Board 241: Developing PLC and Robotic Automation Technician Certificate Program for Service Industries

Dr. Shouling He, Vaughn College of Aeronautics and Technology

Dr. Shouling He holds a position of professor of Engineering and Technology at Vaughn College of Aeronautics and Technology, where she teaches various courses in Mechatronics and Electrical Engineering. Her academic and educational interests focus on Robotics and Automation, Machine Learning, and Mechatronics Education. She has authored over 50 papers published in journals and conferences.

Dr. Douglas Jahnke, Vaughn College of Aeronautics and Technology

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ABSTRACT

This project supported by NSF ATE (Award #2202107) aims to serve the national interest by addressing the shortage of technicians possessing the skills to maintain programmable logic controllers (PLCs) and robots in the service industries. Vaughn College program offers a PLC and Robotic Automation (PRA) Technician Certificate, consisting of 13 credits. It prepares technicians for roles in diverse service industries such as wholesale and retail, pharmaceuticals, food, and beverage, as well as airport baggage and cargo handling [1][2][3]. Additionally, all credits earned through the certificate program are transferable to the college's Mechatronic Engineering program. The college, designated as a Hispanic-Serving Institution, places a strong emphasis on recruiting students from low-income families and underrepresented racial and ethnic groups. The certificate program alleviates the financial burden and time commitment required for students to pursue education, providing them with the means to pursue advanced degrees or offer support to family members seeking greater opportunities.

The project's objective is to establish a one-year certificate program to provide PRA technicians with the essential skills for service industries. To ensure program graduates possess the desired qualifications, the project (a) collaborates with its Business and Industry Leadership Team (BILT) to identify industry needs and develop a curriculum to address them; (b) supports faculty in obtaining training and industry certifications; (c) recruits both high-school graduates, incumbent workers, and college students through newly developed informational materials. Additionally, to enhance diversity within the PRA Technician workforce, the program will collaborate with the college's existing initiatives to attract more female and racial and ethnic minorities. Advancements in the comprehension of technical education for service industries are disseminated through the college website and presented at regional and national conferences [4].

Key words: Robotic Automation, Service Industries, Technicians

INTRODUCTION

Vaughn College, situated adjacent to the busy airport runways of historic LaGuardia Airport (LGA) in New York City (NYC), is a small non-profit institution serving one of the most diverse communities in the nation. Designated by the Department of Education as a Hispanic-Serving Institution (HSI), it caters to a student body where 88% come from minority, low-income, first-generation, and new immigrant families. Simultaneously, it has been recognized by *US News and World Report* as one of the top regional colleges in the North, a distinguished institution for veterans and the leading school nationally for generational income growth.

The college features a well-established B.S. degree in Mechatronic Engineering (MCE), uniquely integrating mechanical, electronic, and computer engineering curricula. This comprehensive approach equips graduates with the knowledge and skills necessary for diverse fields, including Robotics, where those technologies continually converge. The college's MCE program achieved successful accreditation in 2013 and reaffirmed in 2019 by the Engineering Accreditation Commission (EAC). As the program has progressed, a collaborative faculty team spanning

mechanics, electronics, and computing and along with state-of-the art laboratories, has been instituted.

The engineering and technology department at the college has consistently acknowledged the importance of external reviews of our curriculum to ensure the satisfaction of industry needs. The Industrial Advisory Committee (IAC) convenes annually and has done so for the past 25 years. The IAC comprises representatives from industry, government agencies, academia, and other segments, offering advice on current industry trends and the latest state-of-art technologies. These close partnerships with industrial companies enable our students to explore careers and internship opportunities with leading engineering enterprises. Several IAC members are former graduates actively engaged in addressing the professional needs of the department.

Through collaboration with the IAC and former students now employed in the service industry, we have identified a gap in our workforce education and a demand for skilled PLC and Robotics technicians. The city stands as a prominent job hub for banking, finance, and communication in the U.S., doubling as a significant manufacturing center and shipping port. Due to its unique attributes, service industries play a pivotal role in the city's economy. According to the U.S. Census Bureau, service industries are those that produce intangible goods, more precisely services rather than physical products. Examples include warehousing and transportation services, professional and scientific-technological services, health care, and social assistance [5]. Despite the widespread adoption of PLCs and robots in various sectors of service industries, high school graduates and technicians in related fields lack the necessary skills.

With the expansion of service industries, numerous new job opportunities for PLC and robotic automation technicians have emerged, yet there is a lack of training programs to equip these technicians with the necessary skills. According to job posting data from Burning Glass, compiled from 07/2020 to 06/2021 for the New York-Newark-Jersey City, NY-NJ-PA Metropolitan Statistical Area (MSA), there were 1,655 PRA technician positions. These positions exhibit a projected growth rate of 44.6% over the next 10 years [6]. The table below outlines the top ten employers for PRA technicians in the greater metropolitan area, with a notable majority being in the service industry.

Table 1: Top Ten Employers

No	Employer	Industry	Job Postings
1	Jones Lang Lasalle Inc.	Real Estate and Rental and Leasing	51
2	Brookhaven National Laboratory	Professional, Scientific, and Tech. Services	24
3	Honeywell	Wholesale Trade	17
4	GlobalFoundries	Semiconductor	16
5	Anheuser-Busch Companies, Inc	Brewing – Food Services	15
6	Domino's Pizza	Accommodation and Food Services	15
7	US Government	Public Services	15
8	Amazon	Wholesale Trade / Warehouse	14
9	Fancort Industries	Robotic Tooling and Automation Equipment	14
10	Cornerstone Building Brands	Commercial Construction	12

Upon reviewing colleges in the metropolitan area, it was observed that no certificate programs are available to train PRA technicians for the technical roles required by service industries. Additionally, due to the high cost of living in the city, most service industry companies prefer to hire regional residents, as relocating individuals can be challenging. This emphasizes the necessity for a certificate program that addresses this gap and equips students with the essential skills for these technical jobs. To fulfill the need of service industries, PRA technicians should possess solid skills in PLC and robot installation, maintenance, troubleshooting and repairing. Moreover, they should have an essential understanding of fundamentals, enabling them to adapt to new PLC or robotic systems introduced in various workplaces, be it a hospital, warehouse, or other environments. Table 2 illustrates the top 10 co-occurring skills for PRA technician jobs and the number of local postings for those job skills [6].

Table 2: Top 10 Co-occurring Skills for PRA Technician Jobs

Skills (Specialized)	**Postings**	**Skills**	**Postings**
PLC Programming	1,146	Servo Drives/Motors	340
Repair	937	Electrical Diagrams/Schematics	331
Machinery	398	Robotics	321
Predictive/Preventative Maintenance	396	Packaging	290
Schematic Diagrams	365	Wiring	290

To ensure the successful education of PRA technicians with the necessary skills, the college is actively recruiting individuals from the service and automation industries to form a BILT team. The program faculty will collaborate with the BILT team members to develop a curriculum that incorporates experiential and project-based learning, addressing real-world problems from the service industry. This approach aims to facilitate a seamless transition from the classroom to the workforce.

At the college, most of the program's prospective students from partner high schools, or the adult community are individuals from underrepresented minorities, low-income and new immigrant families as well as those who are first-generation college students. One of the significant challenges for these students is the necessity to work to support themselves and their families while simultaneously meeting their tuition obligations to the college. As they transition into adulthood (>18 years old), many families aspire them to secure employment to support younger siblings and parents. Consequently, despite holding high expectations and dreams, these students encounter obstacles on their path to completion. The PRA-TTSI program aims to offer this population of students with an enriched hands-on opportunity, enabling them to earn a certificate to qualify them for a well-paid position upon immediately entry into the workforce. This can establish a financial foundation, allowing them to pursue higher degrees (associates, bachelors, etc.) if they choose to do so. Historically, Hispanic students have shown a tendency to pursue technician jobs that only require a certificate [7]. The transformation of existing programs and the development of new degree pathways will particularly benefit Hispanic and low-income students, empowering them to apply their knowledge and skills to ascend the STEM career ladder from a foundational to an advanced level. By enrolling the certificate program, students will acquire essential STEM knowledge and hands-on skills, boosting their confidence as they pursue future careers in the STEM field. Particularly, nowadays, due to artificial intelligence as

well as autonomous technology development, the learned knowledge of troubleshooting and problem-solving skills would help them keep their jobs in the intensive competitions.

OBJECTIVES, ACTIVITIES, AND DELIVERABLES

The goal of the PRA-TTSI project is to address the demand for proficient PRA technicians in regional service industries. This will be achieved by creating a certificate program that provides students with industry-validated skills in PLC and robot installation, maintenance, and troubleshooting, essential for securing employment as PRA technicians. Three supporting objectives are outlined in the following tables along with corresponding activities, deliverables, responsible parties, and timelines.

Table 3: Project Objective#1

Objective1: Incorporate the knowledge, skills, and abilities required for PRA Technicians into a one-year certificate program		
Activities	**Deliverables**	**Responsible Party**
1.1 Build the BILT and engage with them to determine employer needs in service industries	BILT meeting agenda and minutes.	● PI ● Co-PI
1.2 Collaborate with the BILT to develop and evaluate the curriculum and identify other employers and workers to participate in the curriculum development.	Program curriculum and sample syllabi are submitted to the State Education Department for approval by the end of 1st year.	● PI ● Co-PI
1.3 Faculty visit the industrial companies to gain experience for PLC and robot maintenance & troubleshooting issues existing in service industries.	PRA-TTSI team with high confidence & a strong commitment to educating students on necessary industry skills. Two industrial adjunct faculty will be hired to teach by the 3rd year.	● PI ● Co-PI
1.4 Assess industry satisfaction with the preparation of the program and student learning outcomes	A survey of industry satisfaction will be produced. 80% of industry partners will indicate satisfaction with the program by end of the 3rd year.	● PRA-TTSI team ● External Evaluator

Objective#1: The PRA-TTSI team will utilize its extensive experience collaborating with the IAC committee to develop the BILT team for this program. The college will actively seek members for the BILT from local service industry organizations. Collaborating with the BILT, the PRA-TTSI team will assess and refine the program curriculum to address the knowledge, skills, and abilities (KSAs) required by the industry at the highest level. The evaluation process is designed to be iterative and ongoing, ensuring that the curriculum, including class learning outcomes, laboratory exercises, and technology applications, remains current and adaptable to meet ongoing service industry needs. Additionally, the PRA-TTSI team will visit industrial companies to gain firsthand knowledge of PRA applications in service industries and discuss the skills necessary for PRA technicians. Additionally, adjunct faculty will be hired from service industries to teach certain courses, fostering an active connection with the industry.

Table4: Project Objective #2

Objective 2: Develop new courses and restructure existing courses to align them with the need of service industries		
Activities	**Deliverables**	**Responsible Party**
2.1 Develop classes that incorporate industry-recognized competencies and hands-on learning into the course curriculum	Two new courses (MCT 410 and MCT265) will be developed, and three existing courses (MCT 117, MCT 230 and MCT101) will be-revamped by end of the 2nd year.	● PI ● Co-PI ● Hired instructors
2.2 Purchase two sets of Allen-Bradley PLCs with the corresponding design software environment as well as hardware tools to enhance students' practical experience.	New laboratory devices and handouts are prepared for lab exercises by the end of the 2nd year.	● PI ● Co-PI ● Hired instructors
2.3 Provide faculty with professional training opportunities to obtain industry-recognized certifications	Faculty obtain credentials in Allen-Bradley PLC programming, and motor integrated motion on Ethernet/IP in the end of the 2nd years of the grant period.	● PI ● Co-PI ● Hired instructors

Objective#2: The program faculty will collaborate with the BILT to establish an effective connection between the classroom and industry, developing new courses and revising existing ones to meet the needs of potential employers in service industries. This effort will involve creating exercises and projects that expose students to challenges commonly encountered in their workplaces. Table 5 shows the new and updated courses designed for the PRA-TTSI certificate program. These courses will be modified to enhance the focus on hands-on learning, incorporating lab exercises, including industry-oriented exercises and projects.

Table 5: Courses Covered in the Program

Courses that will be Modified for the Certificate	
MCT 101 Robotics Technologies	Introduces industrial robotics as well as a survey of the technologies and equipment used in manufacturing automation and control. Includes robotic arm work envelopes, & basic programming. Incorporate a survey of automation topics including computer, hardwired controls, sensors and transducers, motors, and actuators. The updated content: robotic arm calibrations, troubleshooting & maintenance.
MCT 117 Electrical Circuit Analysis and Implementation	Covers the fundamentals of D.C. & A.C. electrical systems used for automation and robotics, including basic electrical circuits, electrical measurements and instruments, circuit components & analysis, inductance, and capacitance, and ideal transformers and corresponding theorems. The updated content: circuit wiring safety, safety standards, and health act (OSHA), and shop practices in circuit wiring and wire connection

MCT 230 Digital Logic &Fundamentals of PLCs	Covers the fundamentals of digital logic and PLCs as they are applied in robotics and automation, including number systems, Boolean algebra, logic gates and circuits, flip-flops and registers, counters, timers, memory addressing, as well as the basic PLC programming in Ladder (LAD) and Function Block Diagram (FBD). The updated content: troubleshooting, and maintenance (Siemen S7-1200 PLCs and Human Machine Interface will be used in the lab exercises.)
New Courses to be Developed for the Certificate	
MCT 250 Automation Industry Machinery and Equipment	Explains the basics of the theory, operation, and maintenance of equipment in industry environments with a focus on robotics and automation devices, including a study of general mechanical aspects of the equipment, wiring symbols and diagrams, relay ladder logic, and three-phase power. Motors will be also introduced as well as various switches and contactors, reversing contacts, and variable frequency drives (VFDs) for control.
MCT 410 Allen-Bradley PLCs and Industrial Networking	Covers advanced topics PLC applications in industrial automation, including advanced FBD and Ladder programming with sequence control design, diagnostics, system integration of multiple stations via computer networking. Incorporates lab and project activities that address designing, monitoring, multi-PLC connectivity, troubleshooting, and repairing PLC-controlled industrial equipment as well as the applicable skills on automated lines.

All credits earned from the certificate program are transferable to the MCE B.S. degree program at the college. Should a student opt to commence the certificate program and later decide to pursue the B.S. degree in Mechatronic Engineering at the college, all program credits can be applied towards the B.S. degree requirements.

Presently, the program team faculty have diligently worked towards achieving specialty industrial certifications, including Robots, PLCs and Automation, Industrial Electricity and Equipment, Motor and Motor Controls certifications, aiming to complete them by the end of year two.

Table 6: Recruiting and Retaining Students

Objective 3: Recruit and retain a diverse body of high-school students and incumbent workers, including women and low-income minority students, into the PAR-TTSI program		
Activities	**Deliverables**	**Responsible Party**
3.1 Create multimedia materials targeted at high school & non-traditional students or incumbent workers.	Brochures, posters, and videos will be available on the PRA-TTSI page of the Vaughn website by end of the 2nd year.	● PI ● Co-PI
3.2 Recruit students from four local high schools through digital marketing materials, & annually recruiting events.	Enroll 10 students in the certificate program in the 3rd year.	● VCAT ● PI ● Co-PI
3.3 Engage high school students in various events – workshops, robot competitions & science fairs and serve as a career coach.	Host student recruiting events with presentations and demonstrations of PLC controlled robots in the 2nd and 3rd years.	● PI ● Co-PI

3.4 Participate in the STEP and Upward Bound programs and identify women & minorities, serve as a mentor to present career opportunities	80% of students enrolled in the program will be low-income or minority students and 30% of students will be women.	● PI ● Co-PI
3.5 Invite industrial partners & MCE senior students as mentors to help PRA-TTSI students with techniques and career development.	Recruit mentors from industry partners (2) and MCE students (2) to support women and minority students in PRA-TTSI by the 3rd year.	● PI ● BILT

Objective#3: Educational pathways will be established for high school and non-traditional students, as well as incumbent workers seeking to become PRA technicians or update their skills. The PRA-TTSI team will primarily collaborate with four local high schools. Additionally, the program will be promoted through regional robot competitions and the Annual Science Fair held in the County. The PRA-TTSI team aims to enroll ten students into the program during the 3rd year of the grant period. Furthermore, the recruitment efforts of the PRA-TTSI program will specifically target women, low-income individuals, and traditionally underrepresented minorities, as outlined in the detailed plan provided in Table 6.

Project Timeline

The departments of admissions, financial aid, academic support services, as well as the engineering and technology department will collaborate to ensure compliance with the NSF-ATE requirements for the program. The detailed project timeline and activities are listed in Table 7.

EVALUATION PLAN

To comprehensive assess the success of the grant, data will be collected to measure the progress of each goal and objective throughout the project. The project will utilize internal PRA-TTSI resources within the college and an external evaluator. They will collaborate to refine the evaluation design and specifics, develop, and adapt the needed instrumentation, and oversee data security and analyses.

The evaluation process will encompass planning, formative, and summative methodologies. Firstly, a planning evaluation will be conducted to assess partner's understanding of the project goals, objectives, activities, and timelines. Secondly, a formative evaluation will assess and guide the project implementation, including its operations and processes. Finally, summative evaluation will be employed to assess the project outcomes and impact.

This will take place in the first period of the project's funding. Secondly, a formative evaluation will assess and assist to guide the project implementation, including its operations and processes. This will take place quarterly with reports forwarded to the external evaluator for review and consultation as needed. Thirdly, a summative evaluation will be used to assess the project outcomes and impact. Instruments for each evaluation level and type will be developed using the examples in the evaluation handbook. In all instances, appropriate methods of data collection will be employed, including focus groups, survey instruments, test results, and personal testimony. Results of the evaluation will be reported to the PI, for transmittal to the NSF as appropriate.

Table 7: Project Timeline

Goal: To meet the need of regional industries for skilled PRA technicians by providing industry-validated PLC and robot maintenance, and troubleshooting competencies									
Activities	**Year One**			**Year Two**			**Year Three**		
Objective One Activities	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring
Activity 1.1. Engage with the BILT to determine employer needs in service industries		x	x		x	x			
Activity 1.2. Collaborate with the BILT to evaluate the curriculum and identify new employers & workers to participate in the curriculum development.		x	x		x	x		x	x
Activity 1.3. Visit industrial companies to enhance faculty practical skills.		x	x		x	x		x	x
Activity 1.4. Evaluate industry satisfaction and student learning within the program annually.			x			x			x
Objective Two Activities	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring
Activity 2.1. Develop classes that incorporate industry-recognized competencies.			x		x	x			
Activity 2.2. Purchase laboratory equipment to augment the program.		x	x		x	x			
Activity 2.3. Support faculty participation in industry-recognized certification.		x	x		x	x			
Objective Three Activities	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring
Activity 3.1. Create and update multimedia materials targeted at both high school students, non-traditional and college students.					x	x		x	x
Activity 3.2. Recruit students from local high schools through digital marketing materials & annually recruiting events.						x	x		x
Activity 3.3. Engage high school students in various events - workshops, robot competitions & science fairs.		x	x		x	x		x	x
Activity 3.4. Join STEP & Upward Bound programs to recruit female and minority students	x			x			x		
Activity 3.5. Invite industrial partners & MCE students as mentors								x	x

Table 8: Logic Model

Goal: *To provide to the service industry skilled technicians with competencies in maintenance, troubleshooting, and fundamental programming of PLC, automation, and robotic equipment.*					
Needs	**Activities**	**Outputs/ Deliverables**	**Short Term Outcomes**	**Midterm Outcomes**	**Long Term Outcomes**
Local service industries need skilled PLC& robotic automation technicians for maintenance and trouble-shooting.	Faculty work with industrial partners to develop the curriculum for industry-required skills: PLC and robot maintenance, & troubleshooting skills.	Two new courses in Allen-Bradley PLCs & industry equipment will be developed. Three existing courses will be updated for more hands-on & troubleshooting skills.	Students demonstrate an ability to problem-solving strategies with the end goal that they are ready for life-long learning.	Improved connections between classroom knowledge and applications in the workforce	The program will strongly increase engagement and partnership between the college and local service industry partners.
Local low-income & new immigrant families require quick access to job skills to enter the technical workforce.	Opportunities for workplace visits to provide students direct experience in the application of the learned knowledge.	A 13-credit PRA-TTSI certificate program receives approval by the state and is added to college catalog. All course credits are transferable into the MCE B.S. program.	Students show hands-on troubleshooting skills. This primarily focuses on how theorems are translated to the solutions in the real world.	Students persist in the PLC and robotic automation technician training program and earn college credits from the courses.	Ten graduates with necessary skills to enter the PRA workforce directly at a heightened employment rate.
Students lack direct hands-on skills of the careers in the automation & robotics engineering fields.	Industry partners are invited to on-campus events: seminars or guest lectures to provide students with direct connections to industry.	PRA-TTSI program offers • Industrial connect seminars • Industry company visits • Industry-driven course projects	Students learn PLC& robotic automation skills by participating in industry seminars, industry visits, and industry driven course projects per year	Enhanced student capability leads to an increase in students completing course projects and engaging in career-related activities.	Students are prepared for advanced study in PRA area, or other STEM degrees, including to transfer credits to a B.S. program.
Faculty need professional development to serve service industries	Faculty pursue industry certifications and enhance practical skills with the help of industrial partners	Faculty educate students on necessary skills in service industries. Two industry partners will be hired for teaching.		The project's findings shared with the PLC and robotic automation communities.	

DISSEMINATION PLAN

The engineering and technology department at Vaughn College will ensure that program outcomes are shared at both local and national levels through various channels. Internally, a presentation will be delivered at the annual assessment meeting and outcomes will be incorporated into the college website. The program team will disseminate the project curriculum, courses, and outcomes to serve as models for PRA-TTSI programs in the region and nation via the following activities:

Dissemination to a Local Audience

- **College Journal of Engineering and Technology** Published annually by the engineering and technology department, this journal encompasses the yearly events and activities of the department. It highlights student engagement and club activities, including competitions such as Robotics and UAV (Unmanned Aerial Vehicle), along with student participations in national conferences of professional organizations, such as SWE (the Society of Women Engineers), IEEE (the Institute of Electrical and Electronics), ASME (the American Society of Mechanical Engineers), etc.

- **Industry Connection Seminar** For over a decade, the engineering and technology department has been organizing an annual industry connection seminar. The seminar aims to improve student outcomes in communication and lifelong learning. Considering the rapid advancements in engineering and technology, the seminar is designed to disseminate relevant material and help students cultivate a mindset acknowledging the constant evolution of technology. It underscores the necessity of lifelong learning to meet future professional challenges.

- ***Annual Manufacturing Day (AMD) Conference*** The engineering and technology department initiated the AMD conference to commemorate National Manufacturing Day. Industry leaders are invited to speak to the local community and guests about the latest manufacturing innovations.

Dissemination to a National and Regional Audience

- **National Conferences** The curriculum will be archived through the ATE center. Throughout the grant period, the project team will be expected to attend the annual NSF ATE PI Conference, the NSF HI-TEC Conference, as well as the ASEE Annual Conference. These conferences will have a substantial impact on the PRA-TTSI project, offering opportunities for program faculty to stay informed about rapid industry changes, establish connections with new industry partners and exchange experiences with other institutions sharing similar goals and objectives.

- **Regional and International Student Competitions** The dissemination of the PRA-TTSI program occurs at the regional and international student competitions such as VEX U Robotics. These competitions enrich students' hands-on experiences and creative thinking, equip them with the knowledge and skills needed for success in their professional careers.

- **Student Poster Competitions** Students in the PPA-TTSI program will be encouraged to present their innovative course projects in poster competitions at technical conferences. This

initiative enables the program to disseminate student outcomes among other colleges and universities. In previous years, students have actively participated in regional and national competitions at the conferences hosted by ASEE, ASME, IEEE, SEM (the Society for Experimental Mechanics) and LACCEI (the Latin American and Caribbean Consortium of Engineering Institutions), respectively.

CONCLUSIONS

This project has established an educational pathway to educate PRA technicians for the service industry. The program collaborated with service industry collaborators to develop a curriculum, ensuring that graduates can seamlessly transition to the workforce. Professional development initiatives enhance faculty capabilities, ensuring the delivery of up-to-date PRA technicians. Collaboration with industry partners fosters increased engagement between college faculty and the local service industry. Moreover, the program is structured to allow the transfer of all earned credits towards a bachelor's degree in Mechatronic Engineering at the college, encouraging students to pursue advanced education.

The certificate program offers a pathway to well-compensated positions in service industries as PRA technicians. Simultaneously, it reduces the financial and time commitment required for students to pursue education, thereby enhancing their upward mobility. This initial step towards greater security can empower them to pursue higher degrees or support additional family members in their pursuit of greater opportunities. Introducing this additional pathway to the college community will contribute to increased diversity in PRA technicians. Furthermore, the program aims to share learnings and best practices at regional and national conferences.

Currently, we are actively engaged in student recruitment from high schools and the incumbent workforce, particularly targeting women and individuals from underrepresented low-income and first-generation college families. We anticipate recruiting individuals from low-income and first-generation college families, as well as those from underrepresented racial and ethnic groups, to enhance the diversity of the PRA Technician workforce.

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