time. Since c^{3}bc launched, Biotechnology I and II were successfully added to the state's *Academic Course Guide Manual* and can now be articulated across the state of Texas for undergraduate degree programs.

The c^{3}bc funds were used to modularize the Molecular Techniques course (required for students seeking an AAS degree, Advanced Technical Certificate, or Level-Two Certificate) and the Instrumentation course (required for students seeking an AAS or Advanced Technical Certificate). ACC also used the c^{3}bc funds to update Quality Assurance for the Biosciences as an online course and to develop the Bioinformatics course (required for students seeking the AAS or Advanced Technical Certificate).[24]

After students complete Introduction to Biotechnology II, they must pass a biotechnology placement exam before enrolling in upper-level courses within the department. This placement exam, which includes lab skills and a hands-on assessment, is designed to ensure students have a practical understanding of the field before they proceed with coursework. Students who do not pass the placement exam can still earn the Level-One Certificate.

The Introduction to Biomanufacturing course, which is offered as part of the Level-Two and Advanced Technical Certificates, was designed to provide students with skills needed for their internships (see below), including reading manuals and writing SOPs. The course was developed with support from c^{3}bc and a Wagner-Peyser grant. ACC designed the course because many small-scale manufacturing companies needed employees to conduct technician and data collection work.

When developing the biotechnology programs and certificates, ACC analyzed the needs of the growing biotechnology industry and then made efforts to match the curriculum to them. Nearly half of its instructors were recruited from industry. ACC mapped the Level-One Certificate to various skills standards—national (BioLink), statewide (Texas Skills Standards, TSSB), and local (Texas Essential Knowledge and Skills, TEKS)—to ensure all required skill standards were being covered and aligned.

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[24] ACC surveyed industry partners to explore development of a Bioinformatics Certificate, but determined there was not a need for a certificate program at the time.

Biotechnology I now includes additional safety exercises, while Biotechnology II was revised to add more inventory control exercises and to teach students how to operate and clean a sterile hood, conduct inventory control, and complete regulatory documentation.

Role of Internships

Candidates pursuing the AAS or the Advanced Technical Certificate are required to complete an external internship as part of their program requirements. After earning the Level-Two Certificate, students can elect to complete an internal internship, which can provide them with additional training before seeking employment or an external internship.

Before students begin an external internship, they complete a workshop on resume writing and interviewing. ACC gives companies a manual describing expectations for mentoring and the process for evaluating students during and at the end of the internship. Students also receive a manual on how to safely participate in internship activities. At the end of their internship, students present posters to other students and industry partners to share their internship experiences. ACC's c³bc staff assist with matching students for external internships to ensure a good fit, especially since these internships frequently lead to an employment offer.

Student Population and Recruitment

Targeted Student Population

ACC's biotechnology certificate programs tend to attract individuals with bachelor's degrees or with work experience who seek technical skills training. Many students enroll in the certificate programs to obtain hands-on experience valued by employers. Some students enroll in the courses through the continuing education program, but complete the internship for course credit.

Recruitment Activities

Recruitment activities for ACC's biotechnology program have included classroom visits to the college's biology and chemistry classes and offering workshops to students and industry representatives. Staff met with other colleges to recruit students for the introductory courses (Biotechnology I and II), and they presented to ACC counselors and at professional meetings and conferences. The program was also advertised on the job listings page of Craigslist and to the local workforce investment board.

Student Supports

ACC students receive counseling before and during their enrollment in the biotechnology courses to ensure they are taking them in the right progression. Instructors in the introductory courses support students with developing resumes as part of their courses, and they meet with student individually to provide counseling on internship and job placement opportunities. Faculty also supported students' connections to industry through inviting them to attend networking events. ACC's Biotechnology Club provides students with leadership experience and arranges industry tours to expose students to careers at local companies.

Leveraged Activities and Resources

ACC successfully used the c³bc grant to leverage additional funding and support for the college's Biotechnology Department. The college secured a $4.9 million Emerging Technology Fund (ETF) grant from the state of Texas. In addition to the modifications made under c³bc to improve the Biotechnology I and II courses, ACC partnered with local high schools to offer the Level-One Biotechnology Certificate there. The curriculum was modified to fit the budgetary and time constraints of high school classrooms and to include more career exploration lessons with specific links to local industry.

ACC has also investigated developing a summative assessment for Level I High School students that would be modeled after the Biotechnician Assistant Credentialing Exam (BACE) administered by Biotility at The University of Florida's Center of Excellence for Regenerative Health Biotechnology.

Sustainability

While implementing c³bc, ACC recognized a need for a Medical Device and Biomedical Engineering Technician program to respond to the growing number of employers, including a new medical college, dependent on medical device technicians. Several employers expressed a need for incumbent worker training, and industry partners completed surveys and provided feedback at advisory group meetings to guide the development of the courses and overall program. With the support of leveraged Wagner-Peyser grant funds for equipment and curriculum development, ACC will continue to design that program

Medical Devices Hub

Ivy Tech Community College (Bloomington, Indiana)

Overview of the College

Ivy Tech Community College, lead for the c³bc Medical Device Hub, has 32 degree-granting locations in Indiana, serving more than 170,000 students each year. Ivy Tech offers more than 150 programs in the divisions of Health, Technology, Business & Public Services, and University/Transfer. The college offers more than 1,000 online classes. Nearly two-thirds of the students attending Ivy Tech are White and more are women than men. The c³bc grant was administered by the Biotechnology Department within the School of Technology at the Bloomington campus.

Regional Needs and Goals for Participating in c³bc

Indiana experienced a 12% increase in jobs in research, testing, and medical labs from 2007 to 2012, and it is among the top 10 states in the number of life science workers.[25] The Bloomington region was home to 428 bioscience jobs in 2011, and an additional 117 were anticipated by 2021. The number of Medical and Clinical Laboratory Technician jobs was projected to increase by nearly 24% over 2012–2022, while the number of Biological Technician jobs would increase by nearly 18%, and Environmental Science and Protection Technician (Including Health) and Chemical Technician jobs by some 15–16% during that same time period.[26]

Ivy Tech pursued the c³bc grant to refine courses for the Regulatory Affairs Concentration Certificate, so its curriculum included an emphasis on medical devices, and to develop courses in plastics to support training aligned to the needs of local industry employers.

Partnerships to Design and Implement Activities to Achieve Goals

Ivy Tech had a history of partnering with Cook Medical and its sister companies Cook Pharmica and Cook Polymer Technology to provide employee training prior to the c³bc grant. After the grant, its activities were informed by industry input, and industry professionals taught some of the courses

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25 https://www.bio.org/sites/default/files/SP_Indiana.pdf

26 Data retrieved from: Downloaded from: http://www.hoosierdata.in.gov/FD/overview.aspx

developed with grant funding. For example, an employee from Cook Medical conducted a gaps analysis for four courses and provided recommendations to further align courses with the Medical Device Skill Standards of the Community College Consortium for Bioscience Credentials and with the requirements of the Regulatory Affairs Certificate (RAC), an industry-recognized medical devices/pharmaceuticals credential awarded when students completed a RAC exam administered by the Regulatory Affairs Professionals Society (RAPS). Recommendations included focusing on medical device concepts, in addition to pharmaceutical concepts, in the Regulatory Affairs courses, as well as incorporating more projects and writing-based exercises.

Leadership of the c^3bc Medical Device Hub

One of the major accomplishments of the c^3bc grant was the development of the first skill standards for entry-level technicians within the medical device industry. This effort was led by Dr. Sengyong Lee, Professor and Chair of the Biotechnology Department at Ivy Tech. Prior to the release of this first set of skill standards, states adopted different approaches to credentials, employers were challenged with understanding the skills and qualifications of job applicants, and educators had difficulty aligning the skills taught and credentials offered with ones valued by employers. Biotechnology employers and educators recognized the need for industry-recognized credentials and collaborated through an iterative process to carefully develop the Medical Device Skill Standards mentioned above.

In collaboration with Salt Lake Community College and St. Petersburg College, Ivy Tech led the 3-year development process, which began with a review of the job titles and skills requirements of job openings at local medical device companies. Educators met with representatives from medical device manufacturers to understand the importance of certain skills for entry-level positions. Ivy Tech compiled the skills identified by five colleges (Mount Wachusett and Anoka-Ramsey in addition to the c^3bc colleges) and met with subject-matter experts and industry professionals to further narrow them.

Ivy Tech convened a group of Medical Device Hub partners, comprising 21 educators and 21 industry representatives, for five meetings over 2013–2016. At the first Hub meeting, partners met in small groups to refine the list of workplace functions and associated attributes necessary to perform them, narrowing the core skills to five main functional areas: regulatory affairs, engineering, manufacturing, quality, and instrumentation. Hub members convened a second time to identify the level of competency needed for each skill and knowledge item in the draft standards and to formulate ideas for assessing skills using actual work-based examples. At the third and fourth meetings, Hub partners validated the skill standards and shared assessments. The resulting Medical Device Skill Standards are organized by five critical work functions, each accompanied by key activities, performance indicators, underlying knowledge, and sample assessments. The standards were presented at an industry conference in February 2016, where educators and industry leaders described the process for developing the standards and provided examples of how they have themselves used the standards to enhance their training courses and programs.

The Medical Device Hub's education partners have drawn on the Skill Standards to develop and/or revise existing courses, modules, certificates, and degrees. In addition to the four Regulatory Affairs courses revised by Ivy Tech (see below), St. Petersburg College and Salt Lake Community College used the Skill Standards to develop new courses, and Austin Community College staff used the Skills document as a "backbone" when developing the curriculum for its new medical device manufacturing program. Many of the materials created based on the Skill Standards are freely available through the clearinghouses NTER (National Training & Education Resource), SkillsCommons Repository, and Bio-Link.

Course Development

Regulatory Affairs Courses

Ivy Tech began developing Regulatory Affairs courses in 2008, when Cook Medical identified a need for training for recent college graduates hired as the company expanded. The courses were initially tailored to Cook employees and prepared them to take the RAC exam. The c^3bc grant enabled the college to redesign the courses to align with the Medical Device Skill Standards, to incorporate industry feedback, and to satisfy Indiana's certificate approval process. The courses were revised to include additional medical device content and include case study simulations in which students engage in hands-on exercises, explore the application of regulatory law, and answer scenario questions. The Biotechnology Department offered five, 16-week credit-bearing Regulatory Affairs courses: Survey of Regulatory Affairs; Food and Drug Law; Clinical Trials; Risk Management of Drugs and Medical Devices; and Product Life Cycle. To earn the Regulatory Affairs Concentration Certificate, students must also have completed an English Composition course and a Technical Writing course. The certificate was not industry recognized, but was recognized statewide as a career development certificate, thereby allowing students to qualify for financial aid.

All five of Ivy Tech's Regulatory Affairs courses were offered online using the Quality Matters platform. The college partnered with Anoka-Ramsey Community College in Minnesota to share online courses. Course sharing allowed the colleges to combine student enrollments numbers so they had sufficient enrollment to hold courses, share instructors, and avoid delaying graduation for students in need of specific courses.

Plastics Courses

With the support of the c^3bc grant, Ivy Tech developed three plastics courses: Introduction to Plastics; Injection Molding; and Extrusion Processes. Each course was 16 weeks long and worth three credits. The impetus for developing these courses was the increasing number of medical device manufacturing companies using plastic materials. The purchase of injection molding and tubing extrusion equipment supported Ivy Tech's plastics training. The plastics courses were offered as electives in the Industrial Technology Program, and they focused on plastics processing that is relevant to both automotive and medical device industries. Although Ivy Tech did not offer a certificate for the plastics courses, the courses provided students with skills to apply for Technician jobs with local industry employers.

Courses and Modules in a "Box"

Through its work with the Medical Device Hub, Ivy Tech recognized an opportunity for hub partners to share materials they developed using the Medical Device Skill Standards. To date, three courses and two modules have been developed—Ivy Tech developed the courses Quality Practices, Metrology, and Product Life Cycle; Mount Wachusett Community College in Massachusetts developed two modules on Root Cause Analysis. Each virtual "box" included downloadable materials for an instructor to teach a course. Materials, which can be freely downloaded from NTER and SkillsCommons, include syllabi, lesson plans, lectures, lab notes, slides, assignments, assessments, and a crosswalk between the items in the Skill Standards and course content, as well as recommended credentials for instructors, prerequisites for students, equipment and supply lists, and instructions to format the course for online delivery. Each of these "Courses in a Box" represented the use of the new Skill Standards either to create a new course or to update sections or modules of existing courses.

Student Population and Recruitment

Targeted Student Population

Ivy Tech's Regulatory Affairs courses targeted incumbent workers, especially employees in the medical device industry who wanted to learn more about regulatory affairs. High school graduates who are interested in regulatory affairs were also eligible to take the courses and earn the Regulatory Affairs Concentration Certificate.

Recruitment Activities

Students were recruited through Biosciences Career Education Open House events, and the college conducted ongoing recruitment efforts with regional high schools. A marketing brochure was prepared to advertise the Regulatory Affairs courses and certificates to employers and associations. Staff also promoted the program and certificate to the college's academic advisors and in presentations at meetings of the Medical Device Manufacturers Association. Cook Medical and its sister companies created an "Achieve Your Dream" program that allowed employees to enroll in eligible programs and courses; Cook covered the tuition for courses that were not financial aid eligible.

Salt Lake Community College (Salt Lake City, Utah)

Overview of the College

Salt Lake Community College (SLCC), a member of c³bc's Medical Device Hub, is Utah's largest college. SLCC serves more than 60,000 students each year on 10 campuses and through online courses. The college offers 120 areas of study and awards Associates of Science, Associates of Applied Science, Associates of Arts, and Associate of Pre-Engineering degrees, as well as certificates. The majority of students who attend SLCC are White, followed by Hispanic, Asian, and Black students; and equal numbers are women and men. The college's Biotechnology Program developed the content for the Medical Device Manufacturing Processes and Practices Certificate, while the Continuing Education Division administers the courses. The c³bc grant was administered collaboratively by the two entities.

Regional Needs and Goals for Participating in c³bc

Life science companies make up a large percentage of Utah's economy, with more than 100 focusing on medical devices. In 2011, the Salt Lake City area was home to 2,804 bioscience jobs, and an additional 1,161 were expected by 2021. Between 2007 and 2012, Utah's employment within the bioscience industry grew by 17 percent.[27] In the Salt Lake City region, the numbers of Biological Technician, Chemical Technician, and Medical and Clinical Laboratory Technician jobs are projected to increase by approximately 4% over 2012–2022, while the number of Environmental Science and Protection Technicians (Including Health) jobs is projected to increase by nearly 3% during that same time period.[28]

The c³bc grant provided an opportunity for SLCC to build on prior relationships with Ivy Tech Community College and Forsyth Tech to respond to requests from local employers to provide training for their employees and to develop a pipeline for future ones. The Medical Device Manufacturing Processes and Practices Certificate provided core knowledge and skills needed to be successful in the medical device industry. Training was useful to current employees and also prepared workers for entry-level

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27 https://www.bio.org/sites/default/files/SP_Utah.pdf

28 Data retrieved from: http://jobs.utah.gov/wi/pubs/outlooks/saltlakecity/index.html

positions such as Assembly Technician, Calibration Technician, and Quality Control/Quality Assurance Technician.

Partnerships to Design and Implement Activities to Achieve Goals

The Biotechnology Program partnered with the Continuing Education Division to develop the new program because of the latter's track record in acquiring seed money to develop new programs, certificates, and degrees and in moving those programs to sustainability. Members of the Continuing Education Division also leveraged their relationships with Utah's Department of Workforce Services to promote the Medical Device Manufacturing Certificate program. They met with agency representatives to provide an overview of the program and gave them brochures and flyers to share with workers seeking training and/or employment in the medical device field.

SLCC's Medical Device Manufacturing Processes and Practices Certificate was designed to respond to industry demands for short training courses (as opposed to lengthy semester-long courses), and employers were involved in several aspects of developing the program. With the support of the c^3bc grant, the college hosted a Developing a CurriculUM (DACUM) event with employers to develop the curriculum. Employers informed course content by answering questions about what they would expect new hires to be able to do. This process revealed that many employers were looking for training to help workers transfer what background experience and skills they already had to the medical device field.

SLCC's c^3bc staff initially used the Biotechnology's Program Advisory Council (PAC) to solicit feedback on the Medical Device Manufacturing Certificate but later created a new PAC that included representatives from the biomanufacturing, biotechnology, and medical device industries. The PAC played an important role in SLCC's decision about which courses to develop beyond the four core certification courses. SLCC originally had planned to develop courses that focused on additional skillsets, but later decided to develop courses that focused on quality control and quality auditing. Members of the PAC were interviewed to inform the topics covered in the additional courses, and some provided materials and content for them. More recently, the PAC was convened to discuss transitioning the courses to competency-based modules.

Course Content and Process for Development

Medical Device Manufacturing Certificate

SLCC students earn the Medical Device Manufacturing Processes and Practices Certificate after successfully completing four core courses: Introduction to the Medical Device Industry; Basic Manufacturing Skills; Introduction to Food and Drug Administration (FDA) Regulations; and Introduction to Quality Systems. Each certification course is 8 weeks long and totals 24 hours of instruction. Students can take these as non-credit courses through the Continuing Education program and thus are not required to go through the college's admissions and placement processes. The certificate can be converted to 5 of the 65 credits required for the AS and AA degrees in Biotechnology for matriculated students.

Content for each of the certification courses was designed to reflect the Consortium's Medical Device Skill Standards, which emphasize basic skills such as measurement skills, data analysis skills, and identification of non-compliance skills. Early feedback from students and industry partners prompted SLCC to recruit instructors who were within the medical device industry. To support these instructors, SLCC staff helped them understand adult learning theory and provided feedback on how to improve their course content and delivery. Some of the courses were going to be offered online, and SLCC had instructional designers who assisted instructors develop interactive course activities and assignments. Instructors incorporated their own content expertise and knowledge of manufacturing processes, invited students to share their workplace experiences, and featured guest speakers from local industry. Some courses included tours of medical device manufacturers and emphasized the application of skills in specific jobs within industry. Instructors used pre/post surveys of student learning outcomes for each course to inform and revise the curriculum, as needed.

Additional Industry Preparation

In addition to the four Medical Device Manufacturing Certificate courses, SLCC offered additional courses toward helping students prepare for the American Society for Quality (ASQ) certification: Introduction to Quality Control; Quality Auditing Concepts, in conjunction with an in-house run STUDENTfacturED® internship.

SLCC's STUDENTfacturED® organization is a manufacturing-centered company run by students and supported by its Biotechnology program. By offering a mentored and supportive yet real-world working and learning business enterprise environment, the STUDENTfacturED® program lets students practice concepts and skills acquired through accompanying coursework and exploit educational benefits gained through project-based learning. This training strategy is especially important to the successful and effective comprehension of quality systems and FDA regulations. The goal of the STUDENTfacturED® enterprise is to prepare students, using contextual and practical training, for jobs in biotechnology manufacturing companies.

Student Population and Recruitment

Targeted Student Population

Students who participated in SLCC's Medical Device Manufacturing Certificate program varied in age (from late 20s to 50s) and in prior experience. Some were unemployed and looking to enter the medical device industry; others were industry employees or employees at companies preparing to transition to it.

Recruitment Activities

Recruitment for the program heavily depended on endorsement from employers, who were able to help students understand why they should participate. Two local employers offered their employees incentives for participation—BioFire Diagnostics strongly encouraged its lower-level employees to attend the courses to increase their promotion opportunities, while ATL Technology offered 1% pay raise for each course its employees completed.

Additional recruitment activities included distributing flyers and marketing materials to students on campus and in the larger community. Staff in the Biotechnology and Continuing Education Departments participated in various open houses, career fairs, and expos to advertise the program. They also presented to managers at individual companies as well as local ASQ meetings. SLCC also used social media to advertise the program.

Student Supports

Links to Employment

The staff working the c³bc grant worked with employers to promote internal advancement opportunities for students participating in the Medical Device Manufacturing Certificate.

St. Petersburg College (St. Petersburg, Florida)

Overview of the College

St. Petersburg College (SPC), a member of the c³bc Medical Devices Hub, offers Bachelors of Arts, Associates of Arts, Associates of Science, and Associates of Applied Science degrees, as well as professional, vocational, technical, and advanced technical certificates. The college has 12 campuses/centers. In school year 2014-15, it had approximately 44,000 credit enrollees and nearly 13,000 non-credit enrollees. Less than one-third (28%) of students were enrolled full-time. Both the full- and part-time student populations comprised more women than men (55% full-time, 63% part-time) and were mostly White (66% full-time, 64% part-time), with another 10–15% Black and Hispanic each. Part-time students generally were older than full-time students. The c³bc grant was administered in the college's Engineering Technology Department at the Clearwater Campus.

Regional Needs and Goals for Participating in c³bc

SPC's participation in c³bc was due, in part, to its previous work with national partner colleges on a National Science Foundation grant through which the Medical Quality Systems certificate was developed to support a growing local medical device industry. In 2011, the Tampa- St. Petersburg-Clearwater region was home to 2,503 bioscience jobs, and an additional 804 were expected by 2021. In 2012, Florida had the second largest number of medical device companies registered with the U.S. Food and Drug Administration, and bioscience was one of the fastest growing industries in the region. There was increasing demand for employees who understood medical technology manufacturing and servicing, yet very few Florida colleges offered programs to fill that need. In 2012, SPC was the only college in Florida offering a specialized Medical Quality Systems certificate. Only three other colleges in the state offered the Associate in Science in Biomedical Engineering Technology (BMET) degree, which combined produced fewer than 100 graduates per year. Locally, there were no programs producing biomedical technicians, making it difficult for medical device manufacturers and hospitals to fill all their entry-level positions. Understanding that industry need, SPC set as its goal for participating in c³bc to develop programs producing recognized and stackable medical device and related-industry credentials, including the Biomedical Equipment Technician Certificate and the AS in Biomedical Engineering Technology.

In 2014, Florida was home to nearly 79,000 jobs in the bioscience industry, spanning nearly 5,500 businesses.[29] In September 2016, labor projections for the state of Florida estimated the number of workers employed as Medical and Clinical Laboratory Technicians would increase by 24% over 2015-2023, while the number employed as Environmental Science and Protection Technicians (Including Health) and Chemical Technicians would increase by 15% each, and the number employed as Biological Technicians would increase by 8%.[30]

Partnerships to Design and Implement Activities to Achieve Goals

SPC's c³bc staff developed and leveraged several partnerships—both within and outside of the college—to develop and implement activities to achieve the c³bc goal. Prior to developing the BMET program, the c³bc Program Director visited local employers such as hospitals and medical device manufacturers to observe their operations and discuss skills gaps and workforce needs. From these connections and from

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29 https://www.bio.org/sites/default/files/SP_Florida.pdf

30 Data retrieved from: http://www.floridajobs.org/labor-market-information/data-center/statistical-programs/employment-projections

relationships with local, regional, and state professional organizations, c^{3}bc staff created an Industry Advisory Council for the BMET program, whose members provided guidance on curriculum development, degree structure, and certification design. Some members have taught courses at SPC, providing students with access to instructors with current industry knowledge and expertise. In addition, the Program Director solicited feedback from employers on performance of the program's interns and used the information to refine course content.

Members of the Industry Advisory Council were instrumental in connecting SPC to other businesses and in getting students involved in local professional associations, such as the Florida Biomedical Society and the Bay Area Association of Medical Instrumentation. Employer engagement was thought to be a key factor in generating interest in the BMET program and for fostering its success.

Despite establishing successful partnerships with some organizations, SPC's c^{3}bc Program Director encountered challenges in her early attempts to include the local CareerSource in efforts to identify potential students. In time, however, Career Source became an active partner, hosting informational sessions for students that highlighted its services, including listings of paid internships, job skills workshops, employer networking, and resume development.

SPC's c^{3}bc Program Director worked with other departments on campus to ensure the BMET program was interdisciplinary, and she specifically targeted the departments of Health Sciences, Business, and Computer Science to offer courses for BMET students because those courses prepare students for industry-recognized credentials and were expressly requested by employers. In addition, the BMET program was aligned with the most recognized national industry certification for biomedical technicians—the CBET® (Certified Biomedical Equipment Technician). Upon completing the program's new BMET associate's degree, students will be prepared to obtain the CBET and two other national industry certifications—the CAPM® (Certified Associate in Project Management) and the Comp TIA A+ for PC computer service technicians accredited by the ISO (International Organization for Standardization) and ANSI (American National Standards Institute).

In order to quickly launch the BMET program while waiting for course and degree approvals from the college, the program partnered with SPC's Workforce and Continuing Education division. Through this arrangement, students began taking non-credit courses in the Corporate Training Department, with the understanding that during the wait, students would be able to earn some credits toward an AS degree for their participation. The courses offered through the college's Workforce Institute culminated in the non-credit Biomedical Equipment Technician I certificate, which is recognized as the acceptable credential for entry-level technicians.

Prior to the c^{3}bc grant the College had no institution-wide policy or process for articulating non-credit courses to credit courses. The extensive work done during the c^{3}bc project to include this process in the degree prospective for regional accreditation led to the articulation process defined under the grant as the "college-wide model for non-credit to credit articulation." The process is under review for approval as a college policy.

Course Development

Standards and Content

The c^{3}bc Program Director reported that course development took time because few BMET courses existed. In developing the BMET program, SPC followed Florida's State Curriculum Framework for the Associate in Science in Biomedical Engineering Technology degree and national certification standards;

it also reviewed the curriculum of the three other BMET programs in the state, as well as various out-of-state programs.

In creating courses, SPC's c³bc designers referenced the National Core Standards for BMET, as well as the Core Competencies for the Biomedical Equipment Technician of the International Biomedical Equipment Technician Association. When SPC began developing the BMET associate's degree program, as opposed to a certificate program, the Program Director checked for alignment with industry standards and renamed some courses to be more recognizable to employers. While the Medical Device Hub standards were more suited for medical device manufacturing, the state's framework for the degree program provided sufficient guidance. Where the Medical Device Hub standards were applicable, SPC incorporated them into its curriculum and specified them in course outcomes.

The program's courses include instruction on equipment currently used in the biomedical device field, and students are taught how to use, inspect, maintain, and repair that equipment. Students with workplace experience are sometimes invited to present and teach their peers about equipment they use in their workplaces. The courses also expose students to project management techniques, software, and vendor/manufacturer certifications.

Internships and Other Connections to the Profession

Internships are considered important for SPC students, enabling them to experience a hospital environment. They reinforce understanding of customer service protocols, promote the development of competence in working on professional teams, and provide a "live" environment before entering a job working with technology that is connected to real patients. Hospital clinical engineering departments are sometimes hesitant to host inexperienced interns, largely due to liability concerns. Florida state law also requires employers to pay interns, so internship positions depend on the employer's budget priorities.

To address these concerns, SPC developed a standardized internship with clearly defined student and employer expectations. Interns also enroll in a Field Experience course that provides an instructor/mentor who oversees the student's internship experience. Because the internship is not required until the final semester of the degree, and many students are able to get hired with the certificate courses, internships tend to be carried out at the student's place of employment. Students also complete a Special Topics course. This online course prepares students for the CBET exam and is usually taken with the internship, furthering the student's career preparation. Neither the Field Experience nor Special Topics course is included in the BMET certificate; rather the certificate includes only the core workforce courses. However, both the Field Experience and the Special Topics course are required for the AS degree. While an internship has not been a prerequisite for employers, it is considered to be a valuable work experience.

SPC students explored medical device careers by attending employer-hosted activities at Con-Med, Lakeland Regional Medical Center, Oscor, AeroSonic, Philips Health Care, BayCare Health System, NASA, and Bovie Medical. Local employers invited students to attend company-sponsored trainings provided by equipment manufacturers, providing them an opportunity to interact with vendors and potential employers. Students were encouraged to participate in professional associations and state and local conferences, as part of their process of building a career. In addition, the Lead Faculty (hired to take on the Program Director's current role) was able to provide students with access to its national conference (Tampa, June 2016), which was covered as part of the student fees.

Credential Development and Approval

SPC's degree approval required extensive internal submission and reviews. Internal review by the Curriculum Committee and the Vice President of Academics was followed by review by the Board of Trustees, which approved the proposal. Next, the Florida Department of Education reviewed the proposed degree for compliance with the State Curriculum Framework, made final recommendations, and then approved the degree prospectus to proceed. Last, SPC sought approval from the Southern Association for Colleges and Schools (SACS), the college's regional accrediting body.

By the end of the grant period, SPC had approved the new interdisciplinary AS in Biomedical Engineering Technology (BMET) degree, which includes an embedded CAPM certification and preparation for both the CBET and Comp TIA A+ certificates. Students can earn the BMET degree in 2 years (6 semesters). All final signed documents were completed for the approval of the BMET-AS in September 2016.

Student Population and Recruitment

Targeted Student Population

The BMET degree program allowed for open enrollment, and students could take the college's general education courses at the same time they were taking the introductory core courses. There is a recommended academic pathway for students who come out of high school and a pathway for students who already have degrees. Students' previous credits can transfer (if applicable), and there is a 4-semester pathway where students with existing degrees can receive the AS degree 2 semesters earlier. Conversely, SPC offers two bachelor's degrees to which students can articulate the BMET-AS. These are Health Services Administration, and Technology Development and Management.

Recruitment Activities

SPC's academic advisors assisted with student recruitment for c^{3}bc-developed courses, and the c^{3}bc Program Director created presentations for the advisors so they could learn about the certificate and be able to refer students to the program as appropriate. She also periodically attended meetings with the advisors to update them on the progress of the certificate and degree programs. In addition to outreach and partnership with the college's academic advisors, SPC's student recruitment activities included a Career Exploration Night, promotional videos, outreach to high school students, employer outreach, career fairs, and open houses.

Student Supports

In an effort to increase program retention, the c^{3}bc program required pre-program enrollment advising for students. After students enrolled in the certificate program, they received ad hoc counseling from the c^{3}bc program staff to make sure they were on track to meet the program requirements. Students used *My Learning Plan* to complete an interest inventory, to keep track of required courses, and to register for courses. Prior to *My Learning Plan*, the c^{3}bc team created documents to help students map their academic pathway. The Introduction to Biomedical Engineering course includes a career-planning component, including what it means to be certified versus not certified in BMET. Students also created resumes and conducted mock interviews in this course.

Through the c^{3}bc grant, staff assisted students with job placement by connecting them with potential employers familiar with the program. Many employers in the region use temporary agencies with the intention of hiring the workers if they perform well during their temporary assignment. The program's Industry Advisory Council included a representative of one of the area's frequently used temp agencies.

Through it SPC partnership, BayCare Health System held a 2-hour orientation for all students completing the program and it later hired some students.

Leveraged Activities and Resources

c³bc's Director reportedly leveraged additional donations of equipment and training. For example, one industry vendor delivered a technical training for which it typically charged $2,000 per participant; but the partner donated free seats in the training for 40 SPC students and one instructor. The partner also provided the students with a 2-year certificate of completion, as well as donated two pieces of equipment with a lifetime parts and service guarantee.

Learning Technologies Hub

Forsyth Technical Community College (Winston-Salem, North Carolina)

Overview of the College

Forsyth Technical Community College (Forsyth Tech), the TAACCCT grantee for the c³bc grant and the lead college for the c³bc Learning Technologies Hub, offers more than 200 programs of study leading to degrees and certificates. The college offers courses at two campuses, multiple centers, and online. Forsyth Tech serves approximately 13,000 credit students, 42% of whom are enrolled full-time. Slightly more than one-half of students are White and nearly one-third is Black. The student population is 60% women. The c³bc grant initially was administered by the college's Instructional Services Division and then was transferred to the Economic Workforce & Development Division.

Regional Needs and Goals for Participating in c³bc

The state of North Carolina experienced a 7% increase in jobs in bioscience from 2007 to 2012, and the state's concentration of employment in the bioscience industry is 41% greater than the national average.[31] The Winston-Salem region was home to 760 bioscience jobs in 2011, and an additional 266 are anticipated by 2021. In the Central region of North Carolina, the number of Medical and Clinical Laboratory Technician jobs is projected to increase by nearly 39% over 2012–2022; the numbers of Biological Technician (nearly 12%), Environmental Science and Protection Technicians (including Health) (9%), and Chemical Technician (6%) jobs also are projected to increase over the same time period.[32]

Several factors led to the development of the Community College Consortium for Bioscience Credentials (c³bc), including Forsyth Tech's leadership in biotechnology workforce development. The National Center for Biotechnology Workforce (NCBW) was created in 2004 through a grant to Forsyth Tech under the U.S. Department of Labor's (DOL) High Growth Grant Initiative. The NCBW operated until September 2008 and, on October 1, 2008, the NCBW became an affiliate of the North Carolina Community College System's BioNetwork—a statewide biotechnology training and educational initiative. The NCBW exists through a cooperative agreement between DOL, Forsyth Tech, and BioNetwork. With DOL's TAACCCT award to Forsyth Tech in 2012, the NCBW became the operational site for the c³bc activities. The NCBW is also home to the Bioscience Industry Fellowship Program (BIFP), which is supported through a National Science Foundation Advanced Technological Education

[31] https://www.bio.org/sites/default/files/SP_North_Carolina.pdf

[32] Data retrieved from: http://www.nccommerce.com/lead/data-tools/occupations/projections/prosperity-zones/piedmont-triad-central-region

(ATE) award. The BIFP is a four-week observational and hands-on fellowship program for instructors, which is held in Winston-Salem, NC during June. The program provides an immersion in North Carolina bioscience, including exposure to educational institutions, training facilities, laboratories, classrooms, and industrial sites.

Forsyth Tech's planning for the c³bc grant involved work with the Manufacturing Institute of the National Association of Manufacturers and meetings with bioscience industry executives and educators to delineate the activities that would be conducted by the c³bc college partners. These activities included the harmonization of core skills and competencies across bioscience subsectors of laboratory skills, biomanufacturing, and medical devices; development of stackable credentials to assist displaced workers in securing employment, and the design of new approaches for technology-based learning to increase access and success in community college biosciences programs.

Partnerships to Design and Implement Activities to Achieve Goals

As part of its c³bc grant, Forsyth Tech partnered with Herbalife and the North Carolina Community College System to create a customized training program for Herbalife's employees. The training program, which also leveraged Economic Development funds granted by the state, included online bioscience training in good manufacturing practice; safety; Occupational Safety and Health Administration regulations (10-hour); and preparation for the National Career Readiness Certificate. Forsyth Tech also provided leadership training and American Society for Quality training for Herbalife employees. Herbalife increased salaries for employees who successfully completed the first level of training through Forsyth Tech.

Forsyth Tech's Biotechnology Program convened an Advisory Group twice per year. The Advisory Group included industry representatives, including those whose companies host Forsyth Tech students through the college's cooperative education program. These leaders provided feedback on the overall academic program and whether the students they hosted had gained the appropriate skills and content knowledge from their Biotechnology courses.

Course Development

Online Courses

Forsyth Tech used the c³bc grant funds to invest in the development of online, modularized courses in Biology, Chemistry, Anatomy and Physiology, and Biotechnology and for the new Science Skills Laboratory. Creation of these courses was driven by a desire to offer flexible course and laboratory schedules to students who might not otherwise be able to participate. Online course materials replaced traditional textbooks, making the courses more affordable. Forsyth Tech developed the courses using preexisting outlines, North Carolina's course-level learning objectives, open-source materials, and original materials created by Subject Matter Experts (SMEs). Each module consisted of online assignments and an in-person lab; modules were built of combinations of "granules," which could include text, video, images, animation, audio, self-assessments, and practice activities. These modules and granules could be combined in various ways.

All course content was available to students online via BlackBoard or Odigia, and instructors provided opportunities for students to ask questions and post blog materials through the course site. Members of the college's Instructional Design team supported SMEs to create granules to help students better understand and complete course content in a self-paced environment. Strategies for course design included presenting information in multiple formats and developing engaging materials to support mastery-level learning. Students were assessed at the end of each module, and students were required to pass one module before advancing to the next. As students completed the requirements for each competency-based module, they could seek assistance from instructors during labs or online.

Content from the modules also was offered to students enrolled in traditional face-to-face courses. Some instructors experimented using the materials in a “flipped” classroom format, in which students reviewed content in the modules prior to class and then engaged in active learning exercises during class. Forsyth Tech plans to continue modularizing courses offered by the Biotechnology, Life Sciences, Human Biology and Chemistry Departments.

Science Skills Lab

To accompany the online courses, Forsyth Tech used c^3bc grant funds to open the Science Skills Lab (SSL) to allow students to complete lab activities on a flexible schedule in a supervised setting. Students who accessed the SSL included working students, displaced workers, stay-at-home parents, Early College students, and those who preferred self-paced learning. The SSL could simultaneously serve students from multiple courses, and students signed up to complete their labs during extended evening and weekend hours.

After students reviewed and were comfortable with the online course materials, they reviewed videos, lab handouts and other supporting materials on the corresponding lab before signing up to complete the lab. The videos included animations or SME demonstrations to illustrate the use of lab equipment or specific techniques. Students also had access to lab equipment manuals and safety information documents. Lab documents and instructions guided students in completing each lab assignment, which included data analysis and interpretation after the SSL activity. In addition to lab instructors, students had access to tutors who could help them understand course content. After completing an assignment, students completed a competency assessment that covered course concepts and lab applications from the course module.

Student Population and Recruitment

Targeted Student Population and Recruitment Activities

Forsyth Tech recruited displaced workers to its Biotechnology Program through the One-Stop Centers, the state’s Division of Workforce Services, the Urban League, Goodwill Industries, and various Veterans groups. Staff from the c^3bc program attended meetings held by the local workforce investment board and contacted its staff for assistance as needed.

Student Supports

Students interested in earning a degree in the biosciences met with the college’s Biotechnology Program staff to learn about the biotech industry and to assess their interest and skills in math and science. Students who declared a major within the Biotechnology Department were encouraged to meet with the Retention Manager for the Math, Science, and Technologies Division to develop an individual learning plan, which included SMART academic goals, study skills and strategies for time management, and challenges and possible solutions to perceived barriers. During the last semester of their program, students were encouraged to speak with faculty about their resume and local job opportunities within their field of study.

Forsyth Tech used Starfish Retention Solutions software to identify students in need of academic and/or social supports. Students thus flagged were encouraged to meet with their instructors and the Retention Manager to address challenges with attendance, academic performance, and other factors.

Appendix B: Baseline Equivalence

Students in Forsyth Tech's treatment and comparison groups were closely matched on baseline characteristics (Exhibits B.1 and B.2).

Exhibit B.1. Comparison of Means on Background Characteristics, Students Participating in the Propensity-Score Match for Biology 111

Student Characteristic	Mean or Percent Treatment (n=218)	Mean or Percent Comparison (n=340)	Difference of Means	p-value
Age	24.2	23.7	0.5	0.511
Female	70%	66%	4%	0.413
White	56%	53%	4%	0.443
Asian	3%	2%	1%	0.523
Black	27%	31%	-4%	0.399
Hispanic	9%	7%	2%	0.476
More than One Race	2%	2%	0%	1.000
Race Missing	3%	6%	-3%	0.149
Prior Ed: Grad Degree	0%	1%	-1%	0.157
Prior Ed: BA	5%	3%	1%	0.459
Prior Ed: AA	7%	4%	3%	0.134
Prior Ed: One Year Diploma	4%	4%	0%	0.805
Prior Ed: HS	66%	65%	1%	0.841
Prior Ed: GED	6%	8%	-1%	0.577
Prior Ed: Less than HS	13%	16%	-3%	0.412
Employed Full-Time	21%	19%	2%	0.634
Employed Part-Time	29%	25%	5%	0.282
Disabled	1%	1%	0%	0.654
CPT Algebra Score	31.36	27.07	4.29	0.226
CPT Algebra Score missing	52%	59%	-6%	0.178
CPT Arithmetic Score	39.12	35.3	3.82	0.362
CPT Arithmetic Score missing	50%	56%	-6%	0.180
CPT Reading Score	43.56	43.54	0.02	0.997
CPT Reading Score missing	51%	53%	-1%	0.774
CPT Sentence Skills	44.73	44.65	0.08	0.986
CPT Sentence Skills missing	52%	53%	-1%	0.848

Notes: Propensity weighted means and percentages are shown. Differences and p-values were calculated in propensity-weighted linear regression models with the student characteristic as the dependent variable, and the treatment indicator as the independent variable.

Exhibit B.2. Comparison of Means on Background Characteristics, Students Participating in the Propensity-Score Match for Chemistry 131

Student Characteristic	Mean or Percent Treatment (n=97)	Mean or Percent Comparison (n=107)	Difference of Means	p-value
Age	28.7	28.0	0.7	0.621
Female	77%	76%	1%	0.866
White	69%	57%	12%	0.075
Asian	0%	0%	0%	1.000
Black	19%	23%	-4%	0.480
Hispanic	7%	13%	-6%	0.158
More than One Race	4%	6%	-2%	0.519
Race Missing	1%	1%	0%	1.000
Prior Ed: Grad Degree	2%	2%	0%	1.000
Prior Ed: BA	14%	12%	2%	0.675
Prior Ed: AA	14%	13%	1%	0.837
Prior Ed: One Year Diploma	8%	10%	-2%	0.623
Prior Ed: HS	55%	56%	-1%	0.886
Prior Ed: GED	5%	5%	0%	1.000
Prior Ed: Less than HS	1%	1%	0%	1.000
Employed Full-Time	27%	28%	-1%	0.873
Employed Part-Time	37%	35%	2%	0.766
Disabled	0%	0%	0%	1.000
CPT Algebra Score	29.42	32.33	-2.91	0.593
CPT Algebra Score missing	56%	53%	3%	0.668
CPT Arithmetic Score	35.51	38.61	-3.1	0.610
CPT Arithmetic Score missing	54%	53%	1%	0.886
CPT Reading Score	35.83	36.08	-0.26	0.968
CPT Reading Score missing	59%	60%	-1%	0.885
CPT Sentence Skills	36.59	33.1	3.49	0.599
CPT Sentence Skills	61%	64%	-3%	0.659

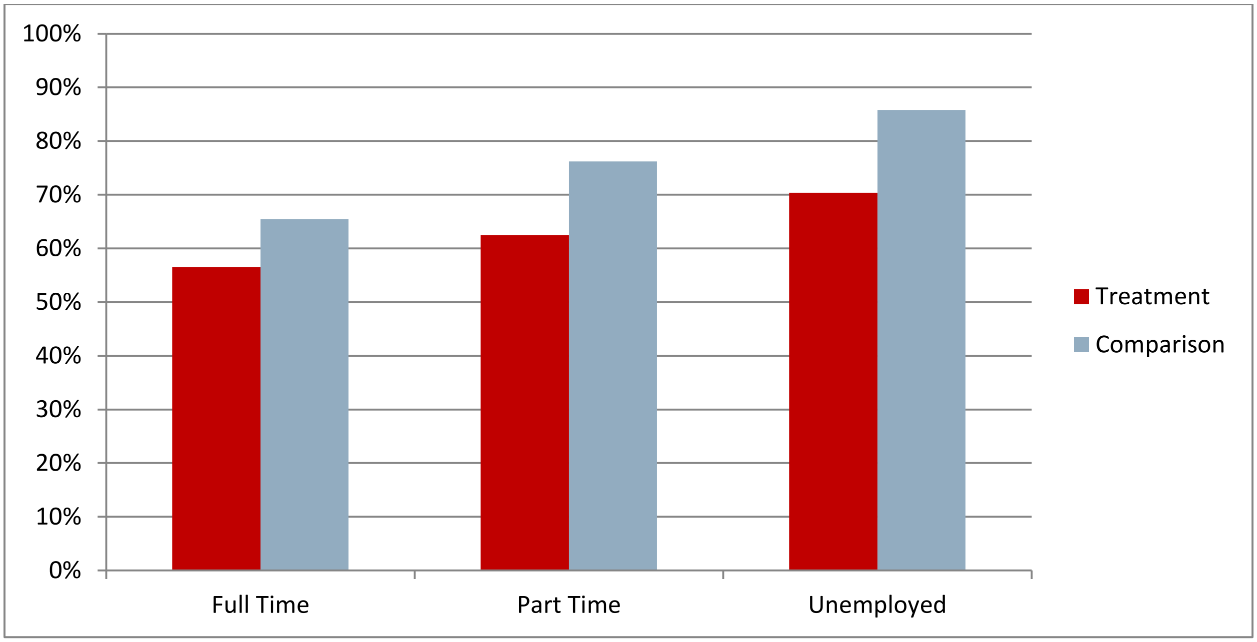
Notes: Propensity weighted means and percentages are shown. Differences and p-values were calculated in propensity-weighted linear regression models with the student characteristic as the dependent variable, and the treatment indicator as the independent variable.

Appendix C: Biology 111 Course Completion for Subgroups

There was no significant variation of the treatment effect on Biology 111 course completion for the following subgroups:

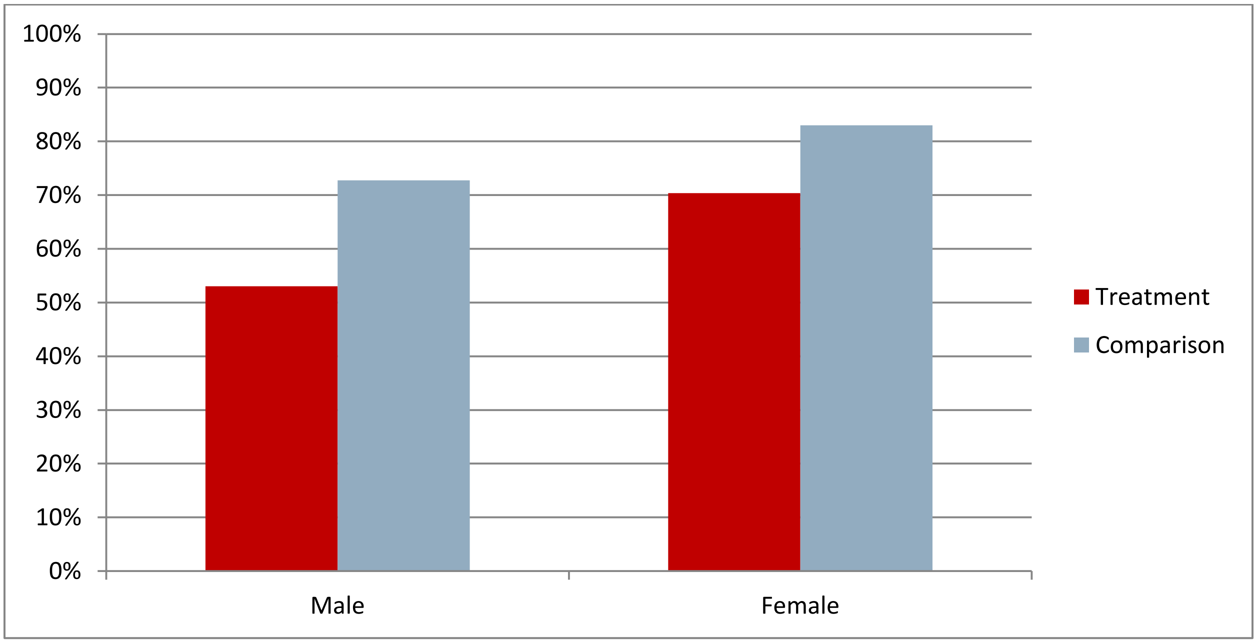
- Employment status –There were no significant differences in the treatment effects by employment status. Across all employment categories, treatment group members were less likely to complete the course (Exhibit C.1);
- Gender – There were no significant differences in the treatment effects by gender. For both males and females, treatment group members were less likely to complete the course (Exhibit C.2);
- Race ethnicity – There were no significant differences in the treatment effects by race/ethnicity. Across race/ethnicity categories, treatment group members were less likely to complete the course (Exhibit C.3);
- Age – There were no significant differences in the treatment effects by age. Across age categories, treatment group members were less likely to complete the course (Exhibit C.4); and
- Placement test taking and performance –There were no significant differences in the treatment effects by whether or not students qualified to waive out of placement tests, or by test scores (for the students who did not qualify to waive out of the tests). Across the test-taking and test performance categories, treatment group members were less likely to complete the course (Exhibits C.5-C.8).

Exhibit C.1. Percent Completing Biology 111 by Employment Status and Treatment Group



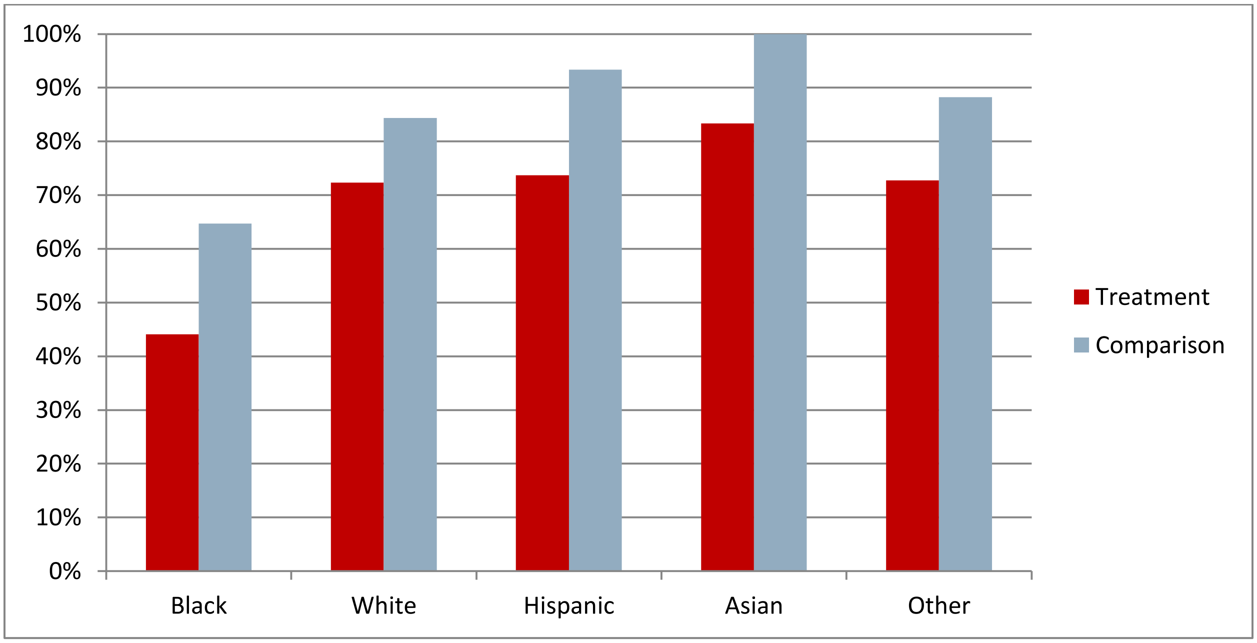
Notes: About half of students were not employed, and about half were employed full time or part time. See Table B.1 for details.

Exhibit C.2. Percent Completing Biology 111 by Gender and Treatment Group



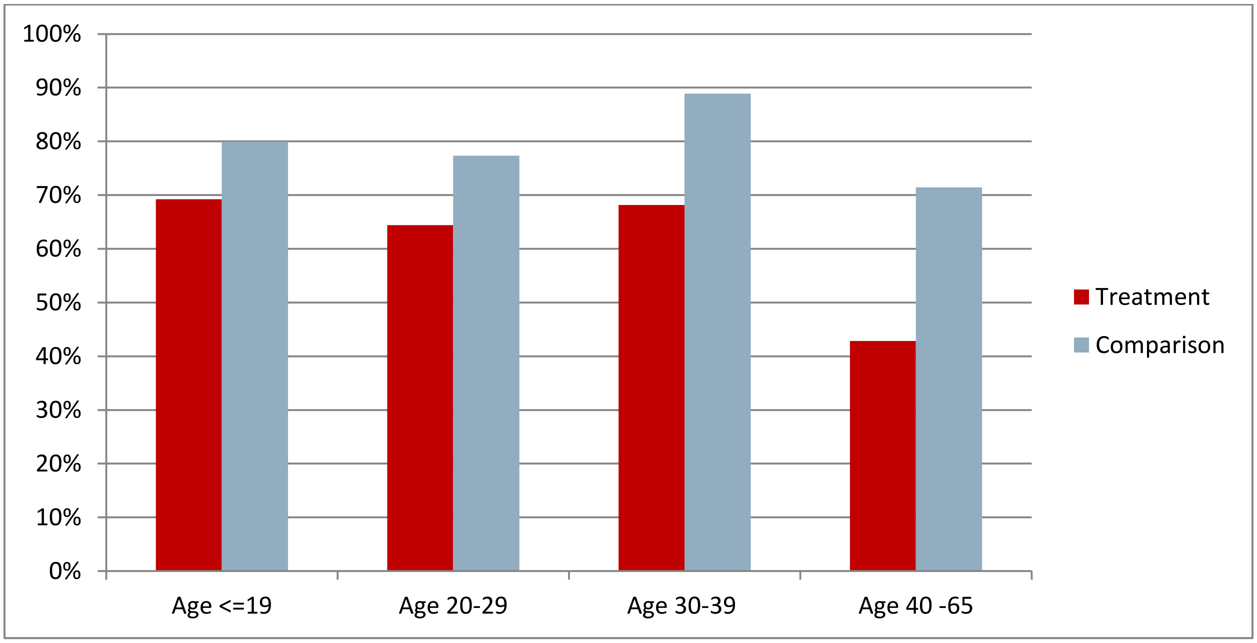
Notes: About two-thirds of students were female. See Table B.1 for details.

Exhibit C.3. Percent Completing Biology 111 by Race/Ethnicity and Treatment Group



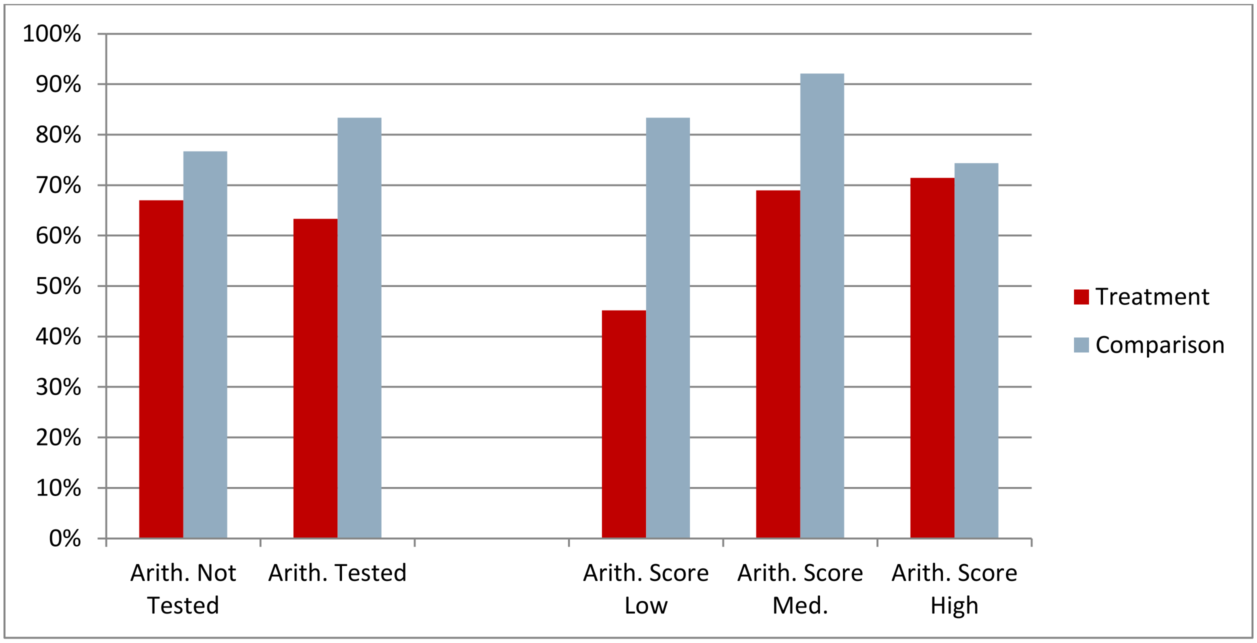
Notes: About half of students were White, almost a third were Black, less than 10 percent were Hispanic, about 3 percent were Asian and about 6 percent were other (includes missing race/ethnicity). See Table B.1 for details.

Exhibit C.4. Percent Completing Biology 111 by Age and Treatment Group



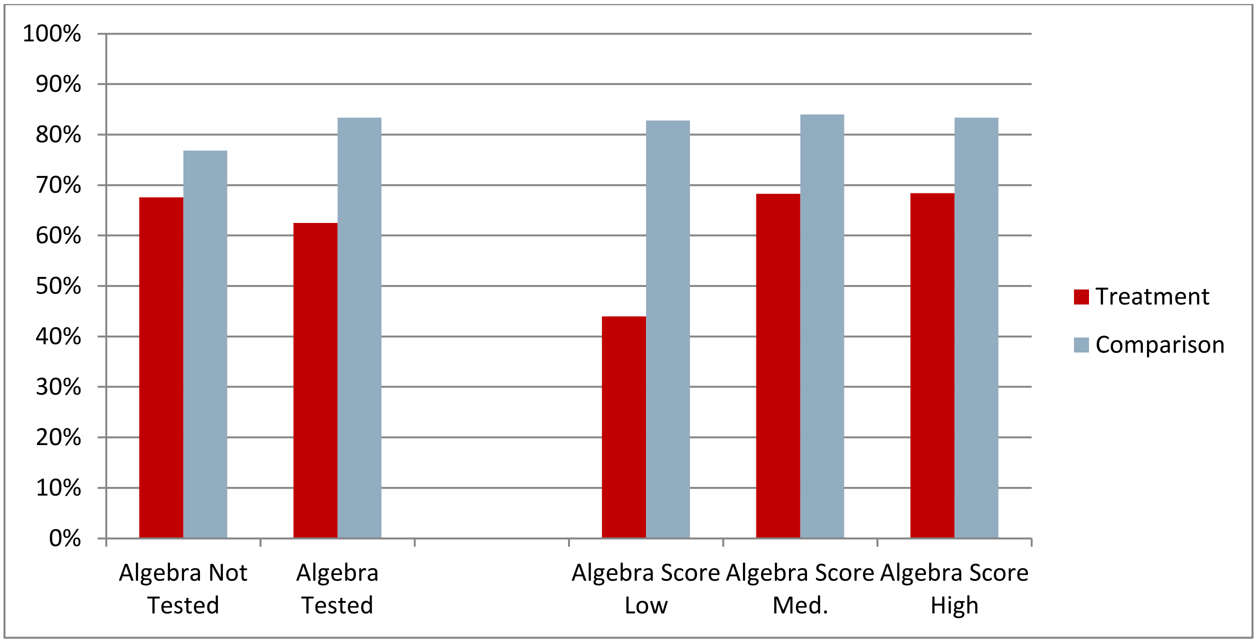
Notes: Thirty nine percent of students were 19 years or younger, 43 percent were 20-29, 11 percent were 30-39, and 6 percent were aged 40-65.

Exhibit C.5. Percent Completing Biology 111 by Arithmetic Test Taking, Arithmetic Scores (for those who took the test) and Treatment Group



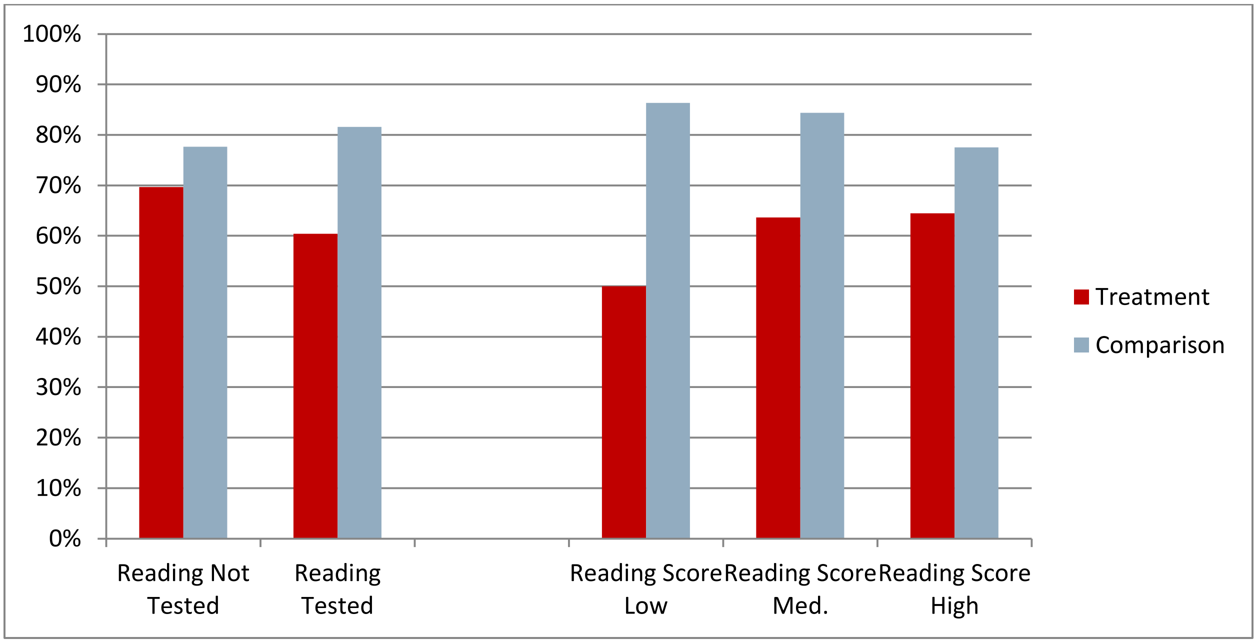
Notes: About half of students were tested. See Table B.1 for details.
The low, medium, and high categories correspond to the lowest 1/3, middle 1/3, and highest 1/3 of scores.

Exhibit C. 6. Percent Completing Biology 111 by Algebra Test Taking, Algebra Scores (for those who took the test) and Treatment Group



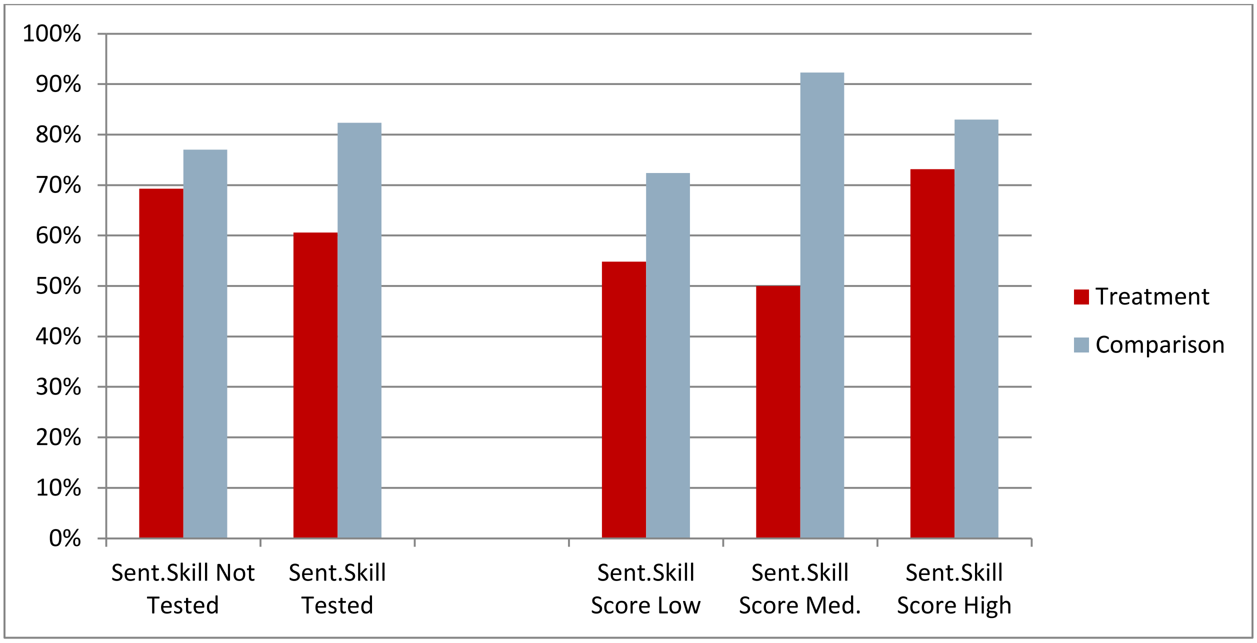
Notes: About half of students were tested. See Table B.1 for details.
The low, medium, and high categories correspond to the lowest 1/3, middle 1/3, and highest 1/3 of scores.

Exhibit C.7. Percent Completing Biology 111 by Reading Test Taking, Reading Scores (for those who took the test) and Treatment Group



Notes: Almost half of students were tested. See Table B.1 for details.
The low, medium, and high categories correspond to the lowest 1/3, middle 1/3, and highest 1/3 of scores.

Exhibit C.8. Percent Completing Biology 111 by Sentence Skills Test Taking, Sentence Skills Scores (for those who took the test) and Treatment Group



Notes: Almost half of students were tested. See Table B.1 for details.
The low, medium, and high categories correspond to the lowest 1/3, middle 1/3, and highest 1/3 of scores.

Appendix D: Demographic and Background Characteristics of c³bc Participants

The demographic and background characteristics of c³bc treatment group participants are presented in the exhibits in this appendix. The exhibits are organized by each characteristic to show the diversity of participants across the colleges.

Exhibit D.1. Gender

College	Female		Male		Missing		Total	
	#	%	#	%	#	%	#	%
All Colleges	458	48.8	472	50.4	8	0.8	938	100.0
Biomanufacturing Hub								
Montgomery County CC	46	59.0	32	41.0	0	0.0	78	100.0
Bucks County CC	12	63.2	7	36.8	0	0.0	19	100.0
Los Angeles Valley CC–Bridge Academy	52	27.6	136	72.4	0	0.0	188	100.0
Los Angeles Valley CC–Biotech Certificate	11	32.4	23	67.6	0	0.0	34	100.0
Medical Devices Hub								
Ivy Tech CC	24	37.6	32	50.0	8	12.6	64	100.0
Salt Lake City CC	28	38.4	45	61.6	0	0.0	73	100.0
St. Petersburg College	34	26.2	96	73.8	0	0.0	130	100.0
Learning Technologies Hub								
Forsyth Technical CC	251	71.4	101	28.6	0	0.0	352	100.0

Exhibit D.2. Age Range at Program Entry

College	≤ 25		26-45		≥ 46		Missing		Total	
	#	%	#	%	#	%	#	%	#	%
All Colleges	340	36.2	437	46.6	159	17.0	2	0.2	938	100.0
Biomanufacturing Hub										
Montgomery County CC	21	27.0	30	38.4	27	34.6	0	0.0	78	100.0
Bucks County CC	12	63.2	6	31.6	1	5.2	0	0.0	19	100.0
Los Angeles Valley CC–Bridge Academy	48	25.6	92	49.0	48	25.6	0	0.0	188	100.0
Los Angeles Valley CC–Biotech Certificate	8	23.6	16	47.0	10	29.4	0	0.0	34	100.0
Medical Devices Hub										
Ivy Tech CC	12	18.8	41	64.0	11	17.2	0	0.0	64	100.0
Salt Lake City CC	10	13.6	39	53.4	22	30.2	2	2.8	73	100.0
St. Petersburg College	32	24.6	74	57.0	24	18.4	0	0.0	130	100.0
Learning Technologies Hub										
Forsyth Technical CC	197	56.0	139	39.4	16	4.6	0	0.0	352	100.0

Exhibit D.3. Race/Ethnicity

College	American Indian / Alaska Native		Asian		Black/ African American		Hispanic		White		Other		Missing		Total	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
All Colleges	2	0.2	93	9.9	173	18.4	111	11.8	503	53.6	32	3.4	24	2.6	938	100.0
Biomanufacturing Hub																
Montgomery County CC	1	1.2	13	16.6	9	11.6	0	0.0	51	65.4	3	3.8	1	1.2	78	100.0
Bucks County CC	0	0.0	3	15.8	0	0.0	0	0.0	16	84.2	0	0.0	0	0.0	19	100.0
Los Angeles Valley CC–Bridge Academy	0	0.0	45	24.0	41	21.8	53	28.2	36	19.2	10	5.4	3	1.6	188	100.0
Los Angeles Valley CC–Biotech Certificate	0	0.0	7	20.6	7	20.6	10	29.4	6	17.6	4	11.8	0	0.0	34	100.0
Medical Devices Hub																
Ivy Tech CC	0	0.0	4	6.2	1	1.6	0	0.0	41	64.0	3	4.8	15	23.4	64	100.0
Salt Lake City CC	1	1.4	6	8.2	0	0.0	7	9.6	57	78.0	2	2.8	0	0.0	73	100.0
St. Petersburg College	0	0.0	7	5.4	28	21.6	15	11.6	77	59.2	3	2.4	0	0.0	130	100.0
Learning Technologies Hub																
Forsyth Technical CC	0	0.0	8	2.2	87	24.8	26	7.4	219	62.2	7	2.0	5	1.4	352	100.0

Exhibit D.4. Highest Education Level at Program Entry

College	High School Diploma/High School Equivalency or Less		Attended Post-High School Training or College		AA/AAS Degree or More		Missing		Total	
	#	%	#	%	#	%	#	%	#	%
All Colleges	355	37.8	180	19.2	335	35.8	68	7.2	938	100.0
Biomanufacturing Hub										
Montgomery County CC	3	3.8	36	46.2	38	48.8	1	1.2	78	100.0
Bucks County CC	11	57.8	4	21.0	4	21.0	0	0.0	19	100.0
Los Angeles Valley CC–Bridge Academy	35	18.6	55	29.2	93	49.4	5	2.6	188	100.0
Los Angeles Valley CC–Biotech Certificate	6	17.6	6	17.6	21	61.8	1	3.0	34	100.0
Medical Devices Hub										
Ivy Tech CC	7	11.0	0	0.0	0	0.0	57	89.0	64	100.0
Salt Lake City CC	11	15.0	25	34.2	36	49.4	1	1.4	73	100.0
St. Petersburg College	40	30.8	34	26.2	53	40.8	3	2.4	130	100.0
Learning Technologies Hub										
Forsyth Technical CC	242	68.8	20	5.6	90	25.6	0	0.0	352	100.0

Exhibit D.5. Employment Status at Program Entry								
College	Employed		Unemployed or Never Employed		Missing		Total	
	#	%	#	%	#	%	#	%
All Colleges	483	51.4	345	36.8	110	11.8	938	100.0
Biomanufacturing Hub								
Montgomery County CC	36	46.2	1	1.2	41	52.6	78	100.0
Bucks County CC	12	63.2	0	0.0	7	36.8	19	100.0
Los Angeles Valley CC–Bridge Academy	46	24.4	142	75.6	0	0.0	188	100.0
Los Angeles Valley CC–Biotech Certificate	13	38.2	21	61.8	0	0.0	34	100.0
Medical Devices Hub								
Ivy Tech CC	7	11.0	0	0.0	57	89.0	64	100.0
Salt Lake City CC	67	91.8	6	8.2	0	0.0	73	100.0
St. Petersburg College	94	72.4	31	23.8	5	3.8	130	100.0
Learning Technologies Hub								
Forsyth Technical CC	208	59.0	144	41.0	0	0.0	352	100.0

Exhibit D.6. TAA Program/TAA Eligible										
College	Yes		No		Don't Know		Missing		Total	
	#	%	#	%	#	%	#	%	#	%
All Colleges	16	1.8	424	45.2	8	0.8	490	52.2	938	100.0
Biomanufacturing Hub										
Montgomery County CC	9	11.6	69	88.4	0	0.0	0	0.0	78	100.0
Bucks County CC	0	0.0	19	100.0	0	0.0	0	0.0	19	100.0
Los Angeles Valley CC–Bridge Academy	3	1.6	70	37.2	7	3.8	108	57.4	188	100.0
Los Angeles Valley CC–Biotech Certificate	0	0.0	15	44.2	1	3.0	18	53.0	34	100.0
Medical Devices Hub										
Ivy Tech CC	0	0.0	64	100.0	0	0.0	0	0.0	64	100.0
Salt Lake City CC	1	1.4	72	98.6	0	0.0	0	0.0	73	100.0
St. Petersburg College	3	2.4	115	88.4	0	0.0	12	9.2	130	100.0
Learning Technologies Hub										
Forsyth Technical CC	0	0.0	0	0.0	0	0.0	352	100.0	352	100.0

Exhibit D.7. Military Status at Program Entry

College	Active Duty/ Reserves		Veteran		Eligible Spouse		Not a Veteran or Eligible Spouse		Missing		Total	
	#	%	#	%	#	%	#	%	#	%	#	%
All Colleges	5	0.6	43	4.6	9	1.0	405	43.2	476	50.8	938	100.0
Biomanufacturing Hub												
Montgomery County CC	0	0.0	3	3.8	2	2.6	0	0.0	73	93.6	78	100.0
Bucks County CC	0	0.0	1	5.2	0	0.0	18	94.8	0	0.0	19	100.0
Los Angeles Valley CC–Bridge Academy	0	0.0	16	8.6	0	0.0	169	89.8	3	1.6	188	100.0
Los Angeles Valley CC–Biotech Certificate	0	0.0	1	3.0	0	0.0	31	91.2	2	5.8	34	100.0
Medical Devices Hub												
Ivy Tech CC	1	1.6	3	4.6	0	0.0	0	0.0	60	93.8	64	100.0
Salt Lake City CC	1	1.4	0	0.0	0	0.0	72	98.6	0	0.0	73	100.0
St. Petersburg College	1	0.8	13	10.0	1	0.8	115	88.4	0	0.0	130	100.0
Learning Technologies Hub												
Forsyth Technical CC	2	0.6	6	1.8	6	1.8	0	0.0	338	96.0	352	100.0

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