

LASER-TEC ANNUAL EVALUATION REPORT YEAR 6

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CONTENTS

LASER-TEC ANNUAL EVALUATION REPORT YEAR 6	
PART I.....	2
Introduction	2
Part II.....	3
Evaluation Methodology	3
LASER-TEC logic model.....	4
PART III.....	5
Evaluation Findings.....	5
Part IV.....	22
Recommendations	22
Part V.....	22
Conclusions.....	22

PART I

INTRODUCTION

LASER-TEC is the National Science Foundation Advanced Technological Education Center of Excellence in Lasers and Fiber Optics (the Center). It is an association of community and state colleges, universities, high schools and technical centers, trade associations, and laser and fiber-optic (LFO) companies. LASER-TEC started its operation in September 2013 based at Indian River State College in Florida, with the following principal partners: Central Carolina Community College (North Carolina), Tri-County Technical College (South Carolina), and CREOL (the College of Optics and Photonics at the University of Central Florida).

The mission of LASER-TEC is to develop a sustainable pipeline of qualified laser and fiber optics technicians to meet industry needs in the United States. To accomplish this mission, the following goals were set:

- 1. Increase and strengthen LFO academic programs to meet the industry demand**
- 2. Create and offer LFO professional development programs for secondary school teachers, college faculty, and incumbent workers**
- 3. Develop LFO curriculum materials for secondary schools, colleges, and industry**
- 4. Develop, promote, and deliver outreach and awareness programs to secondary STEM teachers, advisors, counselors, administrators, and the general public**
- 5. Develop strategies and materials for recruiting and retaining underrepresented groups and to promote diversity in LFO programs**

This report evaluates the progress, accomplishments, and challenges in achieving these goals in year 6 of LASER-TEC operation.

The evaluation results are presented based on multiple data points provided by the Center, evaluations and surveys developed by the evaluator and the Center's management, and also includes the feedback from a variety of stakeholders.

Part II of this report describes the evaluation model and methodology used for this project. The evaluation team started working with LASER-TEC during the proposal development period and created the current evaluation plan. The evaluation plan is graphically represented in the logic model presented on page 4 of this report. Continuous formative evaluations have been done during the five years of operation. Part III lists the recommendations for changes or improvements. Part IV of this report presents the conclusions of the evaluation team.

PART II

EVALUATION METHODOLOGY

A mixed evaluation methodology was used to assess and analyze the goals and their outcomes of this project. The following four questions were asked to facilitate the evaluation process:

- What was proposed to be done?
- How was it planned?
- Is it being done as planned?
- Is the program successful?

The four-level Kirkpatrick and Kirkpatrick method was used to evaluate results and outcomes of the second goal, which focused on teachers' professional development. The following questions were asked:

- To what degree are K-12 teachers, counselors, and administrators satisfied with the content and quality of LFO seminars and the center services? (Reaction Level)
- To what degree did K-12 teachers, counselors, and administrators understand the need to incorporate LFO modules in life sciences classes and career counseling? (Learning Level)
- To what degree are K-12 teachers, counselors, and administrators incorporating LFO modules in life sciences classes and career counseling? (Behavior Level)
- How many new LFO courses, modules, lessons, and career guidance sessions have been added in K-12 schools, and how many students have attended? (Results Level)

In the beginning of the project, the PI met with the evaluator on multiple occasions and outlined the goals, objectives, and tasks of the Center. An evaluation plan was drafted that includes the collection of data for a continuous formative evaluation during each year of the project and a summative evaluation at the end of each year of the project. Feedback from the formative evaluations was provided to the management team on a regular basis so that corrective actions are taken immediately for effective management. The evaluator was responsible for creating the evaluation instruments, scripts for telephone interviews, and other evaluation tools. The Center's staff disseminated and collected the evaluation results from participants and presented them to the evaluator for analysis and report preparation.

This report represents the formal summative evaluation for year 6 of LASER-TEC operation.

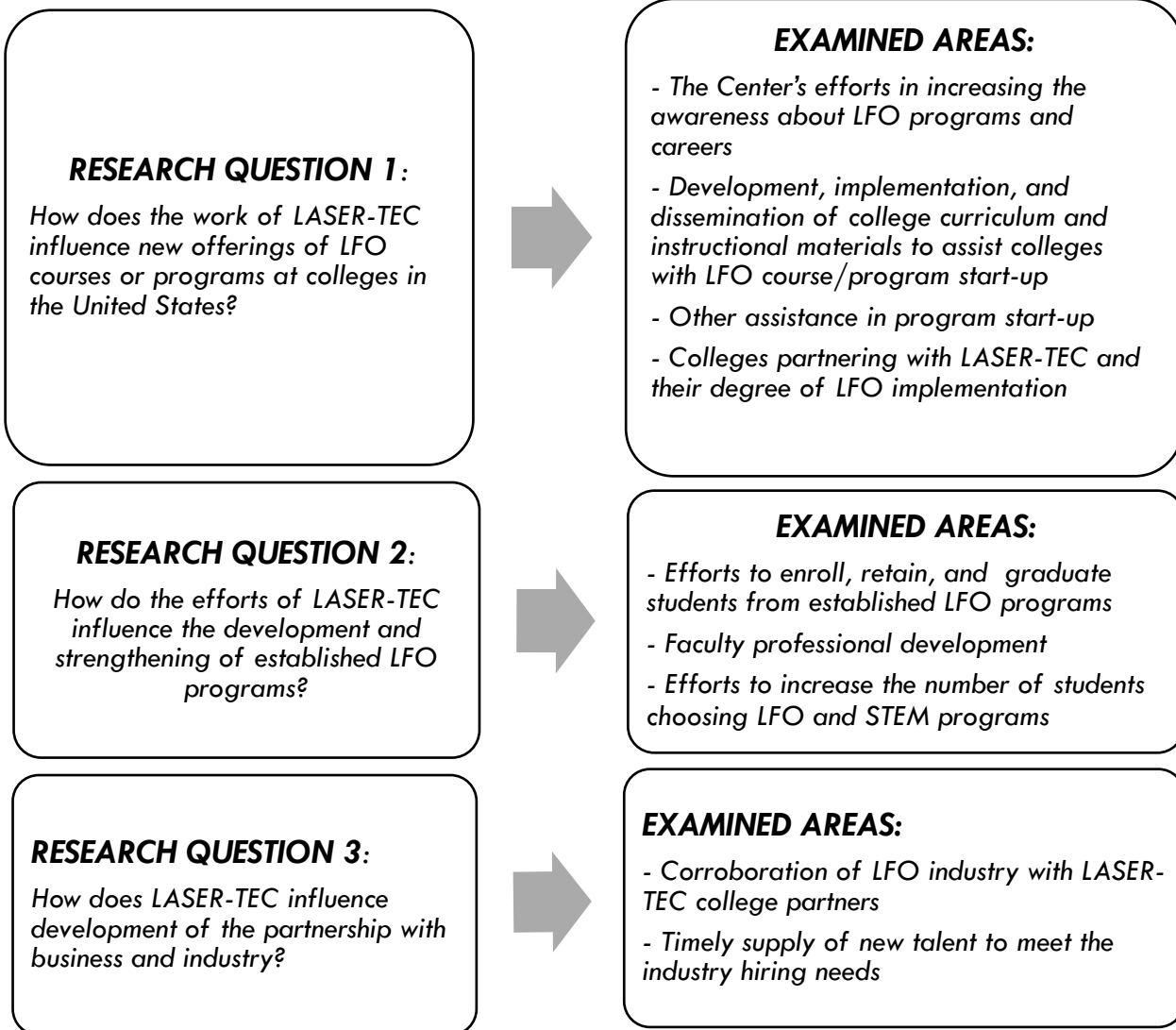
LASER-TEC LOGIC MODEL

RESOURCES	ACTIVITIES	OUTPUTS	SHORT-TERM OUTCOMES	LONG-TERM OUTCOMES	IMPACT
In order to accomplish our set of activities, we will need the following:	In order to address our problem or asset, we will accomplish the following activities:	We expect that once accomplished, these activities will produce the following evidence or service delivery:	We expect that if accomplished, these activities will lead to the following changes in 1-3 years:	We expect that if accomplished, these activities will lead to the following changes in 4-6 years:	We expect that if accomplished, these activities will lead to the following changes in 7-10 years:
Funding from NSF.	Find industry needs in LFO technicians and training.	A list of training programs. A list of training strategies. A list of priorities and timelines for training.	Familiarity with industry needs in the number of required technicians. Familiarity with training needs of the industry.	Quicker responses to industry training needs.	Make US economy more responsive, efficient, and competitive in the global market.
Support from IRSC in infrastructure, offices, computer services, telecommunications, etc.	Establish specialty LFO training labs at each principal partner college.	A number and type of specialized LFO training programs at partner colleges.	A number of technicians trained at each college.	Industry satisfaction to demand in skilled workforce.	Increase the number of well-paid technicians. Strengthen industry by meeting workforce requirements. Strengthen the US economy.
Support from the industry in providing needed information on technician skills and needs.	Create training programs in colleges located close to industry.	A list of LFO training programs at colleges close to industry.	Increase the number of competent technicians available to the industry.	Further reduction in the gap between supply and demand for technicians.	Balance the supply and demand for technicians.
Endorsement from professional societies like SPIE, OSA, and IEEE.	Create a dynamic IAB to establish the direction of the Center.	Growing membership numbers in the IAB. A list of future directions.	Create courses and training needed by industry.	Reduce the response time in the creation of new courses and training	Strengthen and make US economy more competitive.
An action plan for year-to-year operations.	Provide outreach to K-12 teachers, counselors, and administrators.	A number of outreach programs for educators. A number of outreach participants.	Increase number of students studying LFO or related subjects.	Further increase the number of students that study LFO or related subjects.	Strengthen US economy and increase prosperity of graduates with LFO degrees.
Competent Center staff.	Recruit more veterans and minorities.	A number of veterans, minorities, and women in the industry.	Increase the standard of living of veterans and minority graduates.	Further increase the standard of living of veterans and minority graduates.	Strengthen US economy and increase prosperity for veterans and minorities.

PART III

EVALUATION FINDINGS

GOAL 1. INCREASE AND STRENGTHEN LFO ACADEMIC PROGRAMS TO MEET THE INDUSTRY DEMAND.



Findings:

During 2018-2019, the Center continued to put a substantial effort to disseminate information about advantages of LFO infusion into EET and EET-related college programs throughout the nation. The Center has targeted key decision makers in community colleges (administrators, faculty, and staff) and employed both top-down and bottom-up approaches. LASER-TEC staff

has built a large database of over one thousand contacts and has conducted an email campaign about revamping outdated curriculum and informing about LASER-TEC resources that will help with integration of LFO. The Center has also been active in providing information during conferences attended by college faculty and administrators. These activities have resulted in the growth of LASER-TEC college network and the number of colleges advancing in LFO implementation and development.

To track the advancements of colleges within the network, the evaluator and the Center’s management team developed a three-phase classification system which includes preliminary, development, and implementation phases. In 2018-2019, eight colleges are classified to be in the implementation phase, nine in the development phase, and eighteen in the preliminary phase. See figure 1.

During 2018-2019, Iowa Western Community College developed and offered an integrated fiber optics module in the course ELT360 “Lasers in Manufacturing” using LASER-TEC curriculum. Corning Optical Communications assisted the college with the procurement of necessary equipment and tools (Unicams, connectors, and fiber) at discounted rates.

Wayne County Community College is actively pursuing the launch of Photonics and Laser Technology course in the fall of 2019. LASER-TEC curriculum and educational kits will be used to support the course.

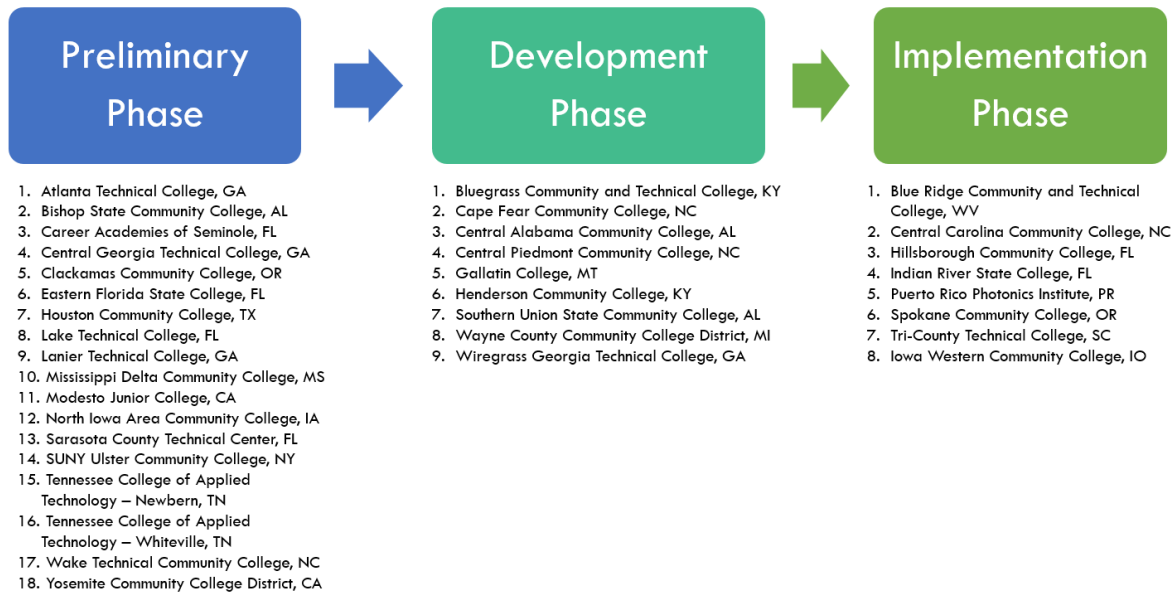


FIGURE 1. LASER-TEC COLLEGE NETWORK ADVANCEMENT

The growth in interest in fiber optics and laser safety lead to LASER-TEC’s expansion outside of the southeast region and currently includes 34 colleges nation-wide. See figure 2.

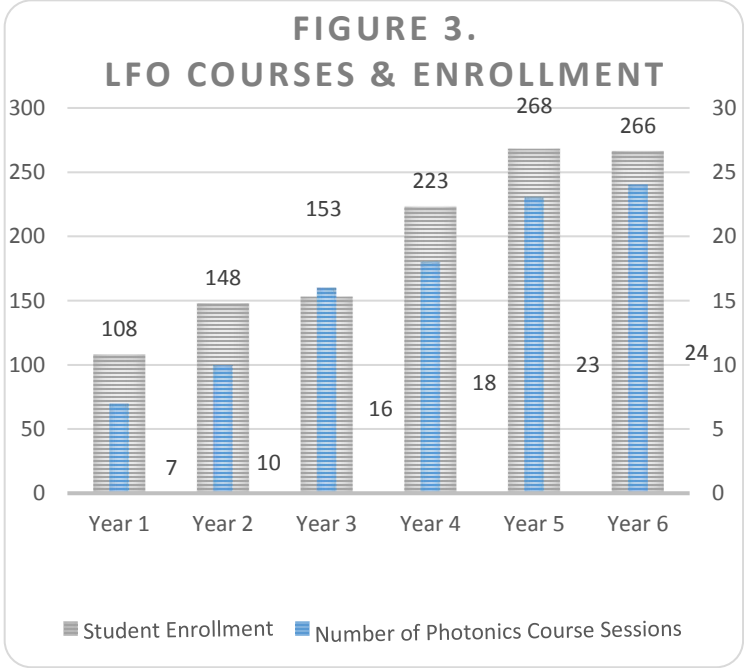


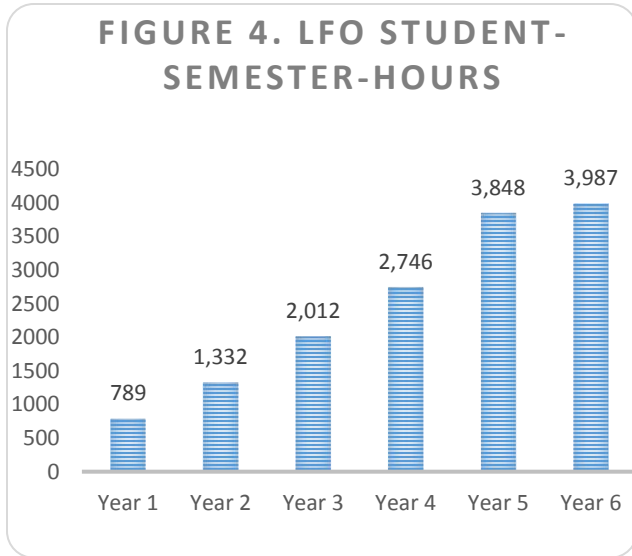
FIGURE 2 LASER-TEC COLLEGE NETWORK

During the sixth year, the number of students in LASER-TEC photonics programs plateaued and remained at the same levels as last year. This sustained levels of student enrollment are the result of diverse public outreach and recruitment campaigns deployed by the Center.

The number of photonics courses, their sessions at partnering colleges, and program enrollment has steadily increased over the last five years and then leveled in year six.

During the 2018-2019, 24 photonics course sessions were offered by the partner colleges as shown in figure 3.





Since the length of courses in credit hours differ at each partner college, the student semester hours (SSH) were used as a metric to evaluate the change in photonics enrollment at the participating colleges. The number of SSH has increased from 3,848 in year five to 3,987 in year six, refer to figure 4. The growth of SSH indicates to the growth of LASER-TEC student enrollment, number of LFO courses, and number of colleges that offer LFO.

During year six, the Center has made a substantial effort to improve and streamline the enrollment process to photonics

programs at the partnering colleges. The Center has facilitated two articulation agreements with local high school districts both in Florida and North Carolina. Seven high schools participate in these programs. In addition, the Center is leading the effort to launch a new specialization of Biomedical Instrumentation at Indian River State College to capitalize the saturated student pipeline at health science programs. Currently, the A.A. program in health science has a pool of over 1,000 students not accepted to the programs. These students can be redirected to pursue the A.S. in EET with specialization in biomedical instrumentation. This initiative is strongly supported by the college administration and currently is being formalized at the institutional level.

Once this pilot program at IRSC is proven successful, it can be replicated and benchmarked at other colleges across the nation. This model to increase the number of students pursuing LFO related careers and secure a gainful employment has a good potential. A great job outlook for biomed technicians and overly saturated applicant pool for health science programs could provide an opportunity for sustained photonics and healthcare interdisciplinary college programs.

The LASER-TEC industry partners provide continuous support to the Center and its colleges. The industry provides the insight and advice on the program design, provide equipment, and participate in information and outreach events. The Center efficiently leverages partnerships to fulfill the nation-wide need for qualified LFO technical workforce with the following major contributors: Watsatch Photonics and Ocean Optics in Spectroscopy, MegaWatt Lasers, Synoptics and IPG Photonics in lasers and laser applications, PCS Fiber, Corning Optical Systems, Anixter, and Transition Networks in fiber optics.

This year, the Center has organized and facilitated on-campus or on-site hiring sessions for 12 LFO companies. This effort enabled industry to acquire qualified workforce, while providing graduates with opportunities for gainful employment. By the end of year six, 49 LFO companies have hired more than 200 LASER-TEC graduates who are working in different sectors of the economy and in almost all 50 states.

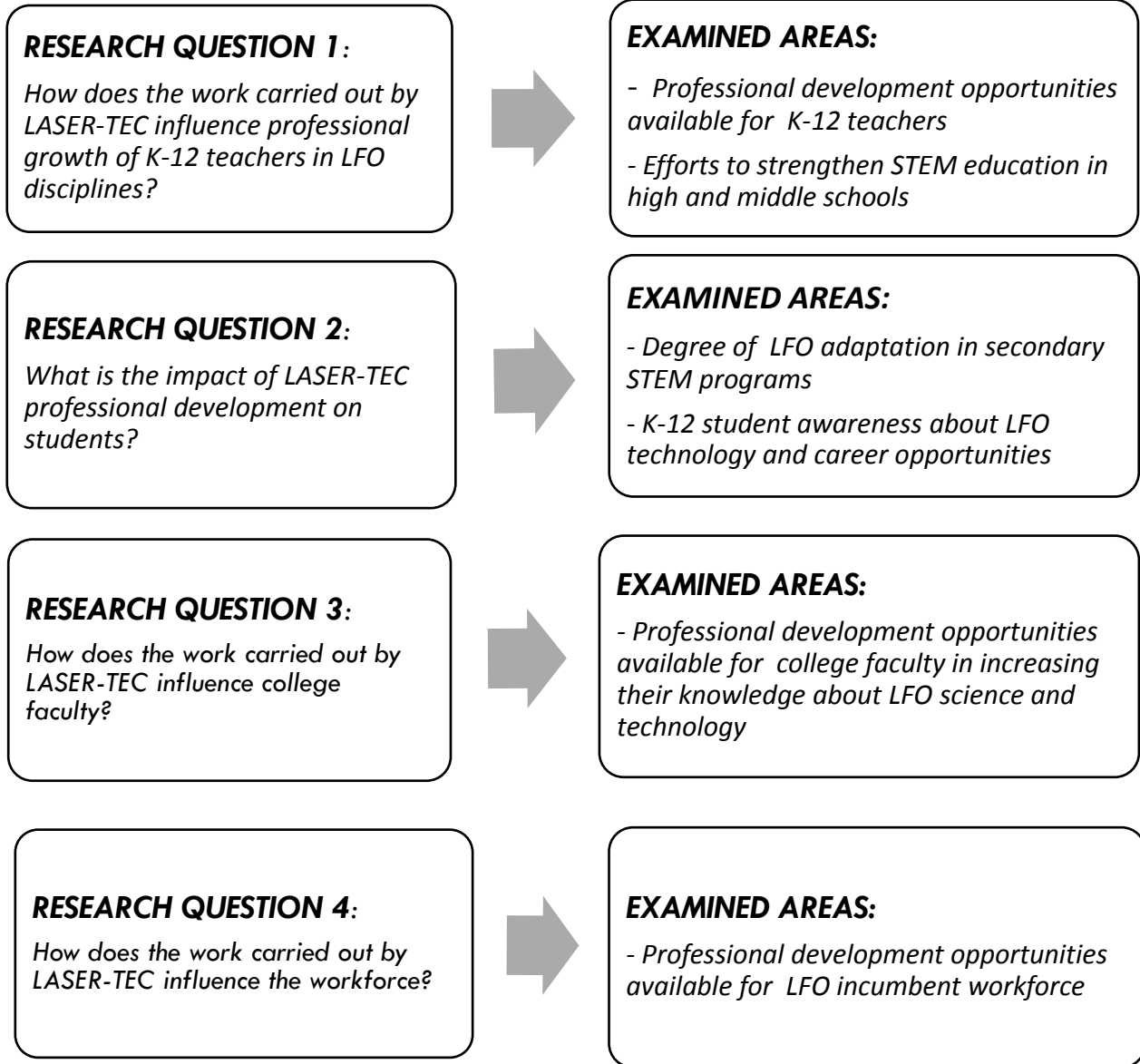
It is evident that the Center conducts a wide-spectrum strategy in engaging the industry and building college/industry partnerships that enable strengthening of the nation's LFO workforce.

Overall, the Center has engaged new colleges in offering LFO courses, expanded outside of the southeast region, increased the number of students in LFO programs, developed new and updated existing curriculum materials, and partnered with LFO industry to create and sustain strong academic programs.

Activities under Goal 1 had the following impact:

- ✓ Increased number of colleges that are aware about LFO
- ✓ Increased number of colleges developing LFO courses and programs
- ✓ Increased number of colleges offering LFO courses and programs
- ✓ Increased output of graduates from southeast colleges
- ✓ Reduced the supply/demand gap for LFO technicians in the southeast
- ✓ The number of students taking laser and photonics courses is 266 in year 6
- ✓ Job placement is at 95% with several students receiving more than one job offer
- ✓ 15 companies routinely recruit LASER-TEC graduates before their graduation
- ✓ Supplied qualified LFO technicians to 49 LFO companies

GOAL 2. CREATE AND OFFER LFO PROFESSIONAL DEVELOPMENT PROGRAMS FOR SECONDARY SCHOOL TEACHERS, COLLEGE FACULTY, AND INCUMBENT WORKERS.



Findings:

LASER-TEC workshops for K-12 educators offer rich content, various hands-on activities, and teacher supplementary materials. The workshop material and delivery format are continuously adjusted based on participants’ evaluations as well as internal evaluation by the Center. During each workshop, all participants are provided with the Light and Optics Exploration Kit accompanied with detailed lesson plans. This approach has been found to be the most immediate and efficient way to impact students and get them interested in STEM and LFO.

One of the main workshop goals is to introduce educators and counselors and achieve a multiplier effect in student LFO awareness. Typically, every teacher has on average 125 students under their guidance every year and a counselor has more than 500 students annually. Workshops are one day in length, typically six to seven hours long, with a combination of lectures, demonstrations, and hands-on sessions. These workshops are conducted in fall, spring, and summer semesters, based on teachers' availability.

During 2013-2019, the Center has hosted 27 workshops to advance technical knowledge in LFO to 351 K-12 teachers and counselors. The influence of these workshops on students is very substantial: the total number of students impacted by LASER-TEC workshops is 33,279.

The Center has modified its approach in conducting workshops. During this evaluation period, LASER-TEC corroborated with local CTE and other K-12 programs to fulfill standard requirements for annual professional development. Staff members of these programs offered recruitment and the logistics for the workshop and LASER-TEC delivered the content and provided teaching tools and kits. This "school-initiated" approach resulted in higher level of teacher's participation. Based on the results of the evaluation, teachers' general interest in integrating LFO into their lessons has also increased from 80% to 88%.

The two-step workshop evaluation is conducted in accordance with the Kirkpatrick and Kirkpatrick model. The first evaluation is offered at the end of each workshop to measure participants' Reaction Level and Learning Level. In general, workshop attendees found the workshop useful and informative, as indicated below.

- Overall, how would you rate this professional development event? *Excellent, 96%*
- Overall, how valuable was the content presented at this workshop? *Excellent, 98%,*
- How likely are you to implement some of the classroom demonstrations into your lessons?
Very likely, 88%
- How likely are you to start a laser and fiber optics course at your school? *Very likely, 20%,*

LASER-TEC has revised a survey conducted by the Center six to twelve months after each workshop. This survey assesses the degree of the workshop content implementation. It is designed to measure behavior and result levels according to the Kirkpatrick and Kirkpatrick model. The survey will be distributed in May 2019.

In addition to K-12 profession development programs, LASER-TEC offers profession development opportunities for college faculty. The evaluation team finds the LASER-TEC's determination to develop and offer professional development for college faculty is an efficient path to LFO programs' strength and sustainability.



Faculty professional development faculty is offered on a continuous basis and includes sponsoring participation in technical conferences and offering seminars on the latest advancements in laser and fiber optics technology.

In 2018-2019 reporting period, LASER-TEC college faculty participated in the laser safety officer training conducted by the Laser Institute of America and workshop on high-power solid state lasers conducted by MegaWatt Lasers.

In addition, the Center has conducted a workshop for 15 faculty members on lasers and fiber optics technology during the North Carolina Community College Conference in Raleigh, NC.

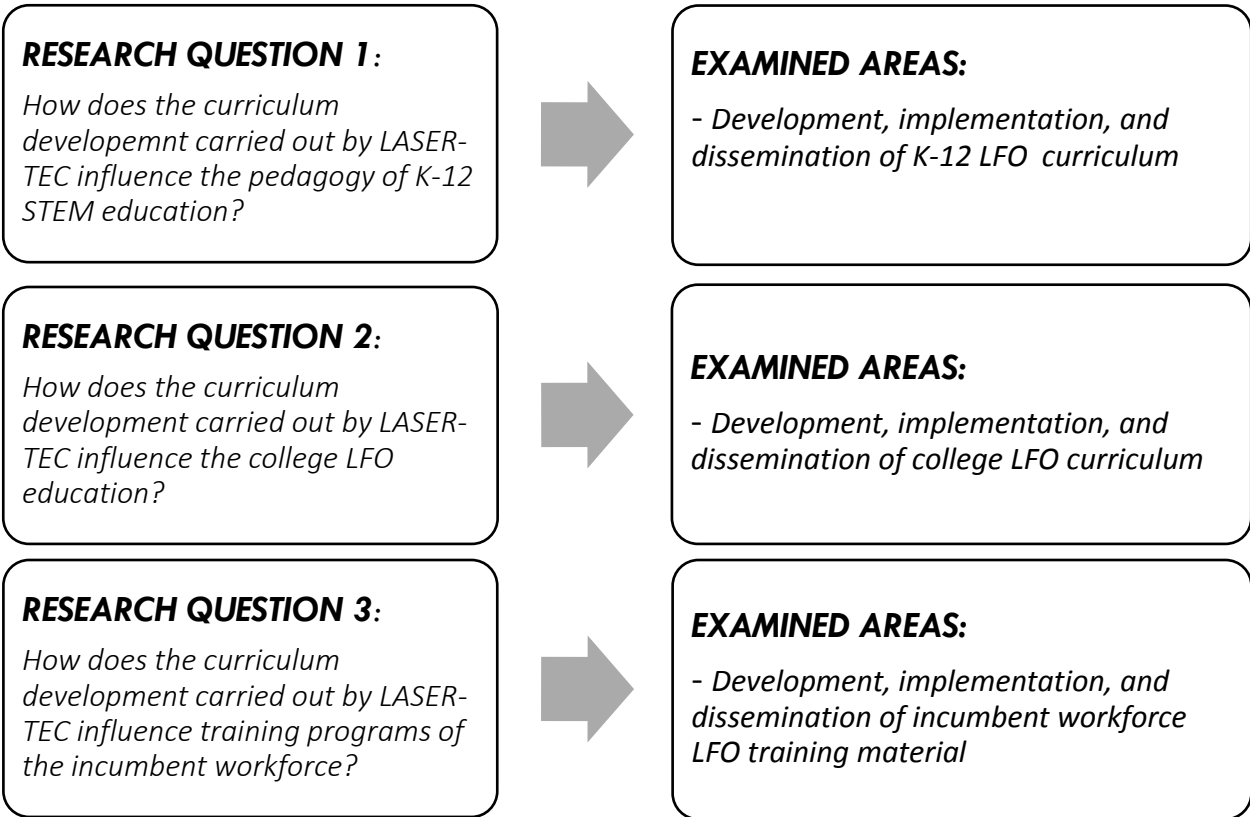
The evaluator finds the Center's effort to help the incumbent LFO workforce update its skill-sets to keep up with the rapid changes of the technology very significant. LASER-TEC has responded to the recent change in the requirement to provide broad signal coverage inside building to access emergency first responders. In partnership with Corning Cable Systems, PCS Fiber, and Notora RF Engineering, LASER-TEC hosted a full-day seminar on distributed antenna systems and small cell technologies. During 2013-2019, total of 153 workers received LASER-TEC training in fiber optics, laser technologies, telecommunications, and IP data networks.

To summarize, LASER-TEC has developed and offered multiple professional development opportunities for K-12 educators, college faculty and incumbent LFO workers.

Activities under Goal 2 had the following impact:

- ✓ Increased infusion of LFO into K-12 STEM disciplines as the result of
 1. increased number of teachers attending LASER-TEC workshops
 2. diversified content of the workshops
 3. availability of LASER-TEC support with the content integration
- ✓ Growth and sustainability of academic LFO programs anchored by continuous faculty professional development
- ✓ Knowledgeable and skilled incumbent workforce in the latest advancements of the LFO technology

GOAL 3. DEVELOP LFO CURRICULUM MATERIALS FOR SECONDARY SCHOOLS, COLLEGES, AND INDUSTRY



The Center has focused considerable time and effort in developing and improving curriculum materials available for K-12, college, and industry communities. Developed materials are constantly being evaluated and reviewed by subject matter experts from the respectful groups. To streamline the infusion, all K-12 materials developed by LASER-TEC are cross-referenced to the Next Generation Science Standards. The Center continuously responds to evaluation by improving the content and publishing a new editions on a yearly basis.

Currently, the Center offers the following materials:

Textbooks: Fiber Optics for Technologists, Light and Optics Exploration Lesson Plans (instructor and student editions), Light and Optics Experiment Book (instructor and student editions).

Modules: Enhanced Spectroscopy, Light Emitting Diodes, Thermoelectric Device Measurement Lab, Solid-State Laser Crystal Manufacturing, Field Service Engineering, and High Energy Pulsed Solid-State Laser Design and Testing.

Educational kits and tools: Light and Optics Exploration Kit, Light and Optics Experiment Kit, Laser-Enabled Security System Kit, Green Laser Pointer with IR Filter.

Bootcamp Kits: Arduino I: Visible Light Spectrum Kit, Arduino II: Wireless Technologies Kit, Arduino III: Game Programming Kit, Electronics Maker Kit.

Educational Videos: Fiber Optics for Technologists Video Series, Instructions for the Laser-Enabled Security System, Projects with Arduino.

Educational posters: Diode Lasers, Fiber Lasers, Helium –Neon Lasers, Nd:YAG Lasers, Laser Safety.

Additional four modules are currently under development: Semiconductor Lasers, LiDAR Technology, Power Meter Measurements, and Optical Coherence Tomography (OCT) Technology.

More information about these resources is in the Appendix 1. Most of LASER-TEC materials can be scaled up or down based on a program’s needs, but the recommended levels of implementation are summarized in the table below.

Resource	College	High school	Middle school
Textbooks and supporting materials			
Fiber Optics for Technologists	x		
Light and Optics Exploration Lesson Plans	x (non-majors)	x	x
Light and Optics Experiment Book	x	x (AP, honors, STEM Academies)	
Modules			
Enhanced Spectroscopy, Light Emitting Diodes, Thermoelectric Device Measurement Lab, Solid-State Laser Crystal Manufacturing, Field Service Engineering, High Energy Pulsed Solid-State Laser Design and Testing	x		
Educational kits and supporting materials			
Light and Optics Exploration Kit	x (non-majors)	x	x
Light and Optics Experiment Kit	x	x (AP, honors, STEM Academies)	
Laser-Enabled Security System Kit	x	x	x
Bootcamp Kits and supporting materials			
Arduino I: Visible Light Spectrum Kit, Arduino II: Wireless Technologies Kit,	x	x	x

Arduino III: Game Programming Kit, Electronics Maker Kit			
Educational posters			
Diode Lasers, Fiber Lasers, Helium – Neon Lasers, Nd:YAG Lasers, Laser Safety.	x	x (AP, honors, STEM Academies)	

LASER-TEC continues successfully leveraging existing resources. The Center is collaborating with the leading publishing agencies (Laser Focus World, Laser Institute of America etc) and photonics companies (Newport, Corning, etc.) in transforming available license-free materials into pedagogical packages. These modules are developed by subject matter experts with extensive field experience and offer comprehensive content on various LFO topics. To ease their implementation into the existing LFO curriculum, LASER-TEC is developing necessary faculty resources: learning objectives, test banks, answer keys, student self-assessment, power point slides, bibliography, etc.

LASER-TEC disseminates curriculum materials through workshops and seminars conducted by the Center throughout the year. The supporting materials are available for download on the LASER-TEC website through the password protected portal.

The Center constantly monitors the degree of implementation of the curriculum by launching surveys and collecting responses. The assessment reveals that K-12 community welcome new additions to the lesson plans and experiments and find them very useful. The degree of curriculum implementation is assessed by a survey conducted among teachers from six to twelve months after they attend the Laser and Fiber Optics workshop. Previous surveys indicated that 76 % of workshop attendees who received the lesson plans and the kit integrated the content into their STEM classes. The new version of the survey is has been revised by the evaluator and the Center’s team. It will be distributed in May 2019.

To conclude, LASER-TEC has developed, improved, and disseminated curriculum materials in multiple LFO technologies among K-12, college, and incumbent workforce communities.

Activities under Goal 3 had the following impact:

- ✓ Increased infusion of LFO into K-12 STEM disciplines
- ✓ LASER-TEC kits create an affordable way to teach photonics in K-12 schools and colleges
- ✓ Mapping the Next Generation Science Standards to lesson plans makes the Demonstration Book useful when integrating LFO in all STEM disciplines
- ✓ Increased infusion of LFO curriculum into college programs and industry training programs
- ✓ 10 new courses are now available to all US colleges
- ✓ 10 new modules are available to all US colleges
- ✓ New modules are being developed
- ✓ LASER-TEC resources support fast-track and affordable training of LFO workforce

GOAL 4. DEVELOP, PROMOTE, AND DELIVER OUTREACH AND AWARENESS PROGRAMS TO SECONDARY STEM TEACHERS, ADVISORS, COUNSELORS, ADMINISTRATORS, AND THE GENERAL PUBLIC.

RESEARCH QUESTION:

How does the work carried out by LASER-TEC influence awareness of teachers, students, and general public about LFO?



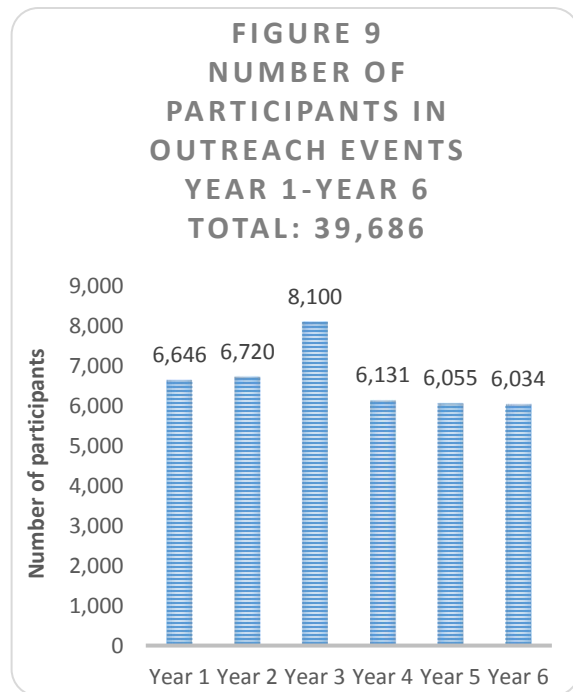
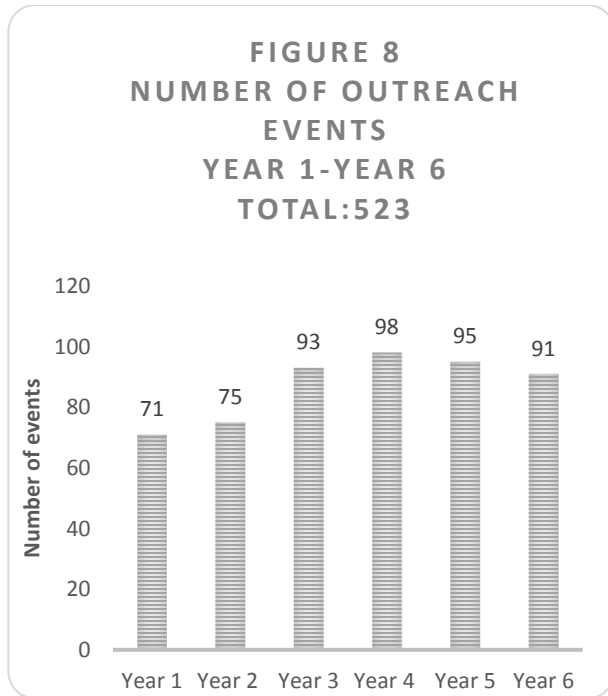
EXAMINED AREAS:

- Development and implementation of LFO outreach programs

LASER-TEC has employed diverse strategies that have proven to be very effective in public outreach, student recruitment, and retention. The results are demonstrated by continuously growing numbers of events and attendees as shown in figures 8 and 9. The number of outreach events has steadily increased, totaling 523 events since the establishment of the Center (see figure 8). The number of students impacted by the Center’s outreach activities reached 39,686 (see figure 9).



The Center’s outreach efforts feed the LFO college student pipeline and are very significant. It is evident that the Center dedicates a lot of effort and time to accomplishing these tasks. The target populations and groups include middle and high school students, teachers, parents, members of general public, counselors, advisors, unemployed, underemployed, veterans, and others.



The evaluator and the Center’s team conducted a close examination of the outreach campaigns and their outcomes. This investigation has revealed that engagement of a large number of K-12 students in short-term events has not resulted in a projected growth of college programs’ enrollment at the end of year 3. The Center’s management evaluated the results and adjusted

its approach. During the last three years, the Center concentrated on long-term events with multiple sessions throughout the whole academic year, focusing attention on each individual student and building his/her fundamental knowledge and skills in LFO. The Center management considers this change will have a higher impact on students' decision to pursue the LFO studies.

During this reporting period, LASER-TEC has offered 14 camp sessions with a minimum of 16 contact hours per camp for 207 middle and high school students. LASER-TEC offers 6 different camps: Tech Like A Girl (in partnership with AAUW), Laser and Fiber Optics, Coding with Arduino Bootcamp - Visible Light Spectrum, Coding with Arduino Bootcamp – Wireless Technologies, Coding with Arduino Bootcamp - Game Programming, Electronics Maker Bootcamp. A total of 466 students participated in LASER-TEC camps.



At the end of each camp session, the Center conducts an evaluation, which revealed that most students (86.7%) believe that skills they learned during the boot-camp will help them in the future. The evaluation results are also used to fine-tune the camps' content and the delivery method. The impact of this effort on the college enrollment will be presented in later studies.

Activities under Goal 4 had the FOLLOWING IMPACT:

- ✓ Increased number of students interested in LFO
- ✓ Increased number of teachers, advisors, and counselors who are aware about academic/ career pathways to LFO
- ✓ LASER-TEC boot-camp provide a long-term LFO engagement platform for middle and high-school students to prepare for college
- ✓ In 2018-2019, total number of participants of LASER-TEC outreach reached 6,034

GOAL 5. DEVELOP STRATEGIES AND MATERIALS FOR RECRUITING AND RETAINING UNDERREPRESENTED GROUPS AND TO PROMOTE DIVERSITY IN LFO PROGRAMS

RESEARCH QUESTION:
How does the work carried out by LASER-TEC influence the diversity of LFO student pipeline



EXAMINED AREAS:

- *Development and implementation of outreach and retention programs designed for culturally/ethnically diverse groups*
- *Development and implementation of outreach programs that increase the number of women in LFO*
- *Development and implementation of outreach and retention programs for active military personnel and veterans*

Findings:

Evaluation of this goal’s activities reveals that LASER-TEC has employed diverse strategies and approaches to reach out to veterans and multiple focus groups to increase cultural and gender diversity in the LFO college pipeline.



LASER-TEC has partnered with local Girl Scout Programs and hosted Saturday events for the junior troop as they earn their STEM badges in Robotics.

The STEAM Mentorship program for low-income middle school girls hosted by the Environmental Learning Center (ELC) is another continuous program that promotes LFO to young girls. This year is the second year of the partnership between ELC and LASER-TEC and the partnership will continue in the following years. This year, 20 ELC girls

will be participating in LASER-TEC camp in July. Fifty three girls have participated in the camps specifically geared catered for young women and girls.

The programs described above are designed for 12-13 years old girls and have not yet directly impacted the enrollment of women in LASER-TEC programs. However, other LASER-TEC recruitment strategies have resulted in the sustained growth of the overall number of female students at LASER-TEC. This year, 27 women, a slight increase from the last year of 23 women, are pursuing an LFO degree with LASER-TEC. This constitutes 9.3% of the total enrollment. It is suggested that LASER-TEC continues diversifying and host more outreach programs to girls and women.



The Center has collaborated with the IRSC and CCCC Minority Affairs Divisions and provided training and resources for students, administrators, and faculty of the following programs: Upward Bound, Upward Bound Math and Science, College Reach-Out Program, Education Talent Search, Summer Residential Program, Bridge Program, TRIO program, and Man of Color. In addition, LASER-TEC has

reached out to local community groups such as Gifford Youth Achievement Center, Science Institute of Discovery, Dasie Hope Center, and others to bring awareness about LFO to the underrepresented and underserved groups.

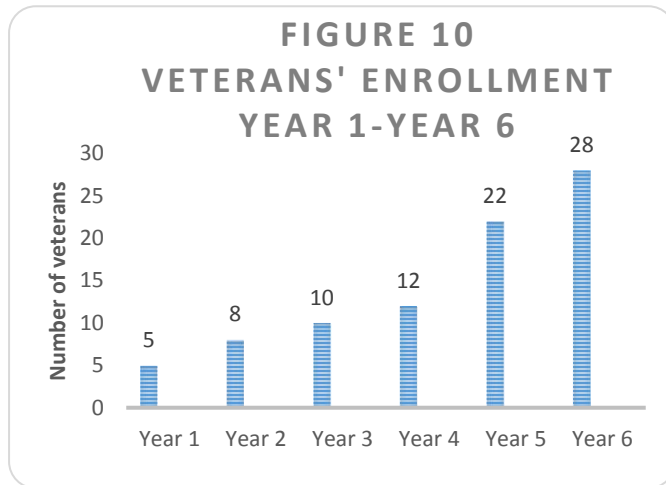
LASER-TEC summer camp curriculum has been fully adopted by the Emerging Technologies Summer Learning Program. This eight-week college transitional program will serve 20 underserved high school students during summer 2019. Students will be introduced to photonics, optics, robotics, Arduino programming, circuit design and principals of electronics.

The overall Center's effort in increase diversity has shown positive results: 44% of the 2018-2019 IRSC cohort and 38% in all LASER-TEC LFO programs consist of students with diverse racial and ethnical backgrounds.

The Center conducted email and telephone campaigns to veteran Transition Assistance Program offices in the southeast United States. Similar campaigns were conducted at military bases in the southeast region.

In the reporting period, LASER-TEC expanded its outreach to veterans to local DVOP, Disabled Veteran Outreach Programs.

The Center has significantly expanded informational materials for veterans and active duty



personnel originally developed by OP-TEC. These brochures intended to help articulate military training (military occupation specialties) to LFO academic credits and provide guidance on admission to an LFO college program. The center is also pursuing establishment of the partnership between Fort Bragg, an U.S. Army installation in NC, CCCC, and PCS Fiber that will provide a platform for training military personnel in the fiber optics technology followed by immediate employment.

Activities under goal 5 had the following impact:

- ✓ Multifaceted engagement and recruitment programs launched by LASER-TEC
- ✓ Increased number of women in LASER-TEC programs
- ✓ Expanded cultural diversity in LASER-TEC programs
- ✓ Increased number of veterans in LASER-TEC programs

GOAL 6. IDENTIFY AND DISSEMINATE LFO TECHNICIANS' SKILLSETS AND EMPLOYMENT NEEDS IN THE UNITED STATES.

During the grant planning and writing phases, LASER-TEC had stated its sixth goal to "Identify and disseminate LFO technicians skillsets and employment needs in the United States". Since then, LASER-TEC has provided assistance to Research Triangle Institute (RTI), a contractor to the U.S. Department of Labor (DOL) and the National Center for O*NET Development, in updating skills, employment, wages, and other relative information for occupation 17-3029.08, Photonics Technicians.

RTI holds all required data collection, surveying tools, and methodology to conduct a nationwide collection effort that is designed to provide data that are valid, reliable, current, and regularly updated. LASER-TEC is planning to continue partnering with RTI and use O*NET website as the information dissemination platform. Since this initiative is successfully led by RTI, O*NET and DOL, LASER-TEC will collaborate with these organizations to "Identify and disseminate LFO technicians skillsets and employment needs in the United States".

PART IV

RECOMMENDATIONS

1. Continue developing and offering programs designed for girls and women in STEM. Develop longitudinal evaluation tools to measure the outcomes and impact.
2. Continue with the search of effective ways to inform active military and veterans about LFO programs and careers.
3. Continue engagement and partnership with the LFO industry through industry-lead conferences, workshops, and seminars.
4. Continue offering tailored curriculum packages and faculty development for colleges across the U.S.
5. Based on the parents' responses collected during camps' evaluation, provide a streamlined pathway for students who attended LASER-TEC camps to LFO college programs. This includes offering additional camps that engage student in the LFO subjects until they are ready for dual enrollment.
6. Provide platform for dissemination of materials and resources developed by OP-TEC and MPEC.
7. With the funding sunset in 2021, plan and prepare to apply for an NSF ATE Resource Center in 2020.

PART V

CONCLUSIONS

LASER-TEC has delivered outcomes and created planned impact in accordance with the logic model evaluation methodology, provided on page 4 of this report.

The Center has increased the number of LFO courses and modules available and offered nationwide. Student enrollment in the participating colleges has steadily increased over the six years as well. During this evaluation period, the Center has expanded its college network; currently, it consists of 34 colleges at the different phases of LFO implementation. Eight colleges have established LFO courses or programs. This resulted in the steady growth of the number of student-semester hours, -the metrics used to measure change in the course offerings and students enrollment. This year, it reached 3,987 SSH.

LASER-TEC continues developing mutually beneficial partnerships with the LFO industry. Career placement of students at IRSC and CCCC is nearly 95%. Many students receive multiple job offers even prior their graduation. The industry partners proactively participate in the curriculum development and continuously contribute to the improvement of the colleges'

laboratories. LASER-TEC also supports the industry with a continuous offering of professional development for incumbent workers.

Since its establishment, LASER-TEC conducted 27 workshops for 351 educators. Surveys conducted six to twelve months after the workshops show employment of the Light and Optics Exploration Kit and lesson plans in K-12 classes. Teachers and administrators commended LASER-TEC for the affordability and entirety of the kits. Mapping the lesson plans to the Next Generation Science Standards makes the demonstration book valuable to all STEM disciplines.

The Center has developed a wide collection of curriculum and other teaching tools to simplify and streamline infusion of LFO in K-12 schools and colleges. Curriculum materials are also available for the industry training in lasers and fiber optics. Currently, LASER-TEC offers 10 LFO courses and 10 LFO modules. Several additional modules are currently being developed. They are supported by LASER-TEC developed textbooks, lab manuals, lesson plans, and multiple cost-effective kits. In addition, to develop and sustain a strong K-12 pipeline prepared for college, the Center has developed curriculum for six different student camps which are offered throughout the year. The Center continuously makes improvement and updates in its materials.

Public outreach and awareness remains one of the biggest focus of the Center. This year, LASER-TEC hosted 91 events for over 6,000 participants. Reaching out to veterans still remains to be still one of the most challenging tasks. During year six, LASER-TEC has changed its strategies to bring awareness to active military personnel and veterans. It has partnered and leveraged resources of the professional societies, participated in the focus conferences, and recruited LFO student veterans to participate in the outreach. LASER-TEC has achieved a moderate increase in the numbers of veterans pursuing LFO. It is recommended that LASER-TEC continues searching for more methods to recruit veterans.

LASER-TEC has done a considerable steps in improving its strategies in recruitment of women and girls. Multiple initiatives have been launched or continued in this evaluation period. Based on the participants' feedback, Teck Like a Girl remains one of the most successful programs as it encompasses many best practices raising girls' awareness about STEM and closing the gender gap.

In summary, LASER-TEC remains to be focused and flexible in its approaches to fulfill its mission to build and sustain a world-class laser and fiber optics workforce.