New Photonics Education and Training Program to fulfill the industrial needs in the Greater Seattle Area

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ABSTRACT

Lake Washington Institute of Technology (LWTech) is a publicly-funded workforce college located in Kirkland, WA. The newest addition to the college's programs list is a two year (AAS) degree in Lasers and Optical Technology which was recently approved. The program is designed for students who desire an entry-level job as a Photonics System Technician or a Specialist in one of the many Photonics companies located in the Seattle Area. In this paper, the authors outline briefly the new program's key elements including the motivation behind selecting this project, the degree pathway, methods of instructions, preparation progress, and the current recruitment activities.

Keywords: Photonics Education, Lasers and Precision Optics, Photonics System Repair, Laser Manufacturing, Fiber-Optic Communications, Optoelectronics, Imaging and Remote Sensing, Laser Light Show.

1. INTRODUCTION

The Importance of Optics and Photonics Education in the U.S.A.

Photonics is "the technology of generating and harnessing light and other forms of radiant energy whose quantum unit is the photon. The area of optics and photonics is typically subsumed as an enabling technology under the heading of other disciplines (e.g., electrical engineering, physics) [1]. It is a key enabling technology that impacts our society in a multitude of areas including information and communications, imaging and remote-sensing, security and defense, healthcare and medicine, energy, lighting, and manufacturing [2]. The growing importance of Optics and Photonics has been highlighted in a series of important reports from the United States National Academy of Sciences [1], [3], [4]. Thus, it could be understood that photonics education (academic and technical) plays a critical and important role in preparing qualified people and ensuring a vibrant and prosperous future for the nation's economy, industry, and many other market segments now, and many decades ahead [1]. Today, the United States has several outstanding universities, institutes of technology, and community colleges that educate students from around the world in dedicated hands-on skill building and research laboratories centered on Optics and Photonics. The field has also expanded greatly beyond the United States, such that many other countries have invested heavily in research and development, manufacturing, and excellent educational facilities [5].

The Need for Photonics Education in Washington State (WA).

In Washington State, manufacturing is approximately a $130 billion industry, with more than 7,000 manufacturing firms currently in operation, and photonics is a strong-growing part of this field. In the Greater Puget Sound region, defined here as the King and Snohomish counties surrounding Seattle, Photonics plays a key role in many manufacturing firms including defense, technology, and biomedical. These employers have "very high-tech" positions open, yet struggle to find skilled labor, and photonics is one of the fields where they have trouble filling open employment positions. A review of labor market data from 2013 showed more than 1,000 job openings in Washington State with a keyword search of '*optics.*' or '*photonics.*' of those postings, 590 were located in the counties surrounding Seattle. On the other hand, approximately 32% of the posted photonics-related technician jobs require specialists with an (AAS) degree or at least a couple of years of experience. The demand for technicians in these fields is at an all-time high, with a projected growth rate of between 5% and 9%. Starting salaries for an entry-level position are higher than the national average.

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Optics Education and Outreach VI, edited by G. Groot Gregory, Anne-Sophie Poulin-Girard,
Proc. of SPIE Vol. 11480, 1148005 · © 2020 SPIE · CCC code:
0277-786X/20/$21 · doi: 10.1117/12.2567314

Based on ONET survey data [6], and data from the Washington State Employment Security Department, the average annual wages in the greater Seattle area, include Seattle-Bellevue-Everett, & Washington is ≈ $65,090, annually or $31.30 for an hourly wage and has an in-demand status.

LWTech's Motivation and Action.

According to the SPIE's global directory of programs in optics and photonics education [5]; around eleven reported states and territories nationwide offer Associate degrees in Optics and Photonics education. This includes California, Florida, Idaho, Iowa, Massachusetts, Michigan, New Jersey, New York, North Carolina, Texas, and Puerto-Rico. There is not a single program in Washington State, therefore, to expand science, technology, engineering, and mathematics (STEM) based technical education programs, and especially to serve many regional photonics partners; LWTech was the first public college that decided to take the initiative by introducing a brand new two-year associate degree (AAS) program in (Lasers and Optical Technology) in the Greater Puget Sound region. The goal is to create another vital pathway for students to earn a better living wage. This new technical hands-on program will offer people a wide variety of rewarding employment opportunities, and great potential for personal advancement. Thanks to the strong relationships that LWTech shares with several industry partners, graduates can find an entry-level job in one of the local companies such as SpaceX, Boeing, Lockheed Martin, Korry Electronics, Stryker, Facebook, Microsoft, and Google. Employment opportunities also exist at national U.S. labs such as Lawrence Livermore National Laboratories (LLNL), Jet Propulsion Lab (JPL), or many others outside the U.S. In this article, LWTech's mission and the motivation behind bringing this specific kind of new technical education to the community are highlighted in the first section. The rest of the sections respectively discuss: a) the collaboration between the program with the local industries and academic organizations such as the University of Washington (UW) in terms of transferable training and internships, b) how the program's pathway is carefully crafted to provide a standards-based and accredited hands-on training experience in one package that covers several of the important areas of Photonics technologies in industry; c) the impact of the program on innovation and entrepreneurship, d) how it applies an interdisciplinary Project-Based Learning (PBL) approach for students; and e) the current program's activity progress on facility preparations, student recruitments and college's student services.

2. PROGRAM PARTNERSHIPS

As an open-door public college, LWTech's institutional mission is to "prepare students for today's careers and tomorrow's opportunities." To approach this goal, the college is always working on creating new/updated educational pathways that align with the local, regional, and national industry [7]. Working in partnership with business advisory committee members is one of the key duties that keep the college relevant to ensure the technical education is fulfilling employers needs. Hence, one of the initial phases of inaugurating the new (LOT) program was developing strong connections and communications with our partners to also include Photonics education advisors (e.g. the National Center for Optics and Photonics Education (OP-TEC), Waco, TX, and the International Society for Optics and Photonics (SPIE), Bellingham, WA), and academic organizations (e.g. the University of Washington (UW), Seattle, WA), and significantly industry advisors.

The college is privileged to have a diverse group of stakeholders including representatives of local manufacturing partners such as Lockheed Martin Corporation, Synrad (A Noventa company), Olympus, Stryker, Microsoft. And from national laboratories such as Lawrence Livermore National Laboratory (LLNL), Jet Propulsion Lab (JPL), and others. This collaboration is indeed working to forge closer cooperation between industry and technical education. On behalf of the college community, the authors deeply express their gratitude for every member who decided to serve the community, contribute to the success of the college mission, and make a positive impact on public technical education.

Upon the recommendations of several college/advisory meetings, the new (LOT) program is designed to support the three broad categories of photonics technicians that could be found in many firms in the greater Seattle area, abridged as the following: a) Photonics specialists. These technicians work in research and development (R&D) laboratories as team members for original equipment manufacturers in lasers, optics, and photonics and as field service techs. b) Photonics-Enabled-Technology technicians. These technicians typically work in industries in which photonics technology enables processes to be accomplished at higher efficiencies or with greater precision. The use of lasers in manufacturing for cutting, welding, measuring, and aligning is an example of this "enabling" principle. c) And lastly, for serving Incumbent Workers who require continuing education. These technicians are already employed but require additional training to advance in their fields or to adapt to changes in the workplace [8].

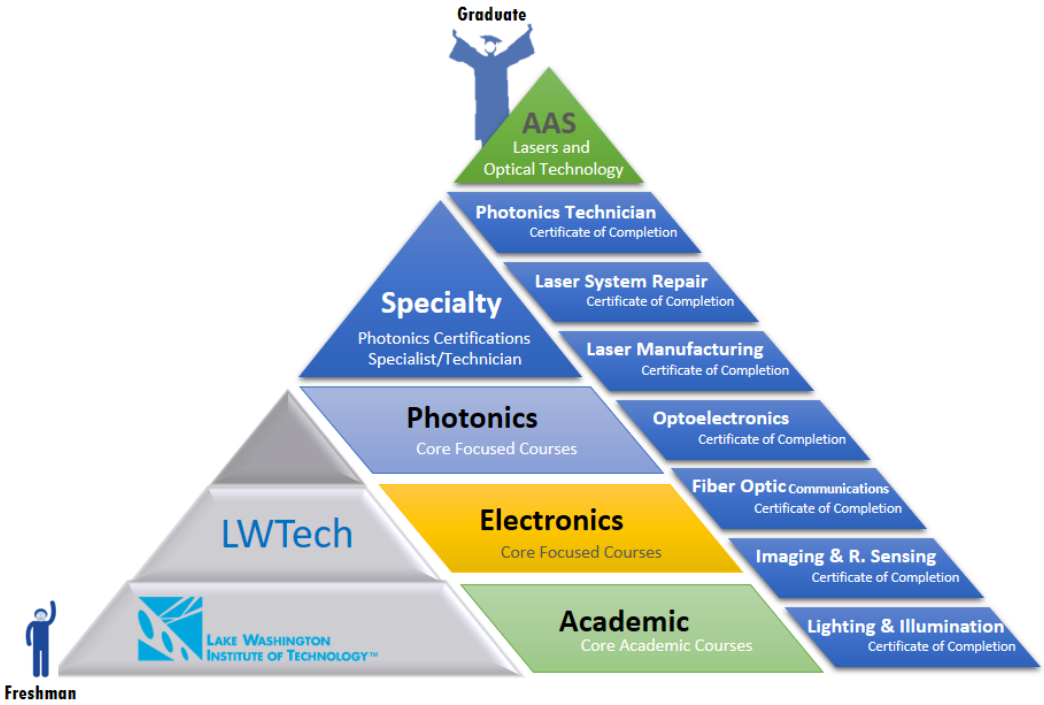

Figure.1. LWTech's new Lasers and Optical Technology (AAS) program structure.

3. PROGRAM CURRICULUM DEVELOPMENT

Program Structure

The new lasers and optical technology (LOT) program is 93 – 94 credits/5 quarters long and is delivered in the evening and through hybrid courses, allowing new and employed students the opportunity for additional training to advance in their fields or to adapt to changes in the workplace. Students can upgrade their skills and receive a degree, certificates, and/or re-certification. The program offers completion and preparation for some of the industry-related certifications from well-recognized organizations such as the Institute of Printed Circuit (IPC) [9], and the Electronics Technician Association (ETA) which is accredited by the International Certification Association Council (ICAC) [10]. The certifications are embedded throughout the program, beginning with the first quarter. We believe this approach will open doors for many students and allow for career opportunities directly upon graduation. To ensure the quality of the teaching outcomes, the program's technical course curricula are built upon the National Center for Optics and Photonics (OP-TEC) [11] skill standards [8], advanced manufacturing technical education (AMTEC), educational literature, e.g. [12], and of course, on other hands-on Problem Based Learning (PBL) approaches recommended by the industry. The program course structure is illustrated in the pyramidical chart shown in, figure.1 above. The structure was carefully crafted to provide students with the most relevant theoretical and practical content. It is based on four-course categories: 1) Core Academics, 2) Core Electronics/Computer, 3) Core Photonics, and 4) Up-dated photonics-enabled-technology (PET). The PET includes advanced courses in telecommunication, optoelectronics, laser-manufacturing, imaging, and remote sensing, and lighting and illuminations. On top of that, the program provides a Laser system repair certification, that provides specific technical pieces of training on photonics system repair where graduates can maintain systems optical and electronics parts found in laser systems, biomedical device-laser based systems, and other similar types of equipment. More information on the program's pathway can be found in the flowchart shown in figure.2.

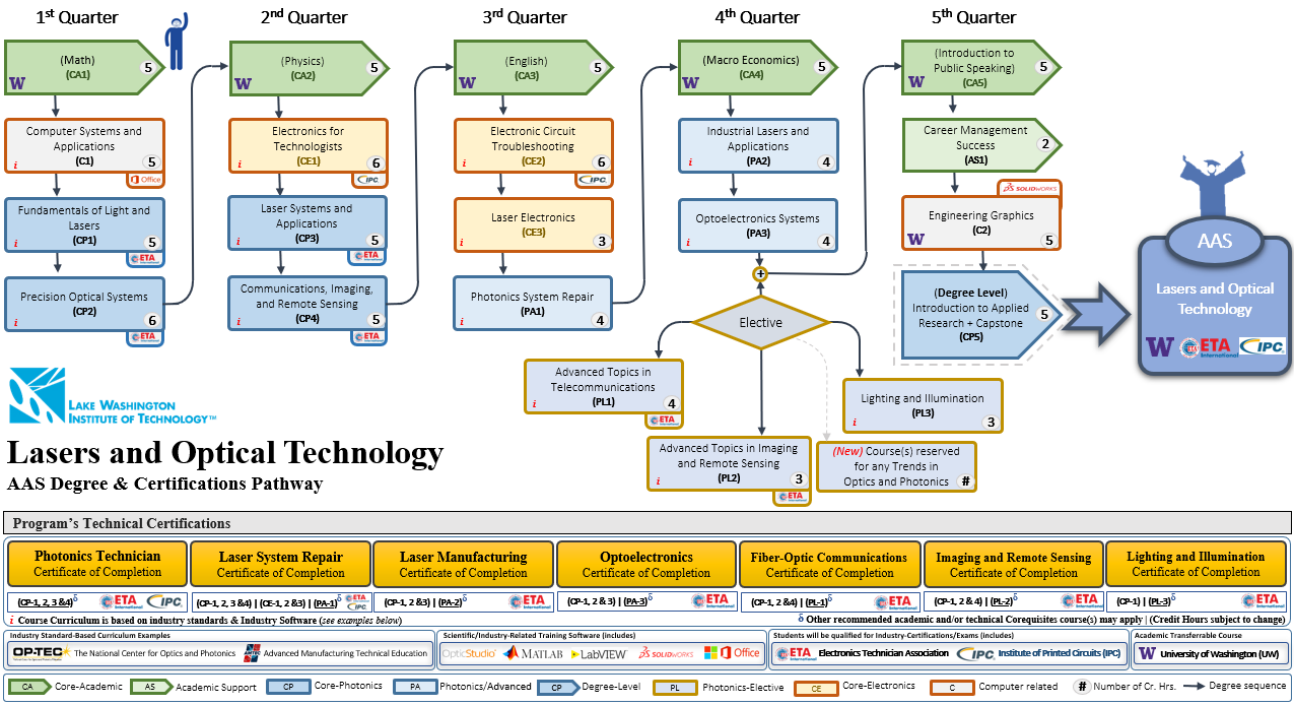

Figure.2. Lasers and Optical Technology Program (AAS) degree and Certifications flowchart.

The degree's core photonics courses are as follows: Fundamentals of Light and Lasers; Precision Optical Systems (Alignment, Metrology, and Quality assurance); Lasers Systems and Applications; and Communications, Imaging, and Remote Sensing. The core Electronics Courses are: Electronics for Technologists, Electronic Circuit Troubleshooting, and Laser Electronics (Sensors and Data-Acquisition emphasized). Supporting Computer courses are: Computer Systems and Applications, and Engineering Graphics. Advanced Photonics-Enabled Technology (PET) courses include: Advanced Topics in Telecommunications (Optical Fiber Communications emphasized), Optoelectronics systems (Nano-technology emphasized, and brief renewable energy photonics related applications), Industrial Laser Systems for Manufacturing (machining, welding, etc.,), Lighting, and Illumination (for the entertainment industry based on laser light shows, etc.,), Advanced topics in Imaging and Remote-Sensing (Monitoring Systems for environment and defense are emphasized), and Photonics System Repair. There is also a reserved course(s) for any new trends in Optics and Photonics technologies that the local industry might request in the future. Lastly, recommended core academic courses include Quantitative Reasoning (Math), General Science (Physics), Written Communications (English), Social Science (e.g. Macro Economics), Humanities (e.g. Introduction to public speaking), and Career Management Success.

Upon completing the (AAS) degree, graduates will be prepared to obtain an entry-level position in the wide field of Optics and Photonics with the ability to perform the following:

- Apply knowledge and skills related to how optics, lasers, photonic devices, electronics, controls, optomechanical devices, and electromechanical devices operate and interface with the equipment, applications, or systems in which they are embedded.
- Measure characteristics of passive optical components, as well as their support and manipulating equipment.
- Perform accurate optical alignments, testing, installation, maintenance, and operations for optical and photonics systems.
- Measure output characteristics of lasers and other light sources.
- Operate, calibrate, and maintain lasers and light-emitting and other photonic devices.
- Integrate photonic devices or subsystems into larger systems and ensure their proper operation within prescribed industrial/manufacturing specifications with proper safety considerations.
- Maintain a clean lab environment and follow established safety rules and regulations.

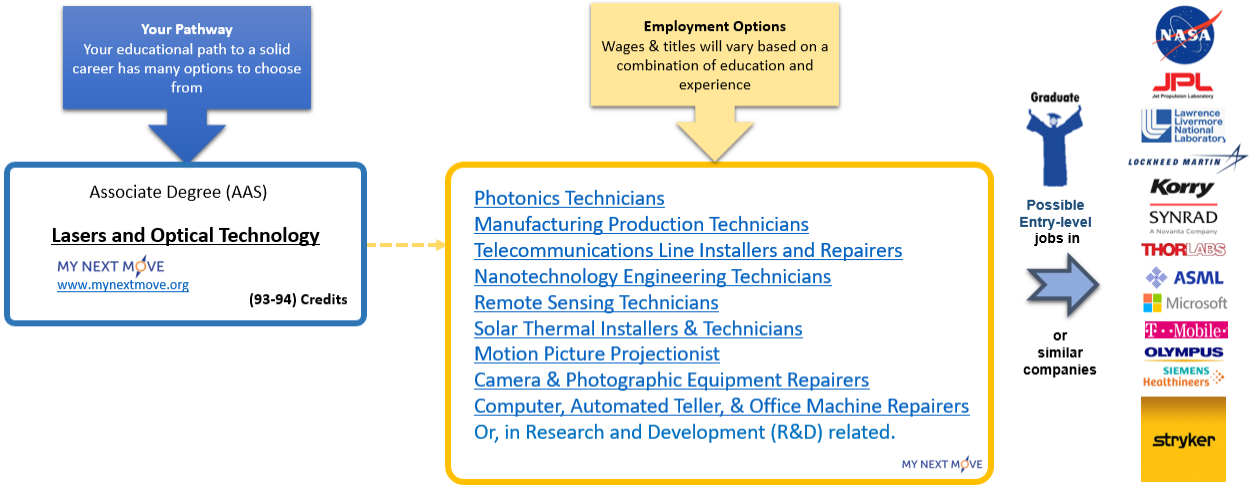

Figure.3. LWTech's Lasers and Optical Technology Program's Career pathway.

- Solve problems using scientific method.
- Establish and maintain cooperative and effective working relationships with others involved in the processing and fabrication of materials and parts.
- Present technical information clearly and concisely in written and oral form.
- Apply knowledge and skills in project management, leadership, career planning, and goal setting.
- Be prepared to successfully sit for several industry-recognized certifications exams in the field.
- Demonstrate critical thinking, teamwork, communication, intercultural appreciation, and. Information literacy skills.
- Meet social science, humanities, written communication, and quantitative reasoning distribution.

4. PHOTONICS ADVANCED CERTIFICATIONS

The new (LOT) program will offer seven new certifications of completion: Photonics System Technician, Laser/Photonics System Repair Technician, Laser Manufacturing Technician, Optoelectronics Technician, Fiber-Optic Communications Technician, Imaging and Remote Sensing, and Lighting and Illumination. In some certifications, graduate students will either earn or be prepared for taking the test of an industry-recognized certificate(s). A brief description of each certification, training/industry certification(s), and the possible entry-level job opportunities are introduced in Table 1. The recommended pathway of each certification is shown in Figure.2.

Table 1: Photonics and Photonics Enabled-Technology Certifications.

#	Title	Certificate Description.	Training / Industry-Recognized Cert(s).	Career Pathway (Examples).
1	**Photonics System Technician.**	Students are prepared to apply basic engineering principles and technical skills in support of engineers and other technical professionals engaged in developing and using lasers and other optical devices and rays for commercial or research purposes.	Graduates will be qualified to pass the exam of the Electronics Technician Association (ETA) – "*Photonics and Precision Optics*" [10], and [13].	National Laboratories such as; Lawrence Livermore National Laboratory (LLNL), and JPL. Companies such as Lockheed Martin, and B.E. Meyers., or other similar in (Figure.3)
2	**Laser/Photonics System Repair Technician.**	Prepares students to apply knowledge of laser systems technologies and skills in maintaining optoelectronic	Graduates will earn IPC-Certifications include: - IPC-J-STD-001G,	Manufacturing industries, Business owners, Hospitals, etc., or other

		systems, including Lasers systems, and, Biomedical laser-based systems.	- IPC-A-610, Qualified for (ETA) related certification exams [10], and [13].	similar companies in (Figure.3).
3	**Laser Manufacturing Technicians.**	Specialist Certificate of Completion prepares students to apply the understanding of laser technologies and their broad uses in the field of industrial manufacturing.	Graduates will be qualified for the use of proper laser beam used for (Machining, Cutting, Drilling, Welding, Surface treatment, material processing, etc.,).	(*Photonics-Enabling-Technology*) Manufacturing industries such as Automotive, (R&D) facilities, or other similar in (Figure.3).
4	**Optoelectronics System Technician.**	Technician Certificate of Completion prepares students to apply the understanding of nanotechnology, microsystems, and semiconductor technologies and their industrial applications.	The hands-on training will be with a future collaboration with high-level academic and industrial training facilities/laboratories.	Nanotechnology technician at companies such as ASML, Microsoft, Facebook, Google, R&D labs, Solar Energy, or other similar in (Figure.3).
5	**Fiber Optic Communication Technician.**	Certificate of Completion prepares students to apply the understanding of advanced communication systems based on the use of fiber optics as enabling technology in their operation.	Graduates will be Qualified to pass the (ETA) – "*Fiber Optics and Data Cabling exam* [13].	Local/National Telecommunication carriers such as T-Mobile, AT&T, Verizon, Frontier, etc., or other similar companies in (Figure 3).
6	**Imaging and Remote Sensing Technician.**	Specialist Certificate of Completion prepares students to apply the understanding of light and optics in imaging.	This training will be focusing on Imaging systems used for remote-sensing applications in military, environmental monitoring, etc.	Environmental monitoring R&D facilities, Defense Research centers, Renewable Energy companies, or similar in (Figure.3).
7	**Lighting and Illumination Technician.**	Technician Certificate of Completion is designed to prepare skilled lighting designers and display technicians for the production of laser light shows.	This training will be focusing on the use of Laser lighting in entertainment applications such as laser shows, etc.,	Professional business owners, or in other similar companies in (Figure.3).
	Degree (AAS)	**Lasers and Optical Technology**	**Please see Figure.2.**	**Please see Figure.3.**

5. METHODS OF PRACTICAL INSTRUCTION

Photonics technicians are the "hands-on" side of an engineering team, responsible for designing experiments, building and troubleshooting prototypes, analyzing and interpreting data, and presenting experimental results to peers, supervisors, and customers [14]. Hence, the methods of instructions followed in our new (LOT) program aims to prepare individuals who must skillfully apply their knowledge of lasers, optics, electronics, and related technologies using critical thinking skills in conjunction with Problem Based Learning to solve real-world problems working side-by-side engineers and scientists. The methods are briefly described in the following paragraphs.

5.1. Applying Problem Based Learning (PBL) approach

Problem Based Learning (PBL) is defined as a dynamic classroom approach in which students actively explore real-world problems and challenges, which requires deeper subject matter knowledge [14], [15], [16]. This approach achieves superior learning outcomes and many technical programs at LWTech use it with great success. An example of a PBL teaching methodology was a project made by our students in the electronics technology department. The project idea was constructing a portable drone (Drone-Sat) capable of providing environmental feedback remotely, capturing video, and

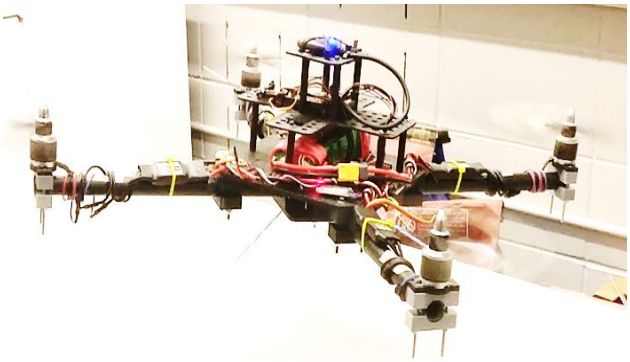

Figure.4. A tested flying drone (Drone-Sat) – made by a group of electronics students, at the LWTech's labs supervised by the lead faculty.

small payload delivery. Students and lead faculty mentors, worked together to build this project from scratch that met the project's goals which were to: (a) Utilizing knowledge gained in the program to demonstrate competency in the field of electronics. (b) Completing an assigned (PBL) industry-based-project from concept to final completion. (c) Employ industry acceptable documentation techniques. (d) Communicate, information of materials, processes, and methodologies to superiors, peers, and subordinates. And (e) Self-assess learning needs and design, implement, and evaluate strategies to promote intellectual growth and continued professional competence. A photograph of the project is shown in figure 4. This project example was a great opportunity for the students to experience a real-world application building challenge, that local industries at Seattle, such as Amazon, and others are pursuing. Students have applied their critical thinking skills, teamwork skills, communication skills, and problem-solving with great success. Hence, upon the proven value of this teaching approach, similar projects will be generated so that students can expand their learning curve and increase their hands-on practical experience. This encourages cross-departmental collaboration (interdisciplinary-activities) between the different programs in our advanced manufacturing division includes Machining, Welding, Innovation, Biomedical-Device, and Engineering.

From (PBL) into regionally-specific application-based scenarios. For the new (LOT), the lead faculty will continue engaging industry partners in developing lab experiments/projects that go beyond basic PBL to enhance it into regionally-specific, application-based learning. This will be accomplished through outreach to local firms, understanding their issues and activities, and integrating those activities into the lab environment. This collaborative process will not only enhance the level of training of our students but will also encourage continued faculty collaboration with regional business partners, resulting in the development of long-term partnerships with members of the community and local industry. While conversations are preliminary, faculty at the University of Washington (UW) have expressed interest in collaboration with facilities and course transferability. The college is hopeful LWTech students will have a strong bridge to UW in the future.

5.2. Encouraging Applied Research

To address the college's core themes [7], the college has recently launched a new initiative to encourage undergraduates to conduct scientific research via an annual applied research symposium. This symposium offers all students and faculty mentors an opportunity to showcase their work concerning products, projects, problem-solving activities, as well as classic research. Our students from all programs and departments can participate. This event will give students and faculty a public platform to, not only communicate and promote the type of work they do; but also to recognize the students and faculty who are leading the way in terms of academic research and innovation. We hope it can become an annual event that supports industry connections and promotes local community building and engagement. For the new (LOT) program, it's a great chance for students to present what they've learned through their classroom projects and research experiences to their families, friends, and the college community. The capstone project of the (AAS) degree (as shown in figure 2) is infused with dedicated applied research that teaches students the fundamentals of scientific thinking and research. Classic research is often scholarly and theoretical, while applied research tends to be more practical, problem, and client-driven.

5.3. Implementing I-BEST-like teaching methods to accelerate student progress

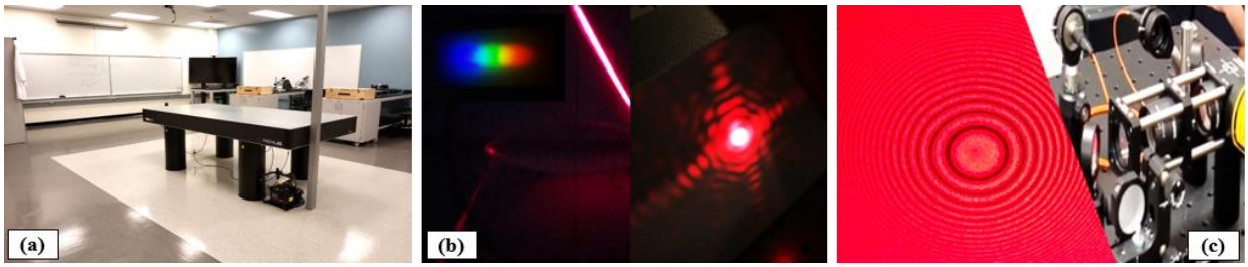

Figure.5. (a) Optics and Photonics lab at LWTech, (b) Some experimental results to study the fundamental physics of light and lasers (c) Advanced photonics precision experimental example such as optical interferometry.

Washington's Integrated Basic Education and Skills Training Program (I-BEST) is a nationally recognized model known to quickly boosts students' literacy and work skills, enabling them to earn credentials and obtain living-wage jobs [17]. I-BEST programs are team-taught, with one faculty member teaching technical content and the other teaching basic skills in math, writing, or English language (50% overlap). The content delivery systems initially developed through I-BEST is based in contextualization, defined here as "the merging of basic Photonics-skills and subject area" instruction.

5.4. Photonics Facilities, Equipment, and Other Resources

A photograph of the new program's lab at LWTech is shown in (figure 5.a). The lab is a combined computer/classroom space ideal for repositioning as a photonics laboratory. The lab space is located in a safe and quiet location on the college campus with existing electrical and light buffering attributes required for running some of the fundamental core Photonics courses. The lab is currently prepared with the essential resources such as, highly stable-optical breadboard tables, optical components, electronics testing devices, optical measurement instrumentations, and laser systems, for conducting the basic core photonics course experiments existing in the fundamentals of light and lasers (CP-1), Laser Systems and Applications (CP-3), and Communications, Imaging and Remote Sensing (CP-4). Some experimental examples are shown in (figure 5.b, and 5.c). The authors are also looking forward to getting the other needed equipment for serving the rest of the program's advanced courses in (figure 2). The program is also looking forward to constructing a small cleanroom for related hands-on teaching and training purposes.

6. RECRUITING ACTIVITIES

6.1. Student Recruitment for the LOT program

Recruiting new students and increasing program enrollment is always one of the top priorities for LWTech. The college team is actively working hard on recruiting non-traditional and underrepresented students to the new photonics program to include veterans, females, and older and undeclared students. For veterans: as they transition from combat zones to the classroom, the most notable concern is the lack of guidance and support available to meet their unique needs. LWTech aims to break down barriers that returning Veterans face by making the study of technology more widely accessible. Additionally, the Military Friendly School list recently named LWTech as one of the top vet-friendly institutions in the nation and our geographic proximity to Joint Base Lewis-McChord (the largest joint base in size), as well as Naval Station Everett, Naval Base Kitsap-Bangor, ensures a continued population of veterans in this region. In addition, the college's veteran center will be responsible for ensuring the skills of returning Veterans are integrated into this newly-designed and highly-collaborative structure of the problem-solving approaches being taught. The center is a partner with existing organizations in the greater Puget Sound to reach Veterans as they transition from military service. Additionally, the leadership and collaboration skills Veterans bring in from the military will be a strong and positive influence on the type of collaboration of our regional hiring industries. By using this model, we will be able to integrate some of these strong community values to all participants, and strengthen both technical and community "fit" for the photonics industries they will be joining.

LWTech is also working on conducting several recruitment events aimed specifically at the female population of students at LWTech as well as in the community. A website will be created that will highlight the role of women in photonics. Recruitment materials targeted specifically at the role of females in the optics and photonics industry will be provided by

organizations such as SPIE. Other LWTech-specific printed materials (posters, flyers, and brochures) with program information will also be developed.

LWTech is also conducting several recruitment events aimed specifically at older and undeclared students. Students who have a designation of "undeclared" or have no assigned program affiliation will receive targeted materials and/or invitations to speak with an advisor or to attend a recruitment activity such as an open house or other recruitment events.

6.2. Marketing the new Program

The college Marketing team is responsible for managing all communication. They use an existing infrastructure to inform people via the campus webpage, internal message boards/screens, social media, radio, TV ads, press releases, bus boards, and electronic and printed materials. Faculty and staff are utilizing a multi-faceted approach to marketing the new lasers and optical technology program to current and future students. These recruitment efforts include: Holding campus kick-off events such as an open-house, all-staff meetings, creating and deploying recruitment messages for students to ensure students are aware of the new program. Staff and faculty conduct Outreach to educational organizations such as high-schools, and universities as well as new local industry partners in the area. Staff reach out to local government agencies that provide educational assistance and worker retraining (e.g. Work Source, Employment Security, and King County Veteran Services), and to local nonprofit organizations that help people reach financial independence (e.g. Multi-Service Center, Hope Link, and Friends of Youth). Faculty and staff work with business and industry groups to help publicize the program to continually engage the industry and to promote upcoming work. Awareness of the program is also achieved at our annual Industry Advisory Committee dinner and regularly scheduled meetings with industry-specific employer groups.

6.3. Student Support Services

LWTech also offers several additional resources to students, including the following: Advising Services, Computer Labs, Counseling Services, Disability Support Services, Employment Resource Center, Financial Aid, Library-Learning Commons, Math Lab, Tutoring Services, Veteran's Support Services, and Worker Retraining Services. These services will be available for supporting the students of the new (LOT) program. More info can be found on the college web site: www.lwtech.edu.

7. CONCLUSIONS

In this paper, the authors presented the current progress of the new LWTech's two-years (AAS) degree program in Lasers and Optical Technology (LOT). The program prepares future Photonics technicians and specialists with new curriculum and advanced technical certifications in optics and photonics that infuse photonics as an "enabling technology". Students/Graduates will be prepared with the most needed skills for technology trends in Optics and Photonics found in the greater Seattle area, including Precision Optics, Laser/Photonics Systems Repair, Laser Manufacturing (machining, welding, etc.,), Optoelectronics, Fiber-Optic Communications, Imaging and Remote-Sensing for Environmental Monitoring and Defense, and even Laser Lighting for entertainment applications. Advanced short duration certification programs lasting less than two years in which incumbent workers receive customized hands-on education/training in specific photonics concepts and skills. The program was recently approved by Washington's State Board for Community and Technical Colleges (SBCTC) and will be available for the public community as soon as possible (Expected by 2021).

8. ACKNOWLEDGMENT

The authors would like to thank the National Science Foundation (NSF), the Pacific Northwest Photonics Technology Project (PNW Photonics) at Lake Washington Institute of Technology (LWTech), and the International Society of Optics and Photonics (SPIE) for their support.

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