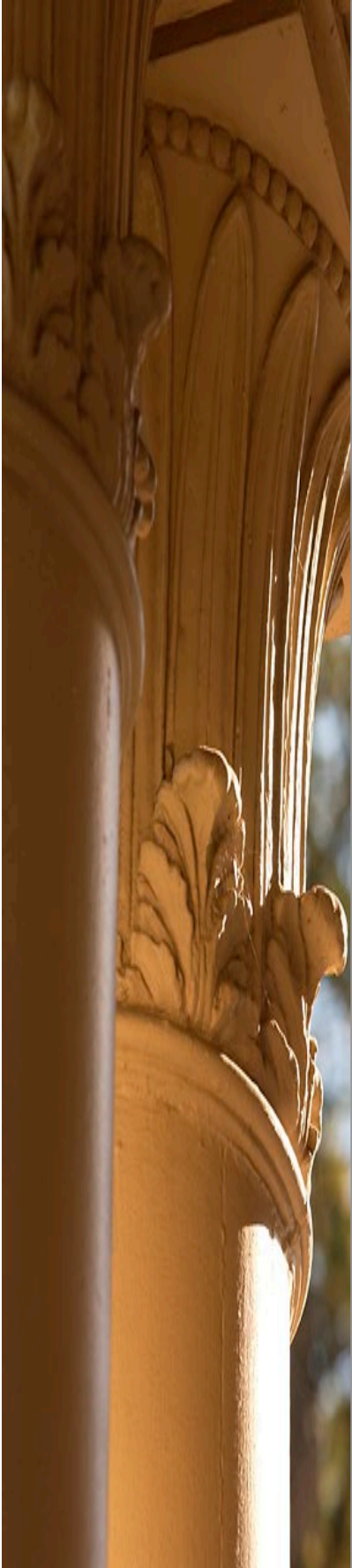




InnovATEBIO National Biotechnology Education Center: Impact Evaluation Report 2019-2024

August 2024

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August 2024



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INNOVATEBIO KEY IMPACT FINDINGS

InnovATEBIO provided value for the community (96%, N=125)	- Strengthened the community - Improved biotechnology programs - Helped educators stay current on emerging trends - Changed views on what community college students can do <i>See pg. 5-6 for themes and quotes about InnovATEBIO value</i>
Community members are doing something differently due to InnovATEBIO (70%, N=138)	- New and revised biotech courses and programs - New partnerships and projects <i>See pg. 5-6 for what the community is doing differently</i>
InnovATEBIO has helped community members ...	- Gain knowledge and/or skills (91%, N=133) - Better understand biotech workforce trends (91%, N=129) - Feel better connected to the biotech community (91%, N=127) - Grow their professional network (84%, N=132) - Develop new collaborations or projects (77%, N=120, <i>See pg. 7 for descriptions of new collaborations / projects</i>) - Better understand the types of projects funded by ATE (90%, N=213) - Gain interest in learning how to apply for an ATE grant (58%, N=210)
InnovATEBIO has helped educators ...	- Strengthen existing biotech programs (88%, N=94) - Better align biotech programs with industry (80%, N=95) - Develop new courses and programs (52%, N=94)
InnovATEBIO has helped students ...	- Know more about different types of biotech jobs (75%, N=1,291 <i>high school students in general biology</i>) - Gain interest in a biotech career (38%, N=1,290 <i>high school students in general biology</i>) - Gain confidence that they could succeed in a biotech career (97%, N=284 <i>students, most from community colleges</i>) - Increase their desire to pursue a biotech career (93%, N=277 <i>students, most from community colleges</i>)
After InnovATEBIO workshops... (N=120)	77% Implemented something from the workshops ~11,941 Students have been exposed to workshop material 49% Changed their Student Learning Outcomes (SLOs) due to the workshops <i>See Table 9, pg. 39-42 for examples of implementation and SLOs</i>

INNOVATEBIO CENTER IMPACT: 2019-2024

Introduction

InnovATEBIO, the National Biotechnology Education Center, was funded by the National Science Foundation's Advanced Technological Education (ATE) program in October of 2019. This report provides a summary of InnovATEBIO's impact since it was funded, through June 2024. It is intended to be an ancillary document to InnovATEBIO's annual reports, which detail the Center's activities and accomplishments.

The report is organized as follows:

1. **Center-wide impact:** Center value that can't be attributed to a single goal or activity but, rather, is a product of the synergy of Center efforts and initiatives across goals.
2. **Student impact:** Student data is gathered in a single section to amplify the voices of the students.
3. **Impact by Goal:** InnovATEBIO is structured by four goals. This section highlights the impact of one or more of the major activities per grant goal.

GENERAL EVALUATION APPROACH

InnovATEBIO is an exceedingly productive organization, as evidenced by Table 1, which details the number of InnovATEBIO webinars, workshops, meetings, and more. This table, while not comprehensive, still totals over 100 events across the past five years. The Center is not only productive, but the leadership team has structured the Center in a manner which allows it to continuously gauge community needs and quickly pivot to meet them. For instance, in the early days of the pandemic, the biotechnology programs in community colleges and high schools needed help bringing their classes and labs online, and InnovATEBIO responded with a series of 14 webinars (focused on community colleges), along with an intensive 5-week Summer Series (focused on high schools). In order to stay up to date with this fast-moving organization, the evaluation team attends all leadership team meetings (1.5 hours weekly), in addition to holding monthly evaluation meetings.

As events arise, the evaluation team meets with the InnovATEBIO team members leading the event. During these meetings, the group discusses the goals of the event, including participant outcomes. The evaluation team then drafts a feedback survey, which is specialized to capture the unique goals of that event or event series.

For instance, in the ATE Project Talks, which is a series of webinars which offer biotechnology-related ATE projects the opportunity to introduce themselves to the InnovATEBIO community, the desired participant outcomes were as follows:

- Gaining awareness of the ATE grant program
- Gaining a better understanding of the types of projects funded by ATE
- Gaining interest in learning how to apply for an ATE grant
- Learning about innovative models, curriculum, and/or ideas that they can use in their program

In addition to measuring the extent to which the participants met the outcomes, the surveys also collect data on the usefulness of the event (and why respondents gave the event that rating) and suggestions for improvement. Survey results are returned after each event in a series, so the InnovATEBIO leads have timely information to fine-tune the events as the series progresses. When the series concludes, the evaluation team returns the summary results for the entire series. Survey summary memos are created for high priority events, which include analyses of the open-ended questions.

Table 1: Number of InnovATEBIO Webinars, Workshops, Meetings, Events and Surveys per Grant Year and Grant Goal

Grant Year	Goal	Event Series	Number of Events	Number of Surveys
1	1	Webinar Series: Spring 2020 (Intensive Response to Covid)	14	12
2	1	Webinar Series: Fall 2020	3	3
2	1	Webinar Series: Spring 2021	2	2
2	1	Webinar Series: CRISPR	3	3
4	1	Webinar Series: Fall 2022	2	2
3, 4 & 5	1	Webinar Series: ATE Project Talks	29	29
3	1	Webinar Series: Advanced PCR	4	4
2	1	Webinar: 5-for-5	1	1
1	4	Workshop: Summer High School Series (Response to Covid)	5	5
2	4	Workshop: Process Development	1	1
2	4	Workshop: Biomanufacturing	1	1
2	2	Workshop: Undergraduate Research Strategic Planning	1	1
3	4	Workshop: High School Teacher Professional Development	6	7
3 & 4	4	Workshop: PCR	7	7
3 & 4	4	Workshop: Methods in Personal Genetics	3	1
3	4	Workshop: Metabarcoding	1	1
3 & 5	4	Workshop: Nanopore	8	8
4	2	Workshop: Undergraduate Research Skills	1	1
5	4	Workshop: High School BACE Workshop	1	1
1 - 4	3	Meetings: National Industry and Workforce Advisory Council	7	13

Grant Year	Goal	Event Series	Number of Events	Number of Surveys
2	4	Meetings: High School Teacher Professional Learning Community	7	3
2 & 3	1	Meetings: InnovATEBIO Community Conversations	10	10
4	3	Meetings: Journey to the Summit / Community Conversations	3	3
5	4	Meetings: State Team Community Conversations	4	4
1	1	Event: The Future of Medicine Day	1	2
2	4	Event: AgBio Symposium	3	3
2	1	Event: Speed Networking	1	2
4	3	Event: InnovATEBIO Summit	2	2
4	4	Event: Hi-Tec Special Interest Group	1	1
3	3	Professional Development: Biosciences Leadership Institute	1	1
5	4	Biotech Pathways for Students with Disabilities Kick-off Survey	1	1
5	All	Community Survey (Center Impact and Workshop Follow-up)	0	1
		Total	134	136

2024 INNOVATEBIO COMMUNITY SURVEY

The primary data source for this report is the InnovATEBIO Community Survey. This web survey was open from February 23 to May 31, 2024. Invitations were sent to the InnovATEBIO newsletter mailing list and prior event attendees. One hundred and eighty-seven (187) individuals responded to the survey.

Below are demographic descriptions of the respondents how they have interacted with InnovATEBIO.

Primary Roles

Respondents (N=183) are educators (71%), administrators (15%), workforce development (15%), industry representatives (6%), biotechnology program alumni (4%), students (10%), and other (3%). Respondents could mark all response options that applied so percentages add to more than 100%.

Institutional Affiliation

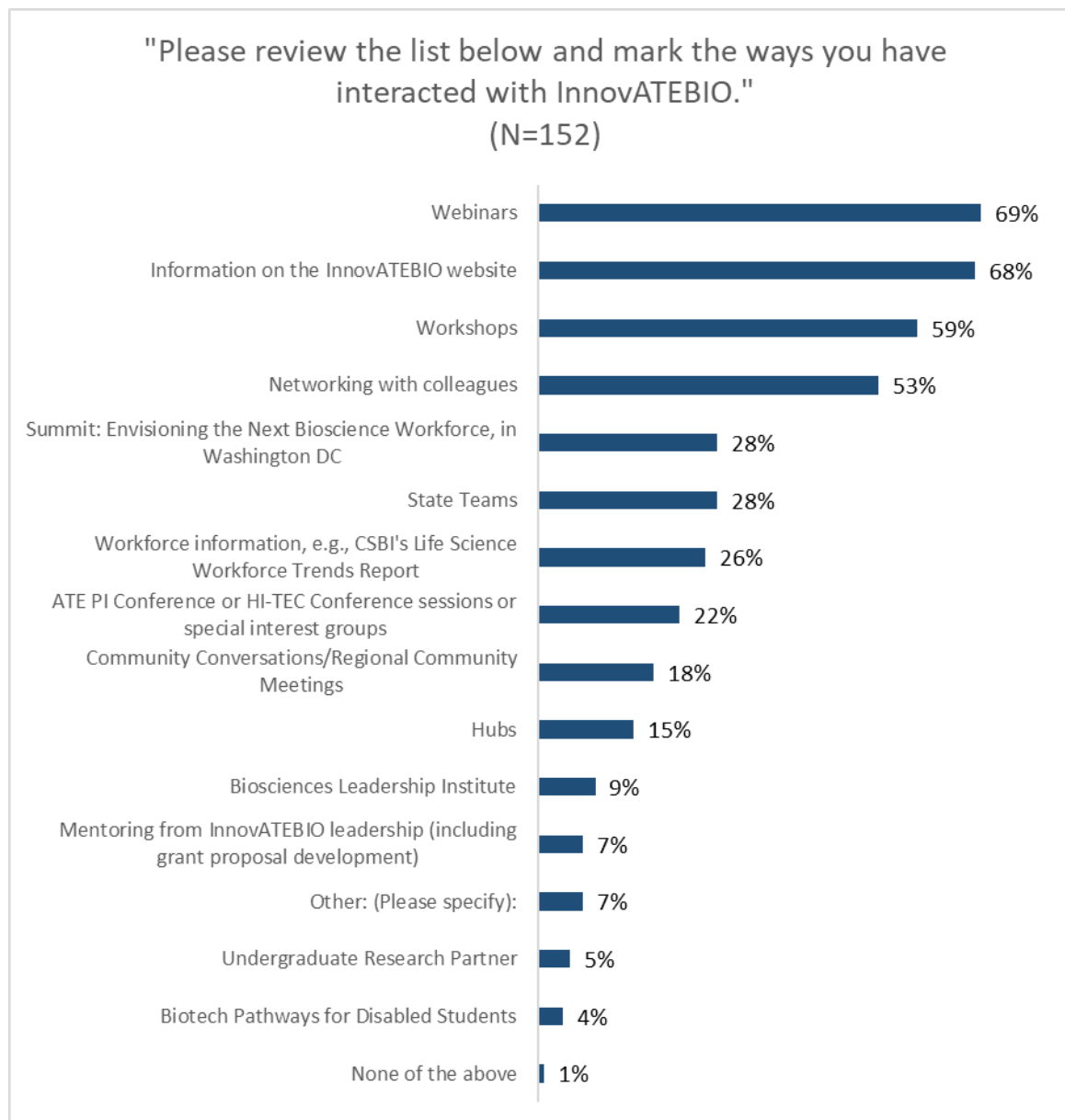
Respondents (N=185) represent primarily educational institutions. Their institutional affiliations include the following: K-12 (44%), 2-year college (40%), 4-year college or university (9%), nonprofit (8%)

biotechnology industry/company (7%), government (2%), and other (4%). Respondents could mark all response options that applied so percentages add to more than 100%.

How the Community Interacted with InnovATEBIO

The four most common ways respondents (N=152) interacted with InnovATEBIO were webinars (69%), information on the InnovATEBIO website (68%), workshops (59%), and networking with colleagues (53%). Roughly one-quarter of the respondents interacted with the Center through the InnovATEBIO State Teams (28%), the Summit: Envisioning the Next Bioscience Workforce, in Washington, DC, (28%), and workforce information, such as the Coalition of State Bioscience Institutes' *Life Science Workforce Trends Report* (26%). (See Figure 1)

Figure 1: How Community Interacted with InnovATEBIO



OTHER DATA SOURCES

Other data sources are introduced throughout the report, in the corresponding sections where the results are presented.

InnovATEBIO Center-Wide Impact

The InnovATEBIO National Biotechnology Education Center (InnovATEBIO) is more than a collection of goals or projects. It is a cohesive Center and, as such, it has produced cross-cutting impacts that span multiple goals and/or fall outside of the defined goals altogether. Center-wide impacts include the following, as described by the community members:

96%: Noted that **InnovateBIO provided value** for them (N=125)

- Increased networking and strengthened community
- Professional development: staying current on emerging trends, hands-on training
- Curriculum and teaching resources, including websites
- Program improvements and support
- Opportunities for students/alumni
- Mentoring, including writing grants
- General information and resources

70%: **Doing something differently** due to InnovATEBIO (N=138)

- Revised and new courses, curricula, and programs
- New partnerships
- Stronger/larger support network
- Increased knowledge, skills, experience, and confidence
- Strengthened teaching skills, teaching new technologies
- Created InnovATEBIO State Teams

A total of 96% of the Community Survey respondents (N=125) indicated that InnovATEBIO has provided value for them and described the value. The strongest themes focused on strengthened networking and community; the professional development that helped them stay current on advances in biotechnology (including opportunities for hands-on training), the curricula and other resources for teaching, and general information and resources. Selected quotations include the following:

InnovATEBIO has been an invaluable resource both for professional development and in finding information/resources to share with my students... The collection of resources, networking and training opportunities InnovATEBIO provides have had a huge impact on our programs and on our students.

Provided curriculum for my classes, as well as materials and equipment to complete hands-on labs with students. Helped me as an educator to feel more comfortable teaching students about biotechnology in classes.

InnovATEBIO has made it possible for me to learn from a community of other teachers, get hands-on training in planning logistics and teaching a lesson, and provided significant resources I would not otherwise be able to acquire for my students through my district.

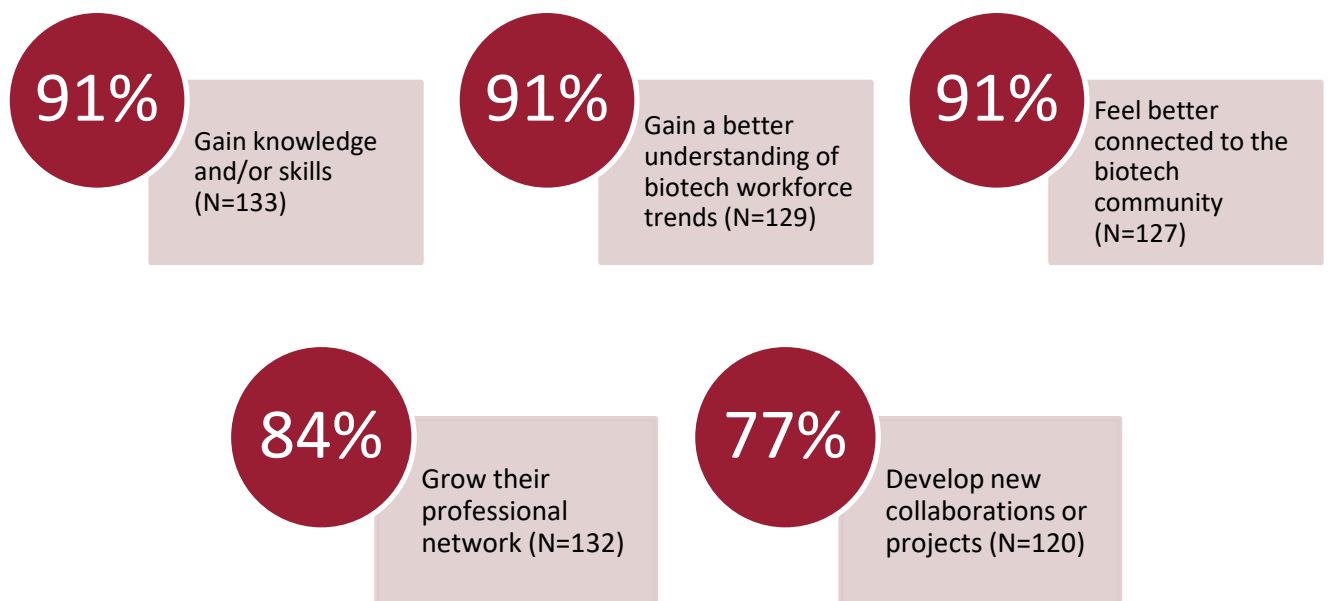
Seventy percent (70%) of the Community Survey respondents (N=138) marked that they are doing something differently as a result of their interactions with InnovATEBIO. In written comments, the strongest themes that emerged were that they revised and created courses, curricula, and programs; developed new partnerships, and strengthened and broadened their support network. Sample quotations in response to this prompt include the following:

After receiving additional training from InnovATEBIO, I began a biotech program at my high school and also got BACE credentialed myself and am hopeful that my first batch of biotech students will also be getting their credential this Spring as well. I'm enjoying this journey and am feeling very supported -- and keep wishing I had time to do even more learning. I will continue.

I have started to teach concepts that I did not have resources to teach last year.

Teaching the latest and relevant content in my courses.

InnovATEBIO has helped community members...

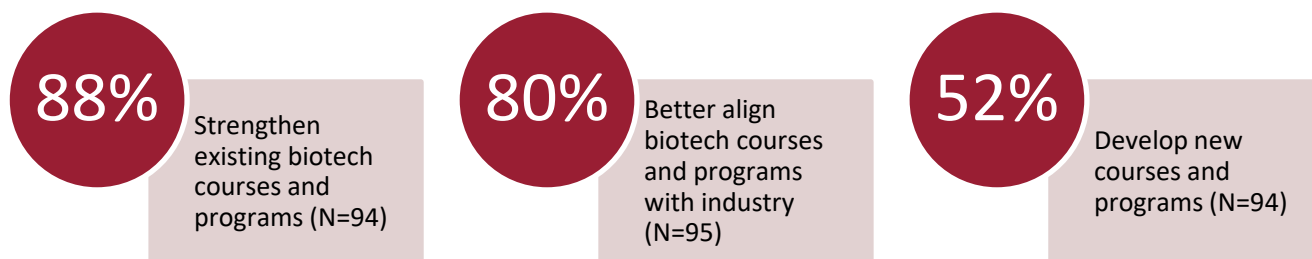


New Collaborations and Projects

Themes from written comments include the following:

- Increasing collaboration and networking amongst educators (across departments, campuses, colleges, and universities), grant recipients, members of InnovATEBIO State Teams (teams consist of organizations active in biotech workforce development within their states), organizations in other states, biotech employers, state BIO organizations, and state representatives
- Forming new partnerships between biotech companies and community colleges
- Creating articulations between community colleges and four-year universities
- Expanding existing curricula (e.g., adding labs, implementing projects, extending a semester curriculum to a yearlong course)
- Creating new courses and programs (e.g., Agricultural Biotechnology Program, gene therapy course, biotech chemistry support course, Biotechnician Assistant Credentialing Exam (BACE) bootcamp course, biotechnology degree)
- Implementing new course projects (including undergraduate research and supply chain projects)
- Adding biotech labs to high school biology courses
- Implementing new techniques in classrooms (e.g., qPCR, algae, pGLO, Alu PCR, taq polymerase, eDNA using qPCR)
- Working with students with disabilities
- Developing common skills credentials across institutions
- Applying for and receiving grants (both inside and outside NSF) with someone met through InnovATEBIO
- Using InnovATEBIO as a means for NSF grant-funded projects to disseminate information to biotech programs
- Joining advisory boards (e.g., for grants, a fermentation collaborative, state BIO organizations)
- Industry donating equipment and supplies to schools starting biotech programs
- Helping programs move labs online during the pandemic
- Collaborating on peer-reviewed journal publications and conference presentations
- Taking advantage of BABEC offerings (e.g., BIOscience Core Institute) and DNA Learning Center gene sequencing and genomics

InnovATEBIO has helped educators...



The most common words the community used to describe InnovATEBIO were “informative,” “innovative,” “helpful,” “collaborative,” “supportive,” and “educational.” (See Figure 2)

Figure 2: Word Cloud: “What 3 words would you use to describe InnovATEBIO?” (N=118)



Student and Alumni Data

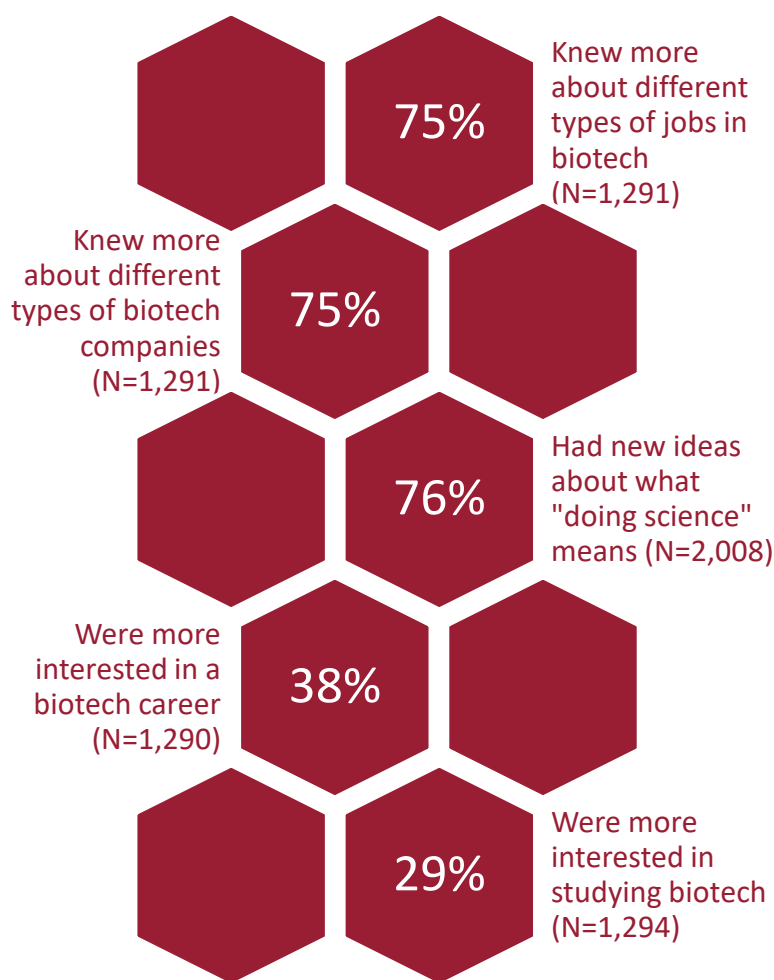
This section reviews five sources of student feedback: 1) high school student surveys completed after their teachers implemented lessons from the *Introduction to Biotechnology Series* teacher workshops, 2) community college student/alumni reflections after presenting their research at the InnovATEBIO Summit in Washington, DC, 3) student surveys completed after participating in student-industry speed

networking events, 4) student surveys completed after using the biotech-careers.org website, and 5) high school student surveys providing feedback on immunotherapeutic biomanufacturing kits.

INTRODUCTION TO BIOTECHNOLOGY SERIES

InnovATEBIO partnered with the Bay Area Bioscience Education Community (BABEC) to offer workshops to high school biology teachers from Title I schools in San Francisco, CA, and beyond.

After biology teachers implemented biotech lessons from workshops, students...



The Introduction to Biotechnology Series involved four unique lessons: 1) Intro to Biotech Lesson, 2) Intro to Micropipetting Lab, 3) Exploring Careers in Biotechnology Lesson, and 4) Biotech Spotlight Session. Since 2021, a total of 10 workshops have been held, with 83 teachers at 56 high schools. After completing the workshop, 53% of the teachers confirmed that they implemented at least one of the series' lessons into their classes. Students in these classes were invited to take a short survey after they finished working through one or more of the lessons. This survey was developed by the BABEC team and is administered by teachers who took part in one of the workshops. The survey is administered on a rolling basis,

Introduction to Biotechnology Series

High School Student Quotations

There are so many fields in Biotech that I didn't know about, and there are more Biotech companies near us than I thought there would be.

I learned that biotech is the future because we are able to make sustainable materials and foods. Biotech companies are encouraging youth to pursue this career.

Last week we learned how to use a micropipette and about the range between acidity and bases as well as the PH scale. It was really interesting and fun and I would love to do more activities with the micropipette.

I learned about the uses of biotech... I also learned about how different types of antibiotics work and what DNA plasmids were. It was a fun experiment and the results were interesting.

I learned that biotech is cool and interesting and can help solve real world problems.

High School Biology Teacher Quotations about Student Impact

It was so cool to see students increase their skills from one day to the next. We were able to take them on a journey from something that felt really basic to something that felt super challenging in one week!

Favorite part of the lesson series: "Seeing students engaged and actively participating and asking genuine questions to learn more about the topics."

beginning October 25, 2021, and continuing through the present. As of March 2024, a total of 2,080 students have completed the survey.

STUDENT POSTER SESSION AT THE INNOVATEBIO SUMMIT: ENVISIONING THE NEXT BIOSCIENCE WORKFORCE

At the InnovATEBIO Summit: *Envisioning the Next Bioscience Workforce*, 20 community college students and alumni presented posters of their research. This event was held at the National Academy of Sciences in Washington, DC, on June 27, 2023. A total of 272 individuals attended the event, representing educators, industry, workforce development, government, and others. Two of the

student/alumni presenters are profiled below, along with their initial reflections on the event and their additional reflections nine months after the event (in March 2024).

Alumni Profile: Miko Mallari

Summit Poster: Mapping Immunogenic Regions in SARS-CoV-2 Variants to Understand PCR Assay Design Using Bioinformatics Tools

Affiliated College: City College of San Francisco



Bio: My scientific journey has been a series of meaningful experiences that ingrained a desire to belong in this field. I have had the pleasure of working with people from diverse backgrounds. I have been involved with the scientific world at the community college level, academic labs, private research institutes, industry, and government-funded groups. As I have been developing as a researcher, I have found an appreciation for all of the work done not only in the lab; but the community that forms around research. These people are lifelong learners, educators, policymakers, and even the patients that many hope these imaginative therapies will help one day. It's clear to me now that it takes a diverse group of people to push science forward. I am currently a staff researcher at UC Berkeley working on how to engineer cytokines to influence cell signaling pathways.

Alumni Reflections: Part 1, Written the Day of the Summit¹

Today we presented our work at the Envisioning the Next Bioscience Workforce Summit at The National Academies of Sciences, Engineering, and Medicine hosted by the InnovATEBIO Community.

While wrapping up my time with the City College of San Francisco, I got involved with the InnovATEbio community, and it started a collaboration that I would keep up to today. I volunteered with a group of educators nationwide to develop undergraduate research-based lesson plans that taught students how to utilize a database like the Immune Epitope Database to learn topics in immunology, vaccine design, protein engineering, and bioinformatics.

A group of students at Waubensee Community College Students in Chicago picked up the result of that project. They created a research project that mapped out immunogenic regions in SARS-CoV2 variants to understand vaccine design.

¹ Part 1 of Miko Mallari's reflections was originally posted on LinkedIn. It is included here with permission.

Some key takeaways from this summit:

- The focus on developing the Bioeconomy, especially highlighting the Executive Order on Advancing Biotechnology and Biomanufacturing
- The importance of creating purpose-driven work to improve retention in the workforce for early-career individuals
- How biotechnology is disrupting healthcare, agriculture, and material science industries. Including topics surrounding ethics, the speed of growth of these industries, and the number of jobs they will create.
- Research topics and trends in regenerative medicine, antibody therapeutics, cell based meats, space exploration, and the influence of AI in drug development were just a few topics covered.

I have been involved with the ATE community since 2021, and it's been such an impactful experience seeing how these educators are shaping the future of our Bioeconomy. It was the first time I was meeting many of my colleagues in person and it was such a welcoming experience. Thank you to everyone that made this happen.

Alumni Reflections: Part 2, 9 Months After the Summit, March 2024

As an early career individual, getting a breadth of exposure to biomedical research has reinforced my desire to be a scientist. As a scientific researcher, I feel an obligation to be informed about the community that surrounds research. The InnovATEBIO conference gave me a better understanding of how policy significantly influences the broader field of biological research, the roadmap at the federal level, and the direction in which the field is going. I left the meeting with further validation that I had made the correct career decisions.

Many InnovATEBIO projects aim to create student research experiences, creating a purpose-based learning experience for the students. The end goal of preparing a project for a conference was a great way to establish a realistic goal that would also add another dimension to our project: presenting the work. Sharing work at a meeting isn't always accessible for students, especially those without access to research opportunities. This project also exposed me to a more senior and mentoring role, an invaluable experience. It was great to finally meet those involved with the project and some connections I made from other InnovATEBIO-affiliated activities.

In the months following the summit, I followed up with some of the connections I made. For example, I had an informational interview with an industry expert regarding the type of computational training that could complement the bench research I was doing for the design and engineering of antibodies.

Alumni Profile: Joanna Sanchez

Summit Poster: Mapping Immunogenic Regions in SARS-CoV-2 Variants to Understand PCR Assay Design Using Bioinformatics Tools

Affiliated College: Waubensee Community College

Bio: My name is Joanna Sanchez, and I am a first-generation college student. My educational journey began at Waubensee Community College, where I received an associate's degree in Applied Science. I am expanding my academic horizons by studying Molecular and Cellular Biology at the University of Illinois Urbana Champaign.



My fascination with Biology began at an early age as it provided a pathway to comprehend the mysterious aspects of our world. This curiosity and my aspiration to enlighten young minds in my community have fueled my journey into higher education. To enhance my comprehension, I participated in a research project, "Mapping Immunogenic Regions in SARS-CoV-2 Variants to Understand Vaccine Design Using Bioinformatics Tools." This experience has honed my research and collaborative skills.

My career path has now pivoted towards Molecular and Cellular Biology, a field that beautifully merges Chemistry and Biology. I am particularly interested in unraveling the mysteries of Biotechnology, especially its potential evolution into biopharmaceuticals and therapies. I firmly believe that these advancements will play a pivotal role in combating debilitating diseases like cancer, Alzheimer's, and many others.

Beyond my discoveries, I am passionate about sharing my knowledge with other first-generation students. In line with Jermaine Lamarr Cole's lyrics from The Sideline Story, "I wish somebody made guidelines on how to get up off the sidelines," I hope to create such guidelines. My goal is to guide students like myself through the complexities of academia, especially those who are first-generation students or belong to minority groups.

In the long run, I am committed to contributing to the collective knowledge in my field and aiding other students in their pursuit of higher education.²

² For additional information about Joanna Sanchez and her research, see <https://joanna-sanchez.github.io/joanna.sanchez.rocha/research.html>

Alumni Reflections: Part 1, Written the Day of the Summit³

As a first-generation Latinx student, I understand the impact that mentoring opportunities can have on students' lives. I am grateful to my mentor, Associate Professor Dr. Sheela Vemu from Waubonsee Community College, for her inspiring and impactful advocacy for student success. Without her continuous support, I would not have been able to embark on the journey that led me to present my undergraduate research on "Mapped out immunogenic regions in SARS-CoV2 variants to understand vaccine design" at the Envision the Next Bioscience Workforce Summit hosted by the InnovATEBIO Community at The National Academies of Sciences, Engineering, and Medicine in Washington, D.C.

Being exposed to the insights of the visionaries who are shaping the Bioeconomy as undergraduate student was a privilege. Through my involvement in undergraduate research, I learned how to collaborate with other students, such as my collaborator Brady Anderson, a Waubonsee alumnus.

I would also like to express my appreciation for the input on our research from the scientists working on the Immune Epitope Database (IEDB), Dr. Mahita Jarjapu, Dr. Marcus Fabiano A. Mendes, and Senior Project Manager Nina Blazeska at La Jolla Institute for Immunology in La Jolla, California.

It was an honor to be present in the conversations about creating a new curriculum to shape the next BioMADE workforce development, with a focus on equity and diversity.

Some takeaways from this Summit:

- Highlight the Executive order on Advancing Biotechnology and Biomanufacturing: Focusing on creating a Bio-technician workforce.
- Biotechnology trends drive new value and the impact of BioManufacturing in creating a sustainable economy.
- Working with K-12 schools, community colleges, and universities BioMADE envisions a future where students are exposed to the tools of biotechnology and their application to the real world through bio-industrial manufacturing.
- The impact biotechnology is creating in healthcare, and other industries like agriculture, and material sciences.
- Various research topics and trends were discussed such as regenerative medicine, antibody therapeutics, cell-based meats, space exploration, and the influence of AI on drug development.

This experience has been inspiring and provided me with invaluable insights into the latest biotechnology trends and the impact of BioManufacturing on creating a sustainable economy.

³ Part 1 of Joanna Sanchez's reflections was originally posted on LinkedIn. It is included here with permission.

My sincere gratitude goes to the InnovATEBIO Community and the National Science Foundation for affording me the opportunity to participate in this summit. I deeply appreciate the knowledge gained from my involvement in undergraduate research and the summit, and I am committed to being an advocate for education for underrepresented students. I hope to use my experiences to become a leader in this field and contribute to student success.

Alumni Reflections: Part 2, 9 Months After the Summit, March 2024

My experience at the Envision the Next Bioscience Workforce Summit hosted by the InnovATEBIO Community at The National Academies of Sciences, Engineering, and Medicine in Washington, D.C., was significant, particularly as I transitioned from community college to university. I did not fully comprehend how important learning about these topics was at the time. However, as a university student, I now understand these insights' far-reaching benefits to my career planning.

I found great value in learning about the advances in biotechnology within healthcare, such as regenerative medicine, antibody therapeutics, and trends in this field. These are topics that I actively seek out in guest speakers at my university. Knowing these areas has provided me with crucial talking points and enhanced my understanding when engaging with active professors in these fields.

The event emphasized diversity and equity and was particularly impactful for me as a first-generation college student. It opened up new opportunities that I wouldn't have known existed otherwise. My interactions with the speakers and other scientists during the event were supportive and enlightening. Many offered words of advice and encouraged me to continue on this path. I had many informative and insightful conversations, learning about the different facets of biology, biotechnology, and engineering and their role in the biotechnology industry.

The experience broadened my perspective and gave me a greater understanding of the scope of these fields I didn't have before.

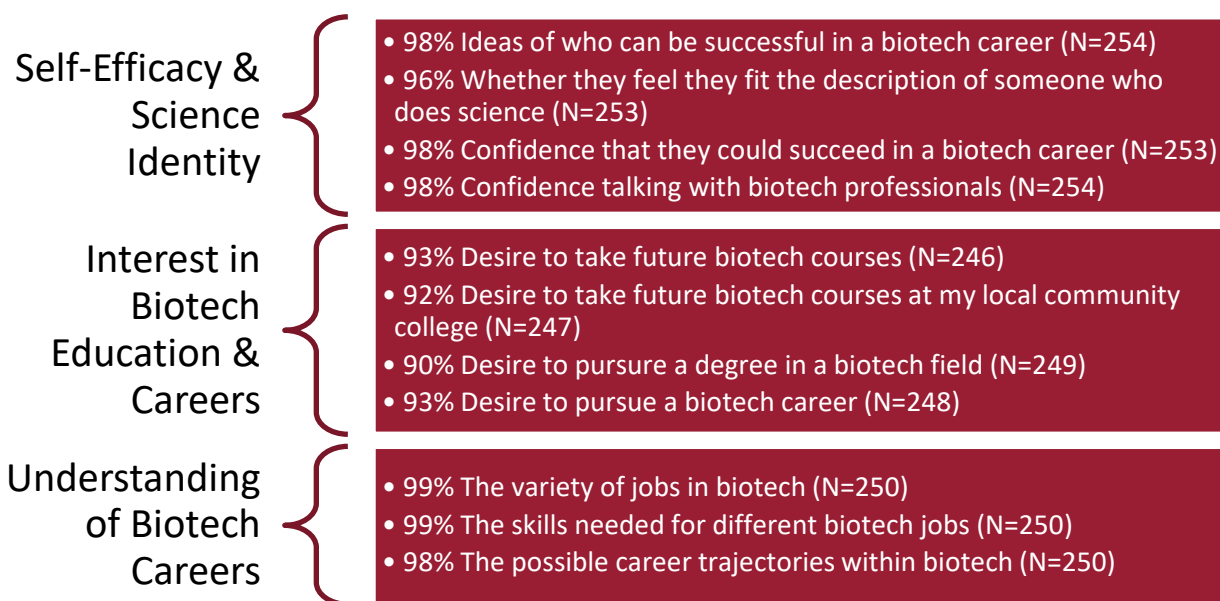
Being exposed to these experiences as a first-generation student has been a privilege. It reaffirmed my commitment to advocate for education for underrepresented students. I hope my experiences can help me become a leader in this field and contribute to the success of other students.

STUDENT-INDUSTRY SPEED NETWORKING EVENTS

The original InnovATEBIO workplan included establishing an alumni network. After thoroughly researching alumni networks, InnovATEBIO determined that establishing a self-sustaining alumni network required far more resources than were available through the Center grant. A separate ATE grant was funded in 2022, and work has continued under the new grant ("Increasing Student Retention and Recruitment Through Alumni Programs, Speed Networking, and Industry Engagement," DUE202011). This grant is considered to be the Alumni Hub of InnovATEBIO.

The 2022-2024 independent evaluation of the Alumni Hub includes student feedback from 19 speed networking events across four community colleges.⁴ These events brought together 342 students and 182 industry and academia volunteers. The majority of students (77%) were from community colleges; 11% attended a four-year college or university, 9% attended a high school, and 3% indicated some type of other school affiliation. In surveys completed after the events, students indicated that the events had impacted their self-efficacy, science identity, interest in biotech education and careers, and understanding of biotech careers.

Speed networking influenced students’...



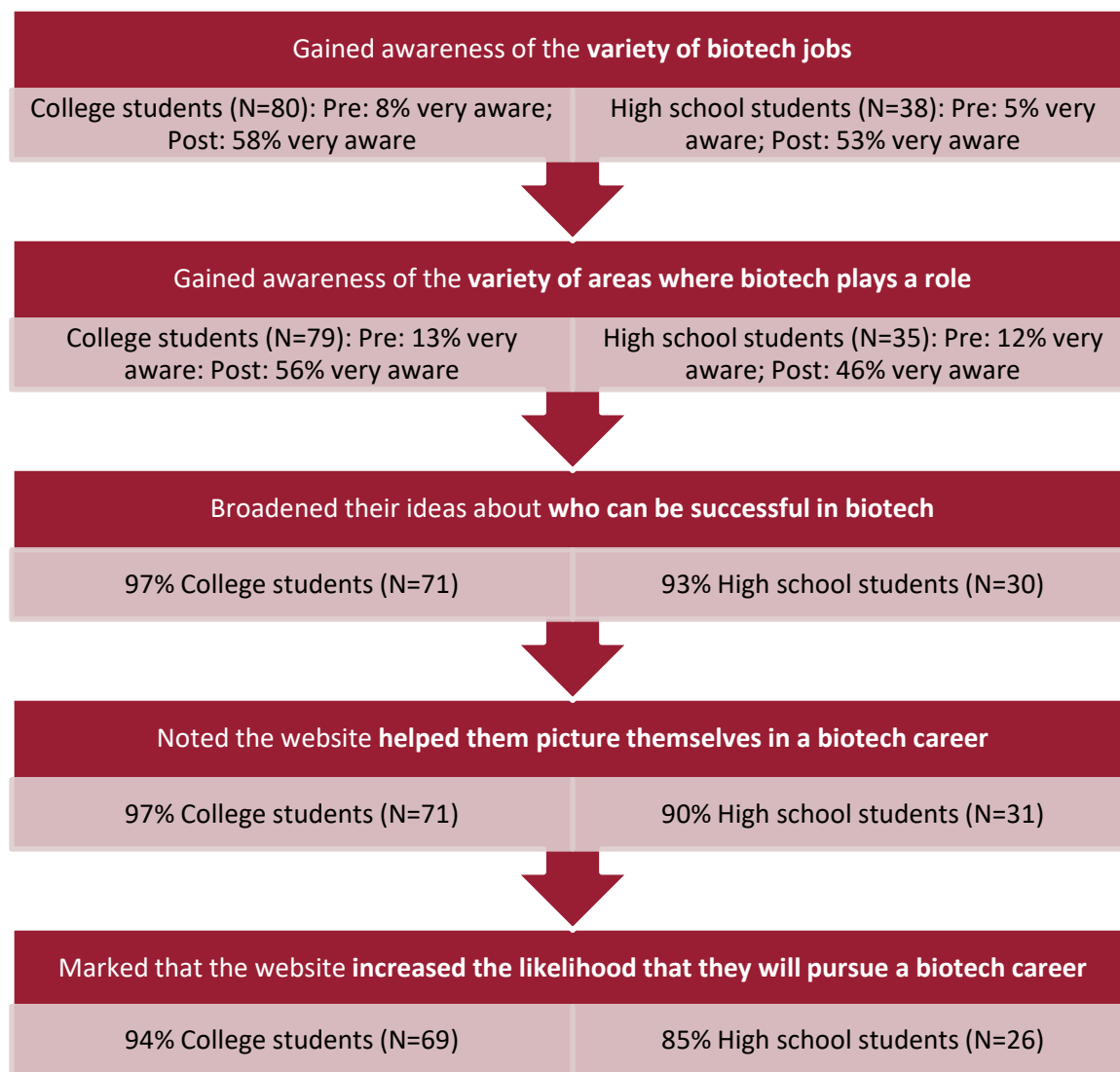
BIOTECH-CAREERS.ORG STUDENT DATA

The website, Biotech-Careers.org, provides a robust set of biotechnology career information, from job descriptions to biotechnology areas to job postings and links to educational program descriptions on the InnovATEBIO website. Biotech-Careers.org was originally developed by InnovATEBIO’s predecessor, BioLink. It split off with its own grant funding when the BioLink Center sunsetted. Biotech-Careers.org is considered an InnovATEBIO Hub.

⁴ InnovATEBIO sponsored one Speed Networking Event in February 2021, before the separate grant was funded.

Students completed web surveys after attending presentations demonstrating the website or after using the website in a class assignment. Respondents consisted of 100 college students (73% of whom attended community colleges) and 47 high school students.

After using Biotech-Careers.org, students...

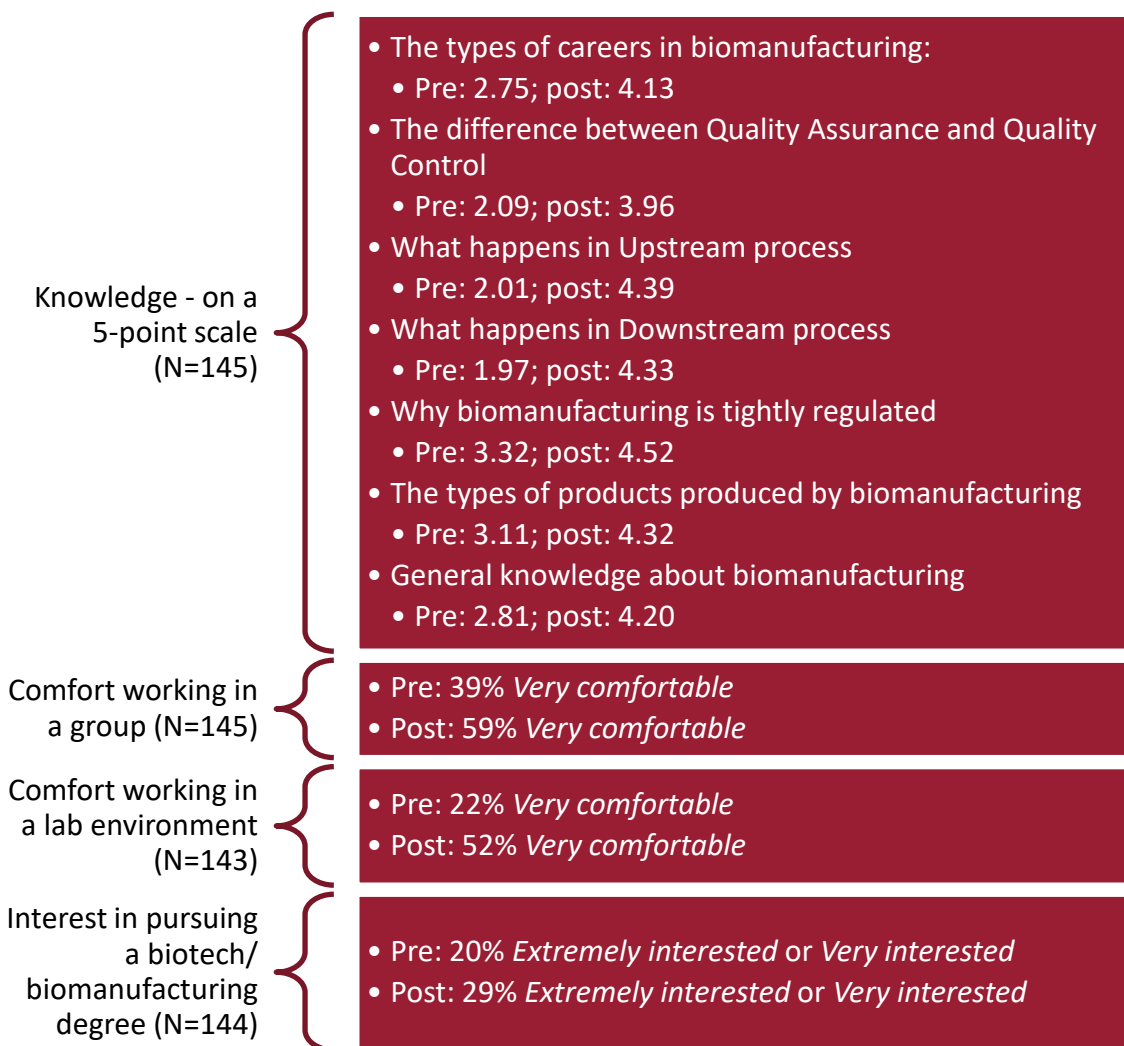


IMMUNOTHERAPEUTIC BIOMANUFACTURING CLASSROOM KITS

In May of 2021, Shoreline Community College received NSF ATE funding for the project, “Establishing a Hub to Support Education of Biomanufacturing Technicians in Cell Therapy and Immunotherapy.” This project is considered the InnovATEBIO Immunotherapy Hub.

In order to expose high school students to immunotherapy career possibilities, the Immunotherapy Hub created a specialized classroom kit that included equipment, experiments, lab procedures, and curriculum. High school teachers checked out the kits from the Hub lending program. After their high school students worked through the kit activities, the students completed an online survey (N=157 students).

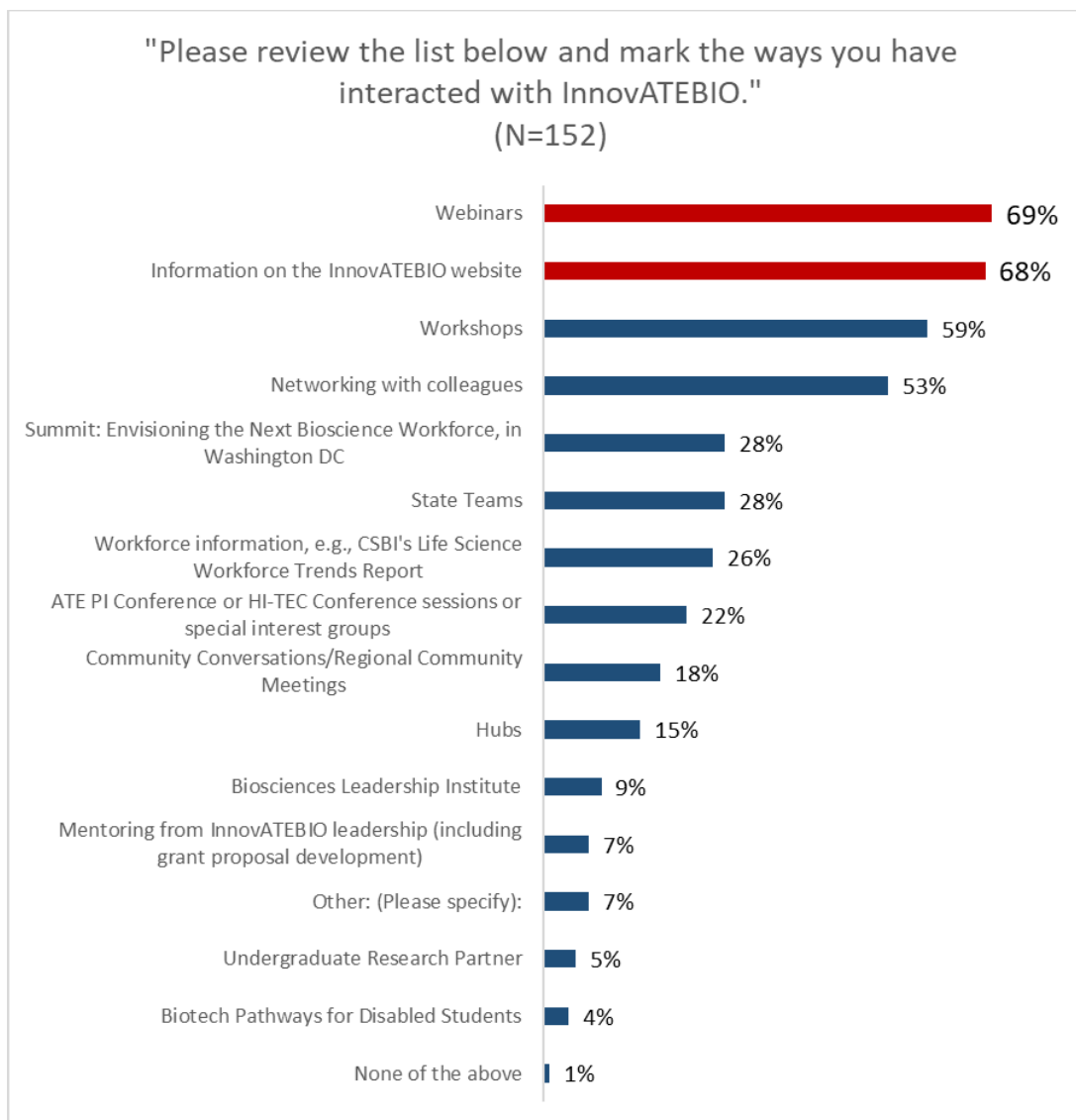
Through the Immunotherapeutic Biomanufacturing Kit, high school students gained...



Goal One

Goal One of InnovATEBIO includes much of the community-building work; thus, **much of the Center-wide impact discussed above can be attributed to Goal One.** Community-building is accomplished through the extensive InnovATEBIO website, regular newsletters, ongoing social media management, holding several series of webinars to disseminate information out to the community, and hosting virtual Community Conversations to gather input about community needs, which are then translated into Center services. One indication of the importance of Goal One activities is that the top two ways Community Survey respondents (N=152) interacted with InnovATEBIO were webinars (69%) and the website (68%).

Figure 3: How Community Interacted with InnovATEBIO



InnovATEBIO Website and Program Database

With detailed biotechnology program pages for community college members and high school affiliates, the website has value beyond the standard use of a website: an avenue for InnovATEBIO to disseminate information. The website also collects information about biotechnology programs, populating a valuable database; this database produces a variety of automated data reports that describe biotechnology education across the country. The database reports are available to the community through the website.

This database is valued beyond the InnovATEBIO community; for instance, InnovATEBIO is called upon by federal agencies and government offices when they need information about biotechnology education. As a case in point, InnovATEBIO is included in the Office of Science and Technology Policy's report, *Building the Bioworkforce of the Future: Expanding Equitable Pathways into Biotechnology and Biomanufacturing Jobs*.⁵ In this report, key sub-recommendations and action steps include InnovATEBIO in the following text:

Action: *The NSF ATE program supports both national centers and projects that support biotechnology and biomanufacturing technician education programs, including the InnovATEBIO National Center for Biotechnology Education. InnovATEBIO is providing leadership in biotechnology technician education, including support for development and sharing of best practices and emerging technologies in biotechnology workforce development at 134 biotechnology or biomanufacturing programs at community and technical colleges in 39 states.*

Newsletter and Social Media

The InnovATEBIO social media community is robust and active. Over the first four years of the grant, InnovATEBIO grew participation in their social media channels to 5,010 InnovATEBIO LinkedIn group members, 1,028 Facebook group members, and 760 X (formerly Twitter) followers. The InnovATEBIO newsletter is distributed to 2,240 college faculty, students and alumni, high school teachers, and government, trade association, industry, and workforce representatives. Thirty percent (30%) of the newsletter subscribers read the newsletter each month.

Webinars and Virtual Meetings

As part of the Goal One activities, InnovATEBIO supported the community by holding a variety of webinar series, virtual meetings, and events. To highlight a few of these in particular, the Spring 2020 webinar series was quickly developed in response to the community's requests for help through the social media channels as society shut down in March 2020 because of covid. In response, InnovATEBIO

⁵ See <https://innovatebio.org/publication/building-the-bioworkforce-of-the-future>

quickly pulled together the Spring 2020 webinar series, which consisted of 14 webinars that focused on how to take biotechnology education online.

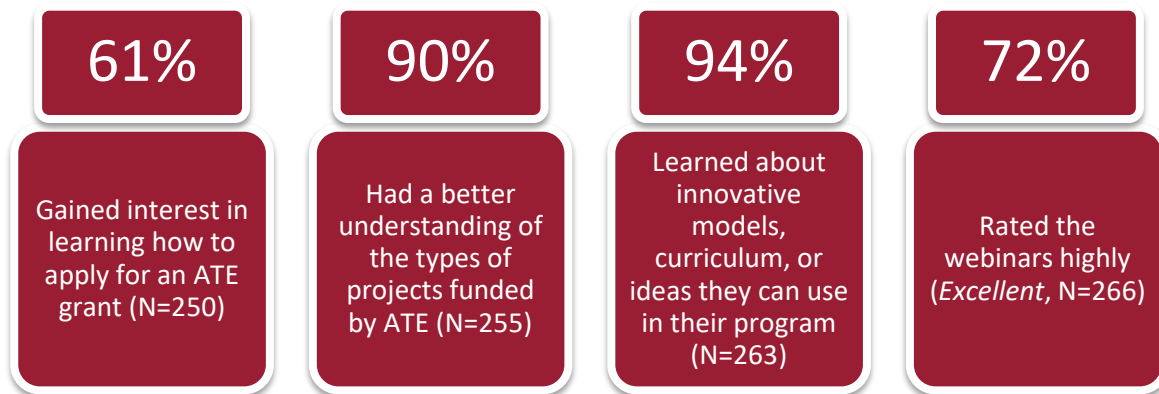
Surveys were administered after each of these events. In addition to measuring the extent to which the participants met the outcomes, the surveys also collect data on the usefulness of the event (and why respondents gave the event that rating) and suggestions for improvement. Survey results are returned after each event in a series, so the InnovATEBIO leads have timely information to fine-tune the events as the series progresses. When the series concludes, the evaluation team returns the summary results for the entire series. Survey summary memos are created for high priority events; these memos include analysis of the open-ended questions.

Table 2: Goal One Webinars, Meetings, and Events

Grant Year	Goal	Event Series	Number of Events	Number of Surveys
1	1	Webinar Series: Spring 2020 (Intensive Response to Covid)	14	12
2	1	Webinar Series: Fall 2020	3	3
2	1	Webinar Series: Spring 2021	2	2
2	1	Webinar Series: CRISPR	3	3
4	1	Webinar Series: Fall 2022	2	2
3, 4 & 5	1	Webinar Series: ATE Project Talks	29	29
3	1	Webinar Series: Advanced PCR	4	4
2	1	Webinar: 5-for-5	1	1
2 & 3	1	Meetings: InnovATEBIO Community Conversations	10	10
1	1	Event: The Future of Medicine Day	1	2
2	1	Event: Speed Networking	1	2
		Total	70	70

Another webinar series worthy of note is the “ATE Project Talks.” This is an annual series of webinars that provides a platform for bioscience-related ATE projects to introduce themselves and disseminate their materials to the community. The ATE Project Talks consisted of 18 projects presenting in nine webinars in 2022, 16 projects presenting in eight webinars in 2023, and 21 projects presenting in 12 webinars in 2024. In 2022, a total of 295 individuals attended at least one Project Talk, in 2023, the unduplicated total was 398 attendees, and in 2024 the unduplicated total of attendees was 233. The webinar recordings continue to be viewed online, an average of 226 views per webinar.

Through the 2022-2024 ATE Project Talks Webinar Series, attendees...



In line with the findings above, the percentage of respondents *very interested* in applying for an ATE grant rose from 37% before the webinars (N=186) to 54% after the webinars (N=196). (See Table 10 in Appendix for results per year.)

Themes from written comments highlight what the participants value in the Project Talks:

1. Valuable information and resources
2. Excellent avenue for networking, sharing best practices and common challenges, and dissemination for ATE-funded projects
3. Examples of innovative programs and processes sparked participants' interest in pursuing similar efforts

Selected quotations about the Project Talks include the following:

It helped me to have a clearer idea of how the [ATE] program works.

It was inspiring for someone just starting a program to see what's possible.

I can see how we can use many of their ideas at our college.

Glad to see these types of webinars with a way to quickly learn & engage with other ATE grants.

Goal Two

MENTORING

InnovATEBIO has provided mentoring for the community, in addition to ATE projects. Since the beginning of the grant, InnovATEBIO has mentored 116 individuals at 99 high schools and community colleges on a variety of topics, from writing ATE grants to setting up advisory boards. This mentoring contributed to community college faculty receiving funding for 34 biotechnology-related ATE projects.

In addition to mentoring individuals, InnovATEBIO provided ATE projects with their own pages on the InnovATEBIO website and gave them the opportunity to introduce themselves to the community through the ATE Project Talks webinar series. (See Goal One above.)

UNDERGRADUATE RESEARCH

In 2019, InnovATEBIO recruited seven Undergraduate Research Institutional Partners, along with an additional five colleges with ATE projects were added to the network. These five additional colleges did not receive any financial support from InnovATEBIO as they were able to support their undergraduate research with their own funds.

InnovATEBIO Undergraduate Research Institutional Partners	Additional Colleges (with self-funded undergraduate research)
1. Austin Community College (TX)	1. College of Alameda (CA)
2. Indian River State College (FL)	2. Green River College (WA)
3. Kansas City Kansas Community College (KS)	3. North Arkansas College (AR)
4. Kennedy King College (IL)	4. Pima Community College (AZ)
5. Northampton Community College (PA)	5. Whatcom Community College (WA)
6. Northern Virginia Community College (VA)	
7. Southeast Community College (NE)	

The pandemic delayed the launch of InnovATEBIO’s undergraduate research initiative. In 2021, InnovATEBIO kicked off this initiative with a virtual Undergraduate Research Strategic Planning Workshop. Eleven (11) of the 12 colleges in the network attended this workshop. (See follow-up results on the value of this workshop below.)

In the ensuing years, InnovATEBIO supported the Undergraduate Research Institutional Partners through providing ongoing mentoring in grant proposal development, strategic planning, and curriculum development, as well as by holding the Undergraduate Research Skills Workshop May 13-15, 2023, in Portsmouth, NH. (See follow-up results on the value of this workshop below.)

InnovATEBIO also developed two research projects to disseminate to the partners. In addition, the InnovATEBIO Summit provided students with the opportunity to present research posters. (See Student Data section above.)

InnovATEBIO also continued to work closely with the Micro Nano Technology Collaborative Undergraduate Research Network. InnovATEBIO students completed academic-year and summer research experiences through this NSF-funded network.

Current Status

Five of the seven InnovATEBIO Undergraduate Research Institutional Partners reached the implementation phase in the 2023-2024 school year. The other two colleges are piloting elements of their plan in the spring of 2024 and plan a full implementation in the Fall of 2024.

InnovATEBIO Undergraduate Research Institutional Partners	Current Status of Undergraduate Research (as described by partners)
Austin Community College (TX)	Piloting components of research plan
Indian River State College (FL)	Piloting components of research plan
Kansas City Kansas Community College (KS)	Project involving the effect of 2-deoxy-D-glucose on the proliferation of kidney cells as proposed cancer therapeutic. Includes analysis by Flow Cytometry, western blotting, pcr (real-time)
Kennedy King College (IL)	CURE into General Biology I course (one section) implementation in Spring 2022. Project involves synthetic biology using International Genetically Engineered Machine (iGEM) to demonstrate techniques DNA extraction, restriction digestion, gel electrophoresis, plasmid prep and transformation, bioinformatics, sequencing
Northampton Community College (PA)	Projects involving DNA barcoding to identify and study biodiversity of local plants using rbcL gene. Developing collaborations with local organic farms and industries. Course embedded – Biology I/II, Genetics, Biotechnology

Northern Virginia Community College (VA)	DNA Barcoding with individual student projects. Local industry partnerships for project development with industry focus– Quest Diagnostics, ATCC, Ceres Nanosciences, Bode Technologies. External academic internships – George Mason University, George Washington University Other academic collaborators – Cold Spring Harbor, James Madison University Typically UREs taking place over the summer, one CURE implemented in BIO 101 Fall 2021 (Meyering)
Southeast Community College (NE)	Project in collaboration with industry partner Neogen, animal genomics, to genotype hyper sociability in dogs (PCR, genomics, DNA barcoding). Piloting course-embedding of dog project in some sections of General Biology, Biotechnology labs. Building student projects including DNA Barcoding in Biology I. Implementing a supply chain project with HS Biotechnology classes. Developing projects to incorporate bioprocessing and process development (DOE)

Undergraduate Research Institutional Partners’ Feedback

Seven (7) individuals affiliated with the InnovATEBIO Undergraduate Research Institutional Partners (UR Partners) completed the 2024 Community Survey. The survey included several open-ended questions for the UR Partners, which asked if UR has been implemented, and, if so, how; what InnovATEBIO’s role or contribution was to the development of UR at their institution; and to describe any impacts of UR.

Table 3: InnovATEBIO Undergraduate Research Institutional Partners Follow-up (N=7)

How UR Is Incorporated	
<i>Has undergraduate research been implemented at your institution? If so, please describe how undergraduate research has been incorporated into your courses, program, or institution.</i>	All but one of the UR Partner respondents indicated that UR is taking place at their institutions. The UR is typically course-based, and in several instances takes place in the general biology courses, as well as biotech courses. Specific projects include K9 CURE, Caffeine SNP CURE, DNA Barcoding CURE, and SEA PHAGES. The one respondent who has not implemented UR noted that they were waiting to acquire important equipment.
InnovATEBIO’s Contribution to UR	
<i>What was InnovATEBIO’s role or contribution to the development of undergraduate research at your institution?</i>	InnovATEBIO’s contribution to UR at the institutional partners included “connection and collaboration,” “support, interactions, and discussions with others,” the InnovATEBIO UR Skills Workshop, the financial support provided to UR Partners, and sharing optional UR projects appropriate for a course.
Impacts of UR	
<i>Have you seen any impacts of undergraduate research in your students, teaching, courses, and/or institution? If so, please describe.</i>	Impacts of UR included increased student interest in research and increased student and teacher excitement about labs.

2023 Undergraduate Research Skills Workshop Follow-up

The 2024 Community Survey asked a series of follow-up questions about the Undergraduate Research Skills Workshop, which took place in May of 2023, 10 months prior to the survey. Among the nine respondents who attended the workshop, all (100%) have found value in it: four (44%) indicated that it has been *Very valuable* for them, and five (56%) marked that it was *Valuable*. No one selected the options *A little Valuable*, *Not valuable at all*, or *Not sure*.

Table 4: 2023 Undergraduate Research Skills Workshop Follow-up (N=9)

100%	Found value in the workshop	44% <i>Very valuable</i> 56% <i>Valuable</i>
56%	Implemented something from the workshop	Starting a CURE Purchased 2 bioreactors, developing labs Ordered fermenter and nanopore sequencer, plan to use this semester
~70	Students have been exposed to the workshop material	
22%	Have changed their Student Learning Outcomes as a result of the workshop	

In written comments, participants described how the workshop has been valuable for them:

Learning new skills and techniques has been valuable in...

- Developing new course material, revising existing courses, and integrating new techniques,
- Providing hands-on training on equipment, and
- Writing grants.

Through the workshop, participants...

- Learned new skills and techniques,
- Expanded their “understanding of the sectors that biotech programs serve, and the range of certificates and degrees that different biotech programs offer,”
- Broadened their network of biotech educators around the country, and
- Deepened their “insight into the importance of URE in bridging equity gaps.”

2021 Undergraduate Research Strategic Planning Workshop Follow-up

To support the development of undergraduate research experiences (URE) in biotechnology programs, InnovATEBIO began accepting applications for undergraduate research institutional partners in February of 2021. Seven institutions were chosen out of 17 that applied. To kick-off this initiative, the Center held a two-day Undergraduate Research Strategic Planning Workshop on May 6-7, 2021. Faculty and administrators from seven URE institutional partner colleges (33 participants) took part in the workshop, where they created a 5-year plan to develop/expand undergraduate research opportunities for students in biotechnology programs at their institutions.

The March 2024 Community Survey asked a series of follow-up questions about the Undergraduate Research Strategic Planning Workshop. Among the four respondents who attended the workshop, all (100%) have found value in it: one (25%) indicated that it has been *very valuable*, and three (75%) marked that it was *valuable*. No one selected *a little valuable, not valuable at all, or not sure*.

Table 5: 2021 Undergraduate Research Strategic Planning Workshop Follow-up (N=4)

100%	Found value in the workshop	25% Very Valuable 75% Valuable
75%	Implemented something from the workshop	
~2,048	Students have been exposed to the workshop material	
25%	Changed their Student Learning Outcomes	"Additional research-related learning outcomes were added to a second majors-level biology course"

Reflections on the workshop include the following, in the participants' own words:

This was the starting ground to our current ATE project so it was very valuable. We were able to meet with industry and admin to start forming ideas for undergraduate research. The idea didn't come during the workshop, but it gave us momentum to create it!

We continue to work that same industry partner. I think we have learned from the industry partner how to more effectively work from an efficient business and industry mindset instead how we often operate in academia. This has been a game changer for our industry meetings and relationships and we have achieved a lot since then!

We have now scaled up via our ATE grant and implemented this in local high schools and our biology classes. We didn't track the data prior to the start of this grant, but just in our local region we have impacted approximately 1500 high school students and 500 college students in the last two years. We also shared this curriculum with the InnovateBIO network and we know that BABEC will be implementing this with their high schools so the numbers are likely higher.

Goal Three

The major Goal Three activities discussed here are the Biosciences Leadership Institute and the InnovATEBIO Summit.

BIOSCIENCES LEADERSHIP INSTITUTE

The Biosciences Leadership Institute (BLI) ran from June 2021 to June 2022. There were 25 BLI participants, representing community colleges and high schools across the US. Due to the pandemic, the BLI was redesigned as a virtual program. The BLI involved viewing video lectures by subject matter experts; taking an assessment (the DiSC) to determine their leadership styles; reading leadership texts and biotech reports; and completing group case studies (on live business cases) and reporting the results back to employers. Participants then designed and implemented a project, where they applied what they learned to their own career. In June 2022, half the group traveled to Winston-Salem for their final presentations, and the other half made their presentations virtually.

In a post-survey at the close of the program (N=25, 100% Response Rate), 75% of the respondents indicated that they had learned something transferable to their day-to-day activities (N=20), and 79% marked that they had seen changes in themselves due to the BLI (N=24). Another 79% noted that they expected their experience at the BLI to be useful in leadership roles (N=24).

Bioscience Leadership Institute Follow-up

The InnovATEBIO Community Survey launched in March of 2024 included a section of follow-up questions for BLI participants, where they were asked to reflect on the BLI in the 21 months since they completed the program. These questions were answered by 12 of the 25 BLI participants, for a response rate of 48%.

75%

BLI was "very valuable" for them.

92%

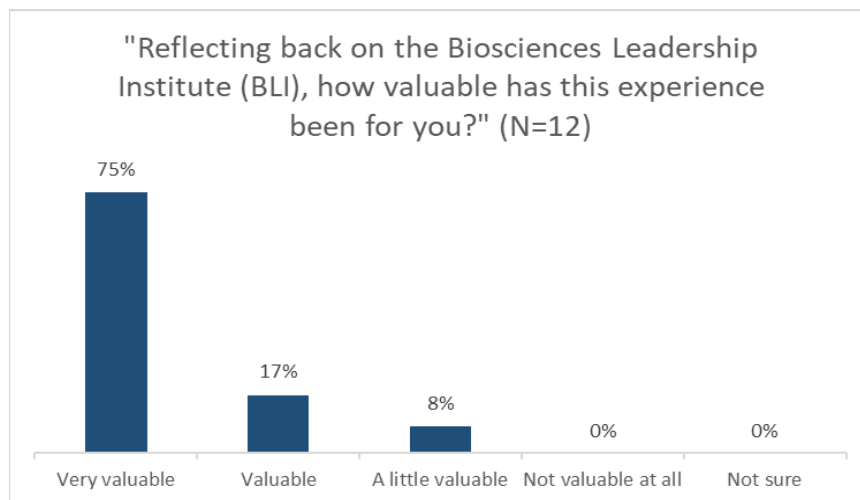
BLI helped them grow as a leader.

92%

Have applied something they learned in the BLI to their professional work life.

Reflecting on the value of the BLI, 75% of the respondents indicated that it was *Very valuable*; 17% marked that it was *Valuable*; and 8% (1 respondent) noted that it was *A little valuable*. No respondents selected *Not valuable at all* or *Not sure*.

Figure 4: Value of the Biosciences Leadership Institute



The survey provided respondents the opportunity write out 1) how the BLI has or has not been valuable for them, 2) in what ways they have grown as a leader,⁶ 3) what they have applied from the BLI to their professional work life,⁷ and 4) whether and how the BLI has impacted them or their career. Many of the same themes appeared across these questions so the themes are summarized below.

The Bioscience Leadership Institute...

- Provided an overview of the industry and its workforce needs
- Showed how industry and academia can collaborate

Participants...

- Developed skills: leadership, conflict resolution, time management, lab, teamwork, communication, interpersonal, management
- Recognized and leveraged their strengths
- Expanded their views on industry
- Strengthened their networks with educators and industry
- Better understood the industry and its workforce needs
- Learned how to set expectations
- Gained confidence and comfort presenting to industry

⁶ This question was only asked of respondents who marked "yes" to "Do you feel that the BLI helped you grow as a leader?"

⁷ This question was only asked of respondents who marked "yes" to "Have you applied anything you learned in the BLI to your professional work life?"

- Improved their interpersonal skills and, consequently, now work better with colleagues, managers, and teams they supervise

Accomplishments since the BLI⁸

- Awarded grants
- Developed new educational initiatives
- Invited to present on panels
- Hosted workshops
- Strengthened and expanded relationships with four-year colleges/universities and industry
- Led InnovATEBIO State Team
- Attained new leadership positions (e.g., Director)
- Earned tenure
- Took on new responsibilities in their current positions

BLI PARTICIPANTS: SELECTED QUOTATIONS

“BLI has been the most impactful training experience in every way. We collaborate with other instructors across the country. We were able to work on projects with industry leaders. What we did felt important and validating. We learned about industrial concerns and challenges with bringing a product to market. I built relationships with instructors I would have never met otherwise. I continue to grow as an instructor and as such, my class continues to evolve into a richer class. I will be forever grateful for my fellowship with BLI.”

“Participating in InnovATEBIO Biosciences Leadership Institute, a year-long program, was inspiring and already proved highly fruitful in furthering my academic career and, of course, helped develop my leadership skills immensely.”

“I am more confident, more knowledgeable (especially with industrial needs), I was able to collaborate with high level people who challenged me and helped me grow, I learned about my DISC style which helped me learn how to communicate more effectively, I continue to learn from my other BLI Fellows though we are scattered across the whole USA.”

“I feel that I am better equipped to listen to folks with varying viewpoints and backgrounds prior to making a decision. When leading meetings, I talk last to provide others the opportunity to share their thoughts and opinions.”

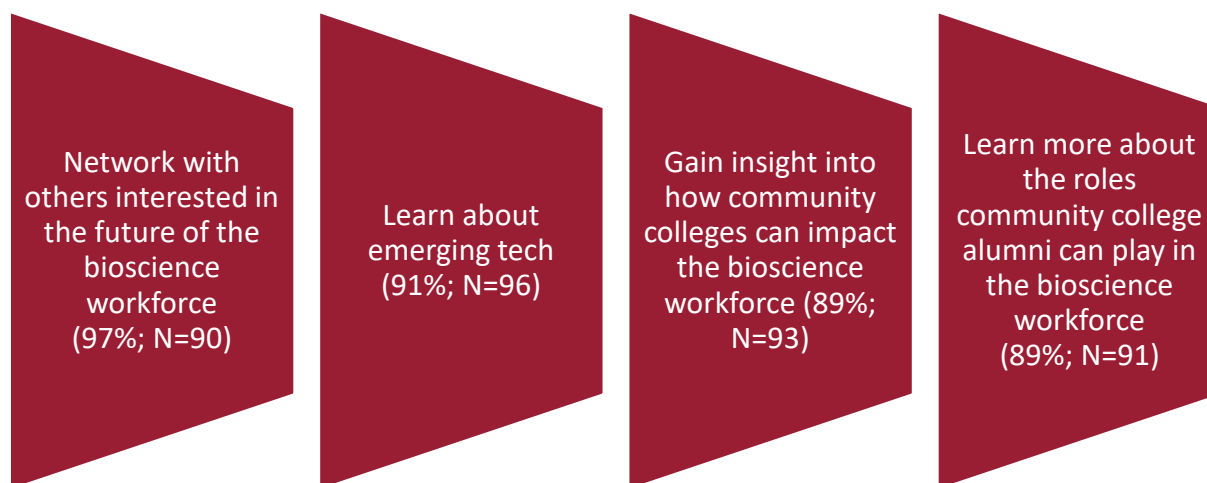
⁸Several respondents also pointed out that it’s difficult to attribute their current success to a single experience.

INNOVATEBIO SUMMIT: ENVISIONING THE NEXT BIOSCIENCE WORKFORCE

In grant year four, InnovATEBIO produced the *Envisioning the Next Bioscience Workforce: Summit on Industry Trends and Needs*, which included two advance virtual meetings, where state teams prepared for the Summit. The Summit was a two-day event held at the National Academies of Sciences in Washington, DC, on June 27-28, 2023, bringing together educators, industry, workforce, professional organizations, and others. A total of 272 participants attended the Day One vision conference, which featured presentations from bioscience industry insiders and career education leaders, and 126 continued on to Day Two, where 21 State Teams began to develop plans to address local and regional biotechnology workforce challenges.

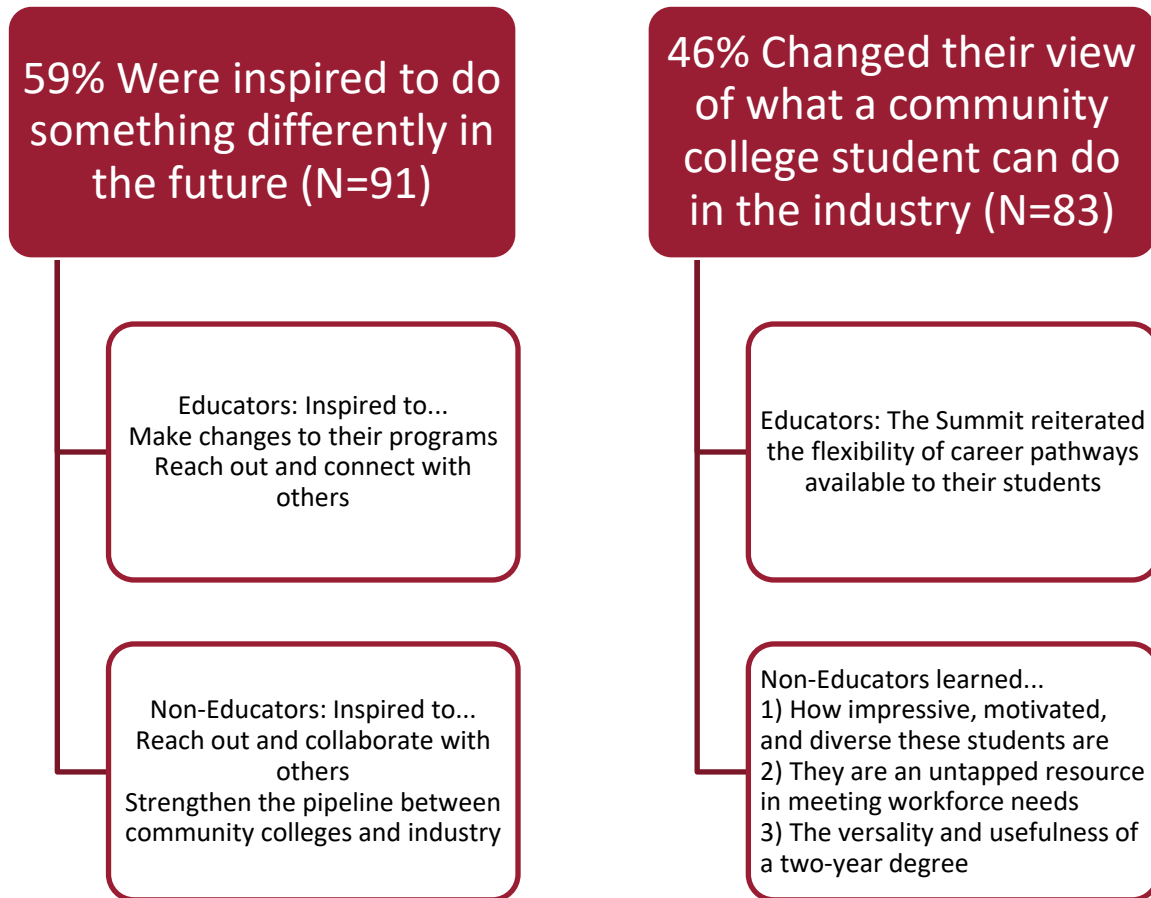
Since the Summit, the State Teams have continued to meet in grant year five, both independently and taking part in a series of InnovATEBIO virtual meetings. State Teams have resulted in new relationships (e.g., between community colleges and state BIO representatives in New York), as well as multiple full-day events and working groups (e.g., in Texas, North Carolina, California, and New York/New Jersey).

Day One of the InnovATEBIO Summit provided opportunities to...⁹



⁹ A survey was administered to participants at the end of Day One of the Summit. One hundred (100) of the 272 attendees completed the Day 1 Summit Survey, for an overall response rate of 37%. One-hundred and twenty-six (126) individuals attended the second day of the InnovATEBIO Biotech Summit. Forty-one (41) attendees participated in the Day 2 Summit Survey, for a 33% response rate.

Due to Day One of the Summit...



Due to Day Two of the Summit, State Teams...

84%	Had a better understanding of emerging bioscience trends
85%	Had a better understanding of the resources available to address gaps and challenges
82%	Were better prepared to respond to opportunities
82%	Were better positioned to contribute to enhancing the bioeconomy
97%	Identified common challenges
97%	Identified gaps
90%	Started to develop an action plan to address the gaps and challenges

Goal Four

Goal Four includes the InnovATEBIO Hubs, which are designed to be the “go-to place for specific expertise to create and support biotech programs in high schools and community colleges.”¹⁰ There are eight hubs, three of which are co-sponsored with their own ATE project grants.

Hub	Impact Data
1. Alumni Network ¹¹	See Student Data section of this report: Student-Industry Speed Networking
2. Careers and Entrepreneurship ¹²	See Student Data section of this report: Biotech-Careers.org
3. High School Pathways	Goal Four
4. Industry and Workforce Development	See Goal Three
5. Supply Chain	Goal Four
6. Student Research	See Goal Two
7. Genomics	Goal Four
8. Immunotherapy ¹³	See Student Data section of this report: Immunotherapeutic Biomanufacturing Classroom Kits

One of the major activities these hubs are responsible for is workshops. The 2024 Community Survey followed-up on 15 workshops that InnovATEBIO held in the first four years of the grant. A series of questions was asked for each workshop the respondent marked that they had attended. (See Table 6 for summary results and Table 7 for results per workshop.) The survey asked how valuable the workshop was and how it was or was not valuable; if they have implemented anything from the workshop; if so, what they implemented and how many students were exposed to the material; if not, what they need to

¹⁰ See <https://hubs.innovatebio.org/>.

¹¹ Funded through “Increasing Student Retention and Recruitment Through Alumni Programs, Speed Networking, and Industry Engagement” (NSF DUE 2202011).

¹² Funded through “A Bridge to Bio-Link’s Future” (NSF DUE 1764225).

¹³ Funded through “Establishing a Hub to Support Education of Biomanufacturing Technicians in Cell Therapy and Immunotherapy” (NSF DUE 1764225).

be able to implement; if their student learning outcomes changed as a result of the workshop and how they changed.

Overall, 94% of the respondents (N=120) indicated that the workshops they attended were *Very valuable* or *Valuable*. Over three-quarters of respondents (77%) implemented something from the workshop. An estimated 11,941 students have been exposed to the material.¹⁴ Almost half (49%) changed their student learning outcomes. In written comments, respondents described the value of the workshops, wrote out what they implemented, and explained how the student learning outcomes have changed. (See Table 9 for selected quotations per workshop.) Full survey results, including suggestions of what respondents who had not yet implemented need in order to implement, were returned to the leadership team.

Table 6: Summary: Follow-up of All InnovATEBIO Workshops (N=120 Respondents, 15 Workshops)		
94%	Found value in the workshops	67% Very Valuable 28% Valuable 3% A Little Valuable 0% Not Valuable at All 3% Not Sure
77%	Implemented something from the workshops	
~11,941	Students have been exposed to material from the workshops	
49%	Have changed their Student Learning Outcomes as a result of the workshops	

¹⁴ This is a conservative estimate of students exposed to the material because it does not account for faculty workshop attendees who did not respond to the survey.

Table 7: Follow-up of InnovATEBIO Workshops, Results per Workshop

Workshop	Count: Responses	Percentage: Workshop Was "Very Valuable" or "Valuable"	Percentage: Implemented	Percentage: Changed Student Learning Outcomes	Est. Number of Students Exposed to Workshop Material
Algae Workshop (2022)	6	100%	83%	50%	222
BABEC: Biotech Bootcamp (2022)	13	100%	85%	85%	1,820
BABEC: Introducing Biotechnology with Carbonation or Bacterial Transformation Workshops (2022-2023)	16	100%	81%	69%	3,303
BABEC: NABT Workshop (2021)	3	67%	67%	67%	310
BABEC: Workshop on Quality (2021)	12	100%	100%	58%	805
Biomanufacturing Workshops (2021)	12	92%	83%	33%	490
DNA Learning Center: Methods in Personal Genetics & DNA Barcoding Workshop (2022, 2023)	7	100%	86%	29%	530
DNA Learning Center: Nanopore Sequencing Workshop (2022)	1	100%	100%	0%	200
DNA Learning Center: Teaching Biotechnology Skills through DNA Metabarcoding Biodiversity Research Workshop (2022)	8	75%	38%	13%	275
High School Teacher Workshop (2022)	5	100%	100%	100%	360
PCR Workshop (2022)	13	77%	38%	31%	320
Process Development with Quality Integration Workshop (2021)	5	100%	100%	40%	123
Summer High School Series (Virtual, 2020)	6	100%	100%	67%	1,065

Workshop	Count: Responses	Percentage: Workshop Was "Very Valuable" or "Valuable"	Percentage: Implemented	Percentage: Changed Student Learning Outcomes	Est. Number of Students Exposed to Workshop Material
Undergraduate Research Skills Workshop (2023)	9	100%	56%	22%	70
Undergraduate Research Strategic Planning Workshop (2021)	4	100%	75%	25%	2,048
Total	120	94%	77%	49%	11,941

Table 8: Follow-up of InnovATEBIO Workshops, Detailed Responses on Value of Workshops

<i>Reflecting back on the event, how valuable has this workshop been for you?</i>	Count: Responses	Very valuable	Valuable	A little valuable	Not Valuable at All	Not sure
Algae Workshop (2022)	6	67%	33%	0%	0%	0%
BABEC: Biotech Bootcamp (2022)	13	92%	8%	0%	0%	0%
BABEC: Introducing Biotechnology with Carbonation or Bacterial Transformation Workshops (2022-2023)	16	81%	19%	0%	0%	0%
BABEC: NABT Workshop (2021)	3	67%	0%	0%	0%	33%
BABEC: Workshop on Quality (2021)	12	75%	25%	0%	0%	0%
Biomanufacturing Workshops (2021)	12	58%	33%	8%	0%	0%
DNA Learning Center: Methods in Personal Genetics & DNA Barcoding Workshop (2022, 2023)	7	71%	29%	0%	0%	0%
DNA Learning Center: Nanopore Sequencing Workshop (2022)	1	100%	0%	0%	0%	0%

<i>Reflecting back on the event, how valuable has this workshop been for you?</i>	Count: Responses	Very valuable	Valuable	A little valuable	Not Valuable at All	Not sure
DNA Learning Center: Teaching Biotechnology Skills through DNA Metabarcoding Biodiversity Research Workshop (2022)	8	38%	38%	13%	0%	13%
High School Teacher Workshop (2022)	5	80%	20%	0%	0%	0%
PCR Workshop (2022)	13	38%	38%	8%	0%	15%
Process Development with Quality Integration Workshop (2021)	5	80%	20%	0%	0%	0%
Summer High School Series (Virtual, 2020)	6	100%	0%	0%	0%	0%
Undergraduate Research Skills Workshop (2023)	9	44%	56%	0%	0%	0%
Undergraduate Research Strategic Planning Workshop (2021)	4	25%	75%	0%	0%	0%
Total	120	67%	28%	3%	0%	3%

Table 9: Examples of Respondent Quotes per Workshop: Value, Implementation, and Change in Student Outcomes

Workshop	Value	Implementation	Student Learning Outcomes
<i>Description</i>	<i>Please explain how this workshop has or hasn't been valuable for you.</i>	<i>[If indicated that they implemented something from the workshop] Please explain what you have implemented from the workshop.</i>	<i>[If indicated that their student learning outcomes changed due to the workshop] Please explain how your student learning outcomes changed.</i>
Algae Workshop (2022)	I was able to learn about algae which had little knowledge of.	We talk about algae as a potential resource in many areas of life, we grow algae and look at trends, we discuss how it might be applied to big issues.	Exposure to material, use of model organisms

Workshop	Value	Implementation	Student Learning Outcomes
<i>Description</i>	<i>Please explain how this workshop has or hasn't been valuable for you.</i>	<i>[If indicated that they implemented something from the workshop] Please explain what you have implemented from the workshop.</i>	<i>[If indicated that their student learning outcomes changed due to the workshop] Please explain how your student learning outcomes changed.</i>
BABEC: Biotech Bootcamp (2022)	This workshop was amazing. I have learned so much about biotechnology and how I can implement it into my classes and I have done just this. The BABEC team is fantastic and really sets educators up for success! I feel so much more confident teaching the lessons and labs in biotechnology after attending their bootcamp!	It allowed me to feel confident in setting up the reagents and equipment for my classroom and I gained technical knowledge, and skills from micropipetting to PCR.	Students are more engaged in curriculum and better able to assess their knowledge of classroom content by identifying and explaining what is happening in lab and how it connects to the content.
BABEC: Introducing Biotechnology with Carbonation or Bacterial Transformation Workshops (2022-2023)	I would not have implemented the labs without the support of the workshop. I needed the opportunity to "see" it and to have my questions answered before I felt confident enough to try it with my students.	I and other teachers in my department have implemented both these workshops, and without BABEC's support, we would be unable to have our biotechnology program at all. The school does not receive enough funding to afford the training nor the reagents and equipment.	Student engagement produces more focused questions during labs. Because these labs teach real biotech lab skills through an accessible lens... my students have been able to feel that ease and confidence with biotech labs. Their explanations and understandings incorporate a more connected understanding of how the variables interact, such as when they reflect on procedural errors that could have affected the yield of a lab.
BABEC: NABT Workshop (2021)	All the resources given to me were utilized in classroom settings and laboratory sessions.	Changed how I teach micropipette skills	The student's involvement and motivation in the class sessions increases.
BABEC: Workshop on Quality (2021)	I had heard about most of the topics, but did not know how to apply them. The workshop gave me some in-depth knowledge about the	The training programs at the 17 community colleges in LA County have instituted training in Quality Control.	It was added as a SLO in the biotech curriculum I wrote for the new courses.

Workshop	Value	Implementation	Student Learning Outcomes
<i>Description</i>	<i>Please explain how this workshop has or hasn't been valuable for you.</i>	<i>[If indicated that they implemented something from the workshop] Please explain what you have implemented from the workshop.</i>	<i>[If indicated that their student learning outcomes changed due to the workshop] Please explain how your student learning outcomes changed.</i>
	methods, and how to apply them.		
Biomanufacturing Workshops (2021)	The learnings from the workshop have been incorporated into our college curriculum. I believe we did the GMP popcorn lab in the workshop - which was incredibly helpful in understanding how the logistics of the lab work when it's implemented. There was also a workshop in 2021 where we discussed the different aspects of quality and did CAPA analysis - which was incredibly helpful as I had not previously been exposed to these practices.	I have implemented the IL-8 purification and manufacturing labs. Now have transitioned to NIST CHO for Fall 2024.	Better understanding of using mammalian expression system and downstream purification steps.
DNALC: Methods in Personal Genetics & DNA Barcoding Workshop (2022, 2023)	We implemented DNA barcoding in our Biology lab courses and have also mentored local high school students to do this project as well.	The Utah Museum of Natural History has implemented the DNA Barcoding program at select sites in Utah as a citizen science program.	<i>No applicable quotes</i>
DNALC: Nanopore Sequencing Workshop (2022)	it provided info and experience for me to effectively advise administrators on equipment purchases and applications to our classes. I could not have done this without the info gained at the program.	new equipment, application to classes, community outreach...	<i>No applicable quotes</i>

Workshop	Value	Implementation	Student Learning Outcomes
<i>Description</i>	<i>Please explain how this workshop has or hasn't been valuable for you.</i>	<i>[If indicated that they implemented something from the workshop] Please explain what you have implemented from the workshop.</i>	<i>[If indicated that their student learning outcomes changed due to the workshop] Please explain how your student learning outcomes changed.</i>
DNALC: Teaching Biotechnology Skills through DNA Metabarcoding Biodiversity Research Workshop (2022)	I have implemented a DNA Barcoding CURE in my biology class	I have used the information I learned in the workshop to help develop the project. We are not ready for the DNA metabarcoding part of the project yet. The main barrier is cost metabarcoding.	No applicable quotes
High School Teacher Workshop (2022)	State and regional networking to share lesson plans and exams.	I am utilizing the Bio-Rad textbook, utilizing several of the labs we did that week, following (for the most part) the course sequence that was shared there by other teachers, went on to take (and pass) the BACE that I heard about that workshop... I could go on and on.	Students have more confidence in applying the content and lab experiences in their future careers
PCR Workshop (2022)	It gave me great information and depth of information. My increased understanding makes it easier for me to explain to others.	Biorad CSI basic PCR kit. And I LOVE the basic Pipetting exercise that we did. It is very basic but works SO well for students learning to pipette. I will always and forever have it implemented when teaching micropipetting!	Knowledge of what qPCR is and how it is used. Previous to workshop we only did basic PCR.
Process Development with Quality Integration Workshop (2021)	Showed how process mapping could be easily incorporated into supply chain project to emphasize the importance of documentation and quality control checkpoints	Created process maps and documentation for supply chain project, teach reasoning for quality control checkpoints during reagents biomanufacturing	Having students collaborate and exchange ideas over RCA help with SLO/ILO and overall community aspect

Workshop	Value	Implementation	Student Learning Outcomes
<i>Description</i>	<i>Please explain how this workshop has or hasn't been valuable for you.</i>	<i>[If indicated that they implemented something from the workshop] Please explain what you have implemented from the workshop.</i>	<i>[If indicated that their student learning outcomes changed due to the workshop] Please explain how your student learning outcomes changed.</i>
Summer High School Series (Virtual, 2020)	This was a very intense workshop that covered the gambit of biotech for the high school classroom in one week. The networking that naturally comes from this was very beneficial. During the height of the pandemic, this provided timely training on how to take a hands-on biotech course and make it work in a virtual environment.	I implemented most of the modules that was covered during online teaching, now i still use the quiz games, LabXchange, and I know more it is just so embedded in my curriculum that I don't know what is from innovate and what isn't.	I focus on both knowledge and lab skills. I teach the PLTW Biomedical Science program. I had to implement Biotechnology I in the program. I can see the difference on the student's performance not just in the medical field but in any biotech field. They have a better perspective and understanding of biosciences.
Undergraduate Research Skills Workshop (2023)	It built a deeper insight into the importance of URE in bridging equity gaps.	Starting a CURE	<i>No applicable quotes</i>
Undergraduate Research Strategic Planning Workshop (2021)	This was the starting ground to our current ATE project so it was very valuable. We were able to meet with industry and admin to start forming ideas for undergraduate research. The idea didn't come during the workshop, but it gave us momentum to create it!	We continue to work that same industry partner. I think we have learned from the industry partner how to more effectively work from an efficient business and industry mindset instead [of] how we often operate in academia. This has been a game changer for our industry meetings and relationships and we have achieved a lot since then!	Additional research-related learning outcomes were added to a second majors-level biology course.

APPENDICES

ATE Project Talks: Results by Year

Table 10: ATE Project Talks, Results by Year

	2022 (9 webinars)	2023 (8 webinars)	2024 (11 webinars)
Gained interest (pre-post) in applying for an ATE grant	Pre: 34% <i>Very interested</i> (N=61) Post: 54% <i>Very interested</i> (N=67)	Pre: 30% <i>Very interested</i> (N=55) Post: 49% <i>Very interested</i> (N=61)	Pre: 46% <i>Very interested</i> (N=56) Post: 61% <i>Very interested</i> (N=56)
Gained interest in <u>learning how to apply</u> for an ATE grant	51% (N=100)	68% (N=85)	65% (N=65)
Had a better understanding of the types of projects funded by ATE	89% (N=100)	92% (N=88)	90% (N=68)
Learned about innovative models, curriculum, or ideas they can use in their program	88% (N=103)	96% (N=88)	99% (N=72)
Rated the webinars highly	68% <i>Excellent</i> (N=105)	75% <i>Excellent</i> (N=88)	73% <i>Excellent</i> (N=70)

2024 InnovATEBIO Community Survey Questionnaire

Welcome to the 2024 InnovATEBIO Community Survey! This survey asks for your feedback on how well InnovATEBIO is meeting your needs. Results will be used to plan future resources and initiatives. Survey results will also contribute to the InnovATEBIO evaluation, which will be shared with the National Science Foundation.

Your responses will be kept confidential by the InnovATEBIO independent evaluator, the Social and Economic Sciences Research Center at Washington State University.

Please note: Within the survey, the term “biotechnology” includes related bioscience areas, such as biomanufacturing.

1. Before receiving this survey, had you heard of InnovATEBIO?
 - a. Yes
 - b. No -> [Go to Q2, Q3, then Skip to Q14]
 - c. Not sure

2. Please select the institution type that applies to you. (Mark all that apply.)
 - a. K-12
 - b. 2-year college
 - c. 4-year college or university
 - d. Government
 - e. Biotechnology industry/company
 - f. Nonprofit
 - g. Other: (Please specify): _____

3. What is your role? (Mark all that apply.)
 - a. Educator
 - b. Administrator
 - c. Industry representative
 - d. Workforce development
 - e. Student
 - f. Biotechnology program alumni
 - g. Other: (Please specify): _____

4. Please review the list below and mark the ways you have interacted with InnovATEBIO. (Mark all that apply.)
- a. Webinars
 - b. Workshops
 - c. Hubs
 - d. Information on the InnovATEBIO website
 - e. Networking with colleagues
 - f. Summit: *Envisioning the Next Bioscience Workforce*, in Washington, DC
 - g. State Teams
 - h. Biosciences Leadership Institute
 - i. Undergraduate Research Partner
 - j. Workforce information, e.g., CSBI's *Life Science Workforce Trends Report*
 - k. Mentoring from InnovATEBIO leadership (including grant proposal development)
 - l. ATE PI Conference or HI-TEC Conference sessions or special interest groups
 - m. Community Conversations/Regional Community Meetings
 - n. Biotech Pathways for Disabled Students
 - o. Other: (Please specify): _____
 - p. None of the above
5. Has InnovATEBIO provided value for you? If so, please describe.
6. What three words would you use to describe InnovATEBIO?
7. Have your interactions with InnovATEBIO helped you to...

	Yes	No	Not Applicable
a. Develop new collaborations or projects?			
b. Gain knowledge or skills?			
c. Grow your professional network?			
d. Gain a better understanding of biotech workforce trends?			
e. Feel better connected to the biotech community?			

8. [If yes to Q7A “new collaborations or projects”] Please describe the new collaboration(s) and/or project(s).

9. [If Q3 = Educator or Administrator] Have your interactions with InnovATEBIO helped you to...

	Yes	No	Not Applicable
a. Develop a new biotech course or program?			
b. Strengthen your existing biotech course or program?			
c. Better align your biotech course or program with industry?			

10. Are you doing anything differently as a result of your interactions with InnovATEBIO?

- a. Yes
- b. No

11. [If yes above] What are you doing differently as a result of your interactions with InnovATEBIO?

12. What programs, services, or materials offered by InnovATEBIO are most valuable to you?

13. How could InnovATEBIO help you? What additional support or services would you like?

Professional Development Follow-up

14. Have you attended any of the following workshops? (Mark all that apply.)

- a. Summer High School Series (Virtual, 2020)
- b. Process Development with Quality Integration Workshop (2021)
- c. Undergraduate Research Strategic Planning Workshop (2021)
- d. Biomanufacturing Workshops (2021)
- e. Algae Workshop (2022)
- f. BABEC: Workshop on Quality (2021)
- g. BABEC: Biotech Bootcamp (2022)
- h. BABEC: NABT Workshop (2022)

- i. BABEC: Introducing Biotechnology with Carbonation or Bacterial Transformation Workshops (2022-2023)
- j. DNA Learning Center: Methods in Personal Genetics & DNA Barcoding Workshop (2022, 2023)
- k. DNA Learning Center: Teaching Biotechnology Skills through DNA Metabarcoding Biodiversity Research Workshop (2022)
- l. DNA Learning Center: Nanopore Sequencing Workshop (2022)
- m. High School Teacher Workshop (2022)
- n. PCR Workshop (2022)
- o. Undergraduate Research Skills Workshop (2023)
- p. None (if Q1 = no AND Q14 = none -> Skip to end of survey)

[For each workshop marked above, loop a set of Q15-Q22]

.....

15. Reflecting back on the [name of workshop], how valuable has this workshop been for you?

- a. Very valuable
- b. Valuable
- c. A little valuable
- d. Not valuable at all
- e. Not sure

16. Please explain how this workshop has or hasn't been valuable for you.

17. Have you implemented anything you learned at [name of workshop]?

- a. Yes
- b. No

18. [If Q17 = Yes] Please explain what you have implemented from [name of workshop].

19. [If Q17 = Yes] How many students were exposed to the material/information you implemented from [name of workshop]. (Estimates are fine.)

20. [If Q17 = No] What do you need to be able to implement what you learned in [name of workshop]?

21. Have your student learning outcomes changed as a result of [name of workshop]?
- a. Yes
 - b. No

22. [If Q21 = Yes] Please explain how your student learning outcomes changed.

.....

BLI Follow-up [If Q4 = BLI]

23. Reflecting back on the Biosciences Leadership Institute (BLI), how valuable has this experience been for you?
- a. Very valuable
 - b. Valuable
 - c. A little valuable
 - d. Not valuable at all
 - e. Not sure

24. Please explain how the BLI has or hasn't been valuable for you.

25. Do you feel that the BLI helped you grow as a leader?
- a. Yes
 - b. No
 - c. Not sure

26. [If yes above] In what ways have you grown as a leader?

27. Have you applied anything you learned in the BLI to your professional work life?
- a. Yes
 - b. No
 - c. Not sure

28. [If yes above] What have you applied from the BLI to your professional work life?

29. Has your experience in the BLI impacted you or your career? If so, please describe.

Follow-up of students who presented posters at Summit [If Q3 = Student or Alumni AND Q4 = Summit]

30. How valuable was your experience presenting a poster at the Summit, *Envisioning the Next Bioscience Workforce*, in Washington, DC?
- a. Very valuable
 - b. Valuable
 - c. A little valuable
 - d. Not valuable at all
 - e. Not applicable
31. Please explain how your experience presenting at the Summit was or was not valuable.
32. What are your top two take-aways from your experience presenting at the Summit?
33. Do you expect that your experience presenting at the Summit will be useful in your studies or career?
- a. Yes
 - b. Maybe
 - c. No
34. [If yes or maybe above] Please explain how your experience at the Summit may be useful in your studies or career.
35. Do you have any additional comments about your experience at the Summit?

Undergraduate Research Partner Follow-up [If Q4 = Undergraduate Research Partner]

36. Has undergraduate research been implemented at your institution? If so, please describe how undergraduate research has been incorporated into your courses, program, or institution.
37. What was InnovATEBIO's role or contribution to the development of undergraduate research at your institution?
38. Have you seen any impacts of undergraduate research in your students, teaching, courses, and/or institution? If so, please describe.
39. Do you have any other comments you would like to share about your interactions with InnovATEBIO?