

LASER-TEC

CENTER FOR LASER & FIBER OPTICS EDUCATION

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FINAL EVALUATION REPORT

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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 in the following eight southeast states: Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Alabama, Mississippi, and Florida. 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 was to develop a sustainable pipeline of qualified laser and fiber optics technicians to meet industry needs in the Southeastern United States. To accomplish this mission, the following goals were set:

1. Assist colleges with existing LFO programs by providing support, professional development, and equipment.
2. Assist colleges without LFO programs to create courses and programs by providing start-up support.
3. Provide professional development for K-12 STEM teachers to bring LFO career awareness to students to create a high school to college student pipeline.
4. Create awareness of LFO careers and a clear pathway for returning veterans to recruit them for participating regional college programs.
5. Develop, expand, and strengthen partnerships between LFO industries and all regional colleges.
6. Expand the membership of the Industrial Advisory Board (IAB) and monitor the supply, demand, and skillset needed by LFO technicians in the southeast region of the US through a strong IAB.

This final report for the NSF ATE award DUE-1304628 evaluates the progress, accomplishments, and challenges in achieving these goals during 2013-2018 of LASER-TEC operation.

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 IV of this report presents the conclusions and suggestions 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 third 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)

At the outset of the project, the PI met with the evaluator on multiple occasions and outlined the goals, objectives, and tasks of this project. 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 staff disseminated the data collection instruments, collected the evaluation results from participants, and presented them to the evaluator for analysis and report preparation.

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 RESEARCH QUESTIONS & FINDINGS

Goal 1. Assist colleges with existing LFO programs by providing support, professional development, and equipment.

RESEARCH QUESTION:

How do the efforts of LASER-TEC influence the development and strengthening of established LFO programs?



EXAMINED AREAS:

- Development, implementation, and dissemination of curriculum and instructional materials
- Efforts to enroll, retain, and graduate students from established LFO programs
- Development and improvement of LFO laboratories
- Faculty professional development
- Institutional support
- Efforts to increase the number of students choosing LFO and STEM programs

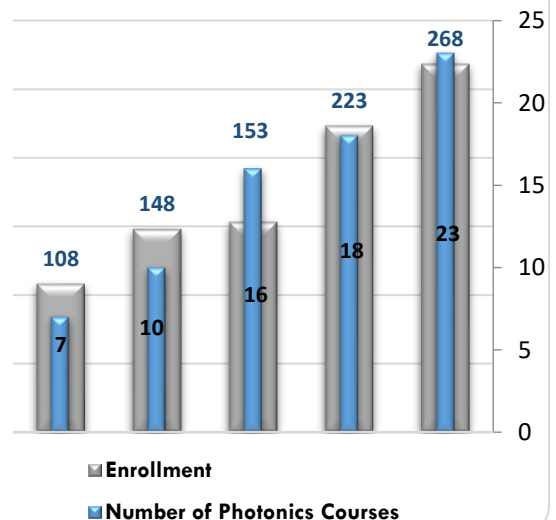
Findings:

The number of students in LASER-TEC photonics programs has increased consistently from the baseline of 108 in 2013 to 268 in 2018—an increase of 148%. This sustained growth of student enrollment is largely attributed to the diverse public outreach and recruitment campaign deployed by the Center and its partner colleges.

The number of photonics courses and program enrollment has steadily increased over the last five years. LASER-TEC has developed or updated ten photonics courses. The number of offered photonics course sessions per academic year has increased from 7 in year 1 to 23 in year 5.

The Center has developed seven video lectures to accompany the “Fiber Optics for Technologists” textbook, available on the Center’s YouTube channel. These lectures were developed to guide

**Figure 1
Photonics Courses and Program Enrollment
Year 1-Year 5**

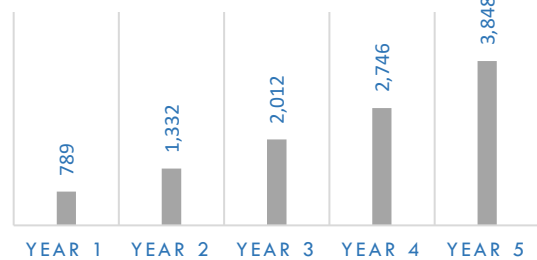


students through the theoretical content of the book during traditional and online classes. These classes are taken by college students and LFO technicians occupying or seeking positions in fiber optics.

The Center has developed curriculum for several LFO subject areas. In addition to topics in fiber optics, LASER-TEC has developed and assisted colleges in infusing modules in laser technology, LED technology, spectroscopy, solar technology, biomedicine and LFO –enabled automation systems. Currently, the following LASER-TEC modules are available for colleges nationwide: LED technology, Semiconductor processing, Photonics devices, Spectroscopy technologies, Solid-state crystal growth, High-power pulse lasers. Four modules are being developed: Enhanced Raman Spectroscopy Lab, Thermoelectric Device Measurement Lab, Stand Alone PV System Design, Megawatt Solid State Laser.

LASER-TEC increased student enrollment in its photonics courses and responded to industry requests for updated skills by creating and delivering new curricula.

Figure 2
Student Semester Hours
Year 1-Year 5



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 participating colleges. The number of SSH has almost quadrupled, since year 1, an increase from 789 in 2013 to 3,848 in 2018, as shown in figure 2.

Continuous faculty professional development and improvement of the laboratory facilities, increased the number of photonics course offerings by all partner colleges.

In a short period of time, five new laboratories have been developed and now support the Center's academic programs. Swift allocation of space and infrastructure for the new laboratories indicates strong institutional support, which in turn reveals the high potential of program sustainability. In addition, LASER-TEC ensures the programs' smooth succession and sustainability by continuously training new college faculty in the latest developments of LFO science and technology.

LASER-TEC has employed part-time dedicated recruiters proven to be very effective in public outreach and student recruitment. The results are demonstrated by the large and continuously growing numbers of attendees as shown in figures 3 and 4. The number of outreach events has steadily increased, totaling 432 events since the establishment of the Center. The number of students impacted by the Center's outreach activities reached over 33,000.

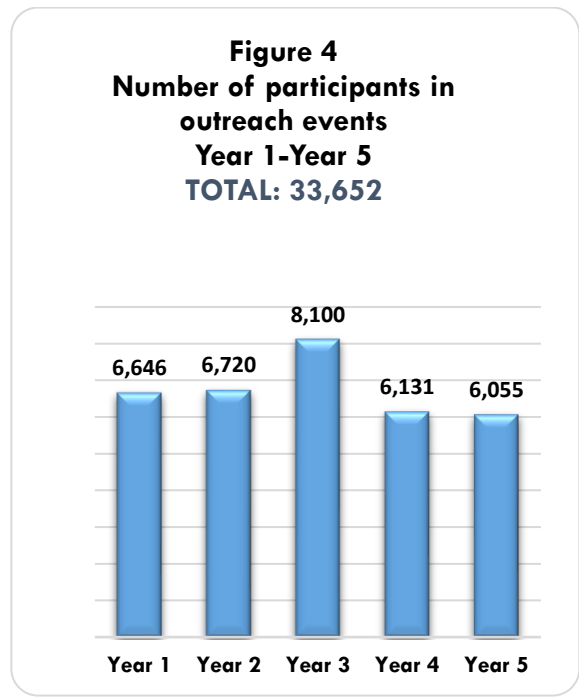
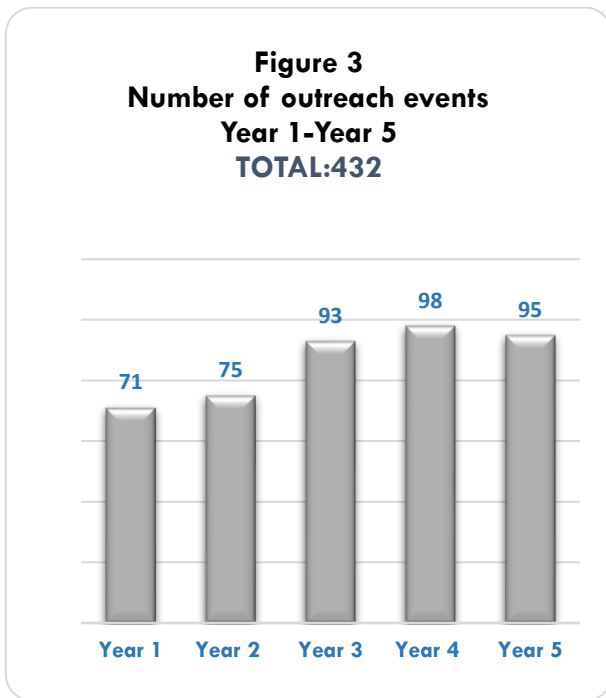
The Center's outreach efforts feed the LFO college student pipeline and are very significant. It is evident that the Center dedicates a lot of effort and time to accomplishing these tasks. The key groups include middle and high school students, teachers, parents, members of general public, counselors, advisors, unemployed, underemployed, veterans, and others. LASER-TEC has leveraged collaboration with the other NSF ATE centers, such as OP-TEC and MPEC, and reached out to the K-12 community outside the southeast region.

The Center has adjusted its approach to student enrolment and engagement by offering long-term outreach events throughout the whole academic year, focusing attention to individual students and building their fundamental knowledge and skills in LFO.

Last year, 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 year 4 and 5, 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.

LASER-TEC has offered 29 camp sessions with a minimum of 16 contact hours per camp for 411 middle and high school students. LASER-TEC has responded to the need of additional activities and has developed additional camps. By the end of year 5, 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.

At the end of each camp session, the Center conducts an evaluation, which revealed that most students (83.3%) think that skills their 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.



The Center’s outreach efforts are significant and are targeted at the right populations which will affect future growth of LASER-TEC programs.

ACTIVITIES UNDER GOAL 1 HAVING LONG-TERM IMPACT:*Curriculum development:*

- ✓ 10 new courses are now available to all US colleges.
- ✓ 10 new modules are available to all US colleges.
- ✓ Increased faculty knowledge.
- ✓ 5 new LFO laboratories have been established.

Enrollment and placement:

- ✓ The number of students taking laser and photonics courses increased to 268 in year 5, 148% increase since year 1.
- ✓ Job placement remains at 95% with students receiving more than one job offer.

STEM awareness:

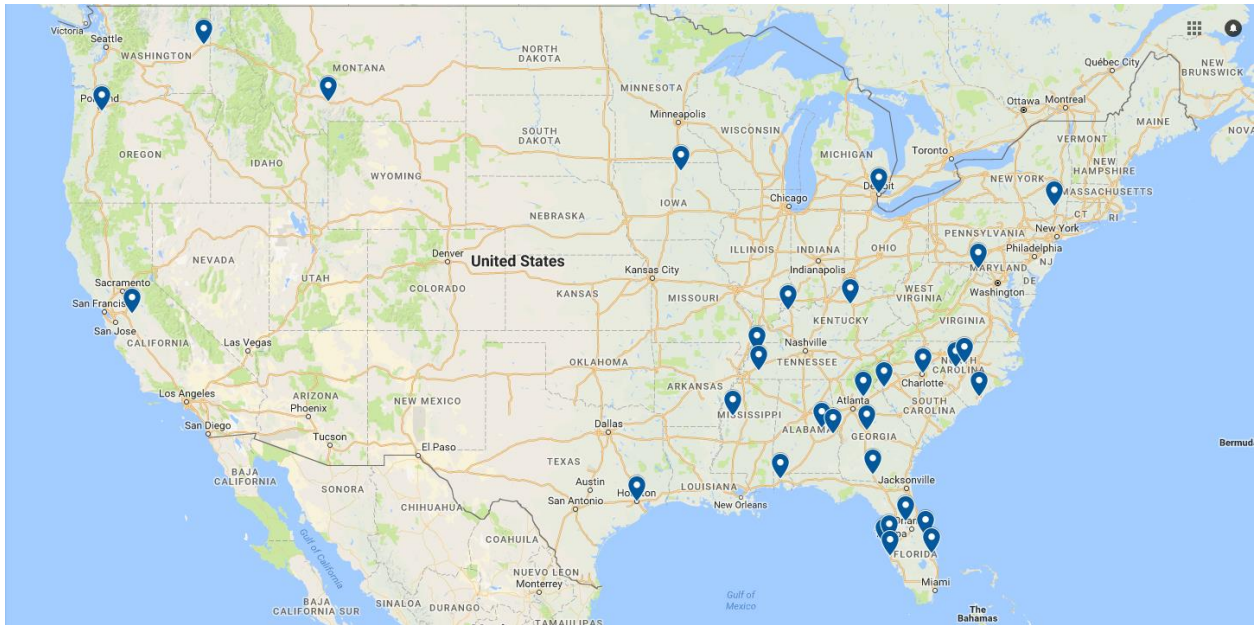
- ✓ The total number of all middle and high school students who attended LASER-TEC events in 2013-2018 reached 27,597.

Goal 2. Assist colleges without LFO programs to create courses and programs by providing start-up support.**Findings:**

During year 1 – year 5, LASER-TEC conducted 14 email campaigns reaching out to more than 1,000 southeast college faculty and administrators each time, presented at 36 conferences for the purpose of bringing LFO awareness, and invited more colleges to join the network. At the same time, college members received continuous support in establishing or sustaining LFO programs. These efforts resulted in a balanced advancement of the LASER-TEC college network. By the end of the grant, 34 colleges are in the process of offering LFO courses, see figure 5.

These colleges are at different stages of LFO program 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, as shown on figure 6.

As it was identified in the previous Evaluation Reports, under favorable conditions, it takes a college two to three years to progress between the preliminary and implementation phases. The relatively slow progress is associated with the required faculty development, facility establishment, and following the necessary processes and policies within each institution.

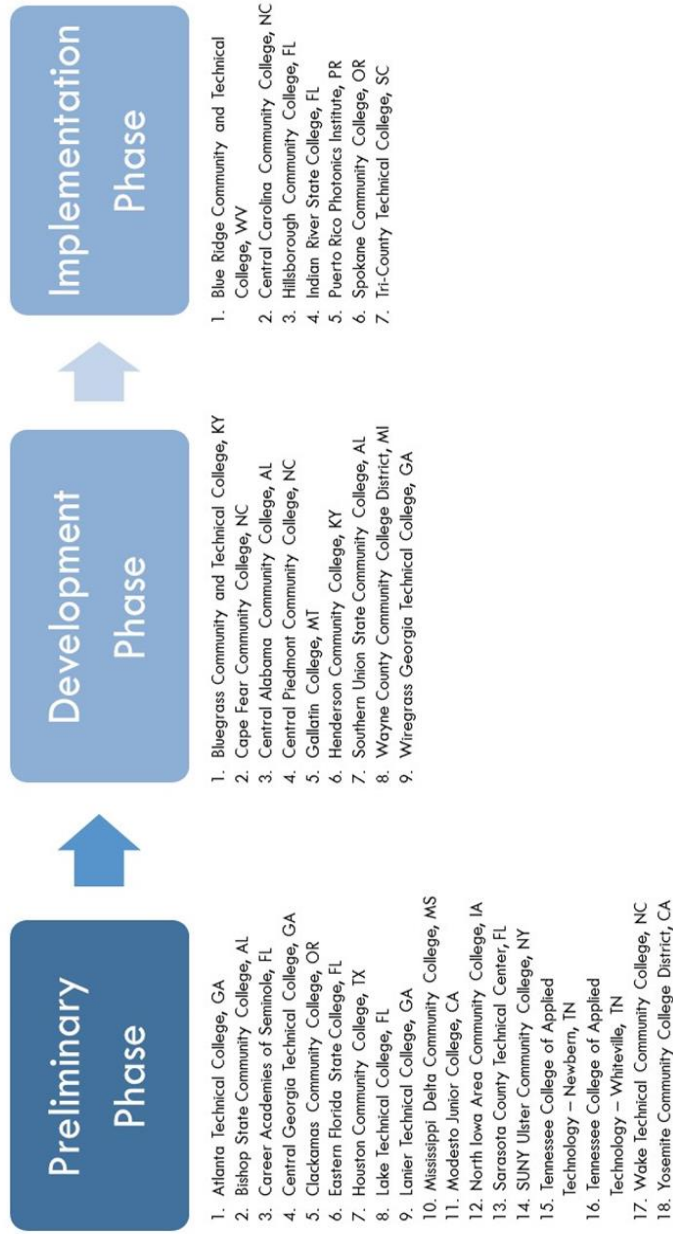
Figure 5. LASER-TEC College Network

In 2018, seven out of 34 colleges, are classified to be in the implementation phase (see Figure 6), nine in the development phase and the rest are in the preliminary phase.

As the result of strengthening existing LFO college programs and starting the new programs, the annual output of graduates from the partner colleges increased from 98 to 253 students, an increase of 155%. A total of 569 students have graduated from LASER-TEC colleges nationwide between 2013 and 2018. The annual enrollment in LASER-TEC colleges grew from 108 to 268 students, an increase of 148%.

LASER-TEC has offered curriculum that reflects local industry presence. For example, in Florida and Georgia, where there is large number of fiber optics companies, colleges are mostly interested in offering fiber-optics-related courses. In North Carolina, where there is a large number of laser companies located in the Research Triangle, there is a greater demand for laser-related curriculum. In Kentucky with the growth of the industrial sector, laser safety is an important part of a maintenance technician training.

Figure 6. College Network, LFO Implementation Phases

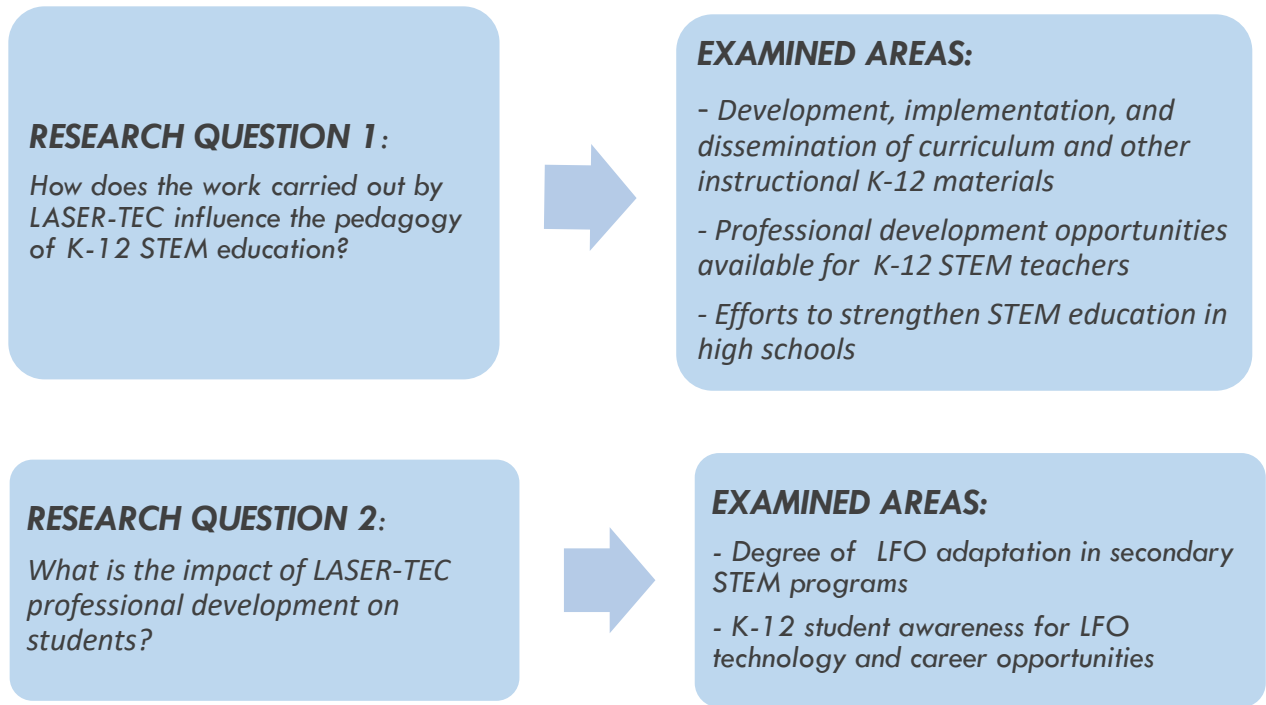


The college network grew from 12 colleges in year 1 to 34 in year 5. The level of engagement and support by the Center has advanced as well.

ACTIVITIES UNDER GOAL 2 HAVING LONG-TERM 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.

Goal 3. Provide professional development for K-12 STEM teachers to bring LFO career awareness to students to create a high school to college student pipeline.

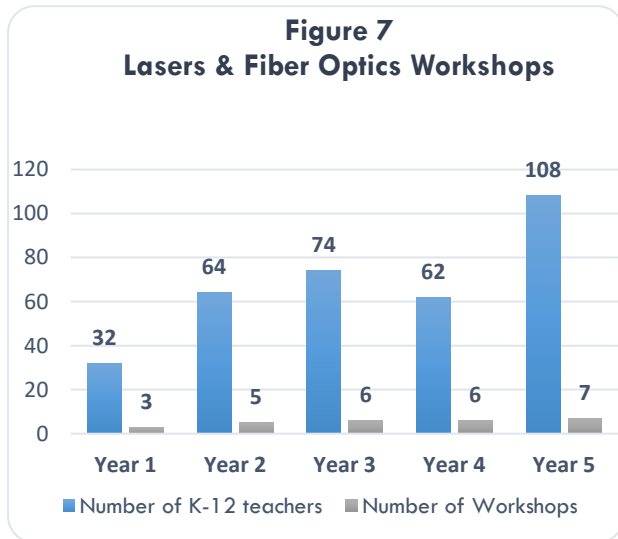


Findings:

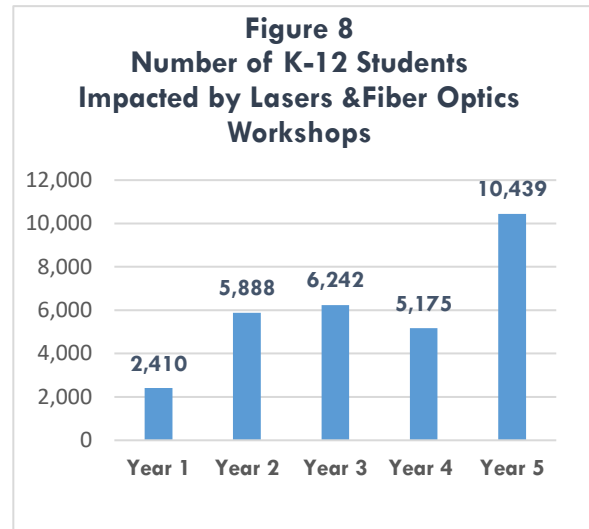
LASER-TEC workshops offered rich content and various hands-on activities, and they have been profoundly supported by teacher materials. The workshop content and delivery format have been continuously adjusted based on participants’ evaluations as well as internal evaluation by the Center. One of the main workshop goals was to teach educators and counselors and achieve a multiplier effect in student LFO awareness. Typically, every teacher has on average 125 students under their tutelage every year, and a counselor has more than 500 students annually. LASER-TEC workshops are seven hours long with a combination of lectures, demonstrations, and hands-on sessions. These workshops were conducted in fall, spring, or summer semesters, based on teacher availability. Figure 7 and Figure 8 below demonstrate the growth of the number of workshops, participants and impacted students between Year 1 and Year 5. The total number

are as follows: total number of workshops - 340, total number of participants- 340, and total number of students impacted by LASER-TEC workshops is 30,154.

In previous years, the Center has modified its approach in conducting workshops. LASER-TEC has 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 and LASER-TEC delivered the content and provided teaching tools and kits. This “school administration initiated” approach resulted in higher level of teacher’s participation, averaging 18 teachers per each workshop compared to previous of 10 teachers per workshop. Based on the results of the evaluation, teachers’ general interest in integrating LFO into their lessons has also increased from 80% to 88%.



Total number of workshop: 27
Total number of K-12 teachers 340



Total number of students impacted: 30,154

A two-step workshop evaluation is conducted in accordance with the Kirkpatrick and Kirkpatrick model. The first evaluation is conducted 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, 85%*
- How likely are you to start a laser and fiber optics course at your school? *Very likely, 25%,*

Six months after each workshop, a second evaluation is conducted in a form of an electronic survey to assess the degree of implementation. This survey is designed to measure behavior and result levels according to the Kirkpatrick and Kirkpatrick model. The findings related to the six-month follow-up survey are summarized below:

- Percent of received responses: 38%.

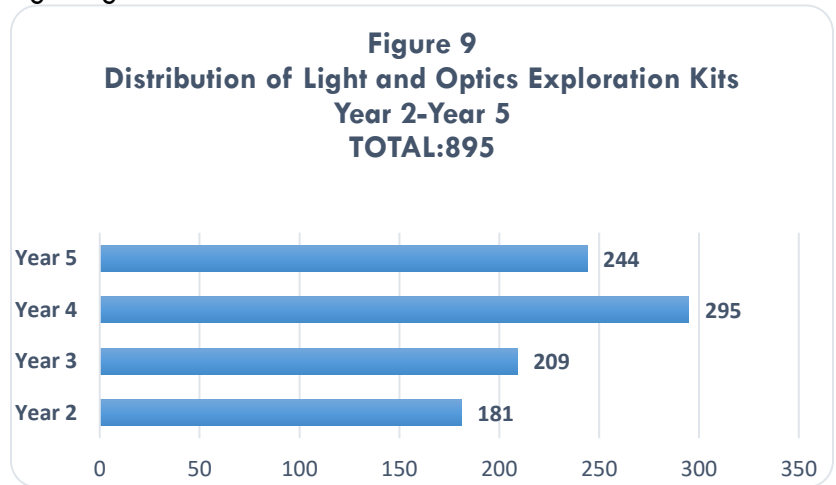
- 76 % of responders used the kit and the lesson plans in their STEM lessons.
- All 15 lesson plans have been used by responders for their lessons.
- 76% of responders who used the kit and lesson plans stated that the kit and lesson plans are useful and contain all necessary information to help them prepare for the lesson.

A relatively high content implementation level of the workshop content in K-12 STEM classes is sustained by the availability and quality of the teachers' resources developed by LASER-TEC. During each workshop, all participants are provided with the Light and Optics Exploration Kit accompanied with detailed lesson plans.

In the 2018 edition of the teacher's demonstration guide, LASER-TEC updated all lesson plans and referenced them to the Next Generation Science Standards, which have been adopted by most of the States. This change has been welcomed by teachers who can now be more effective in introducing emerging technologies and getting students interested in STEM and LFO.

During this grant, LASER-TEC has distributed 895 Light and Optics Exploration Kits in more than 25 different states, as shown in figure 10.

In addition to the Exploration Kits, LASER-TEC has also developed Laser-Enabled Security System Kits as well as Arduino Visible Light Spectrum, Arduino Wireless Technologies, Arduino Game Programming and Electronics Maker kits use in the student camps.



LASER-TEC has done an exemplary job in providing professional development in LFO to K-12 teachers and has created high quality educational materials referenced to the latest national Next Generation Science Standards.

ACTIVITIES UNDER GOAL 3 HAD THE FOLLOWING LONG-TERM IMPACT:

- ✓ Increased infusion of LFO knowledge into K-12 STEM disciplines.
- ✓ Increased number of students interested in LFO careers.
- ✓ LASER-TEC kits create an affordable way to teach photonics in K-12 schools.
- ✓ Mapping the Next Generation Science Standards to lesson plans makes demonstration book useful to all STEM disciplines.

Goal 4. Create awareness of LFO careers and a clear pathway for returning veterans to recruit them for participating regional college programs.

RESEARCH QUESTION 1:

What is the Center's impact on veterans' enrollment to LFO programs?

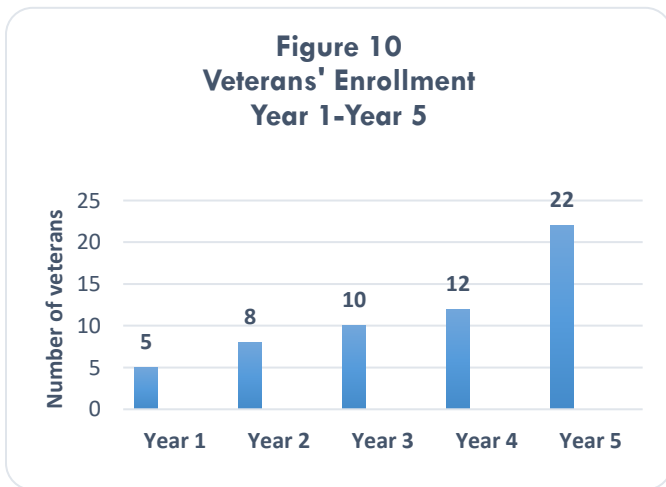


EXAMINED AREAS:

- Awareness strategies to veteran community employed by LASER-TEC
- Veteran enrollment in partnering colleges

Findings:

During the span of this grant, the Center has pursued multiple strategies to reach out and engage active military personnel and veterans. The Center has developed and maintained a pro-active partnership with the colleges' Veterans' Affairs offices and participated in multiple veteran-focused events and conferences. The Center has also used online platform such as ACP AdvisorNet to connect with military community. Multiple email and telephone campaigns to veteran Transition Assistance Program offices has been conducted by the Center in the southeast United States. The center has been 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. The Center also hosts the page on its website dedicated to veterans: <http://www.laser-tec.org/veterans.html>. All LASER-TEC efforts have resulted in the growth of the number of veterans pursuing LFO studies, however, the overall numbers remained to be moderate.



A possible explanation for a modest growth of veterans pursuing LFO with LASER-TEC colleges is the aggressive marketing of for-profit colleges attracting the majority of veterans. An excerpt from the *Tampa Bay Tribune* states "For-profit schools received \$1.7 billion in veterans' benefits during the 2012-13 academic year, 41 percent of all G.I. Bill dollars and almost as much as the cost of the entire program just four years earlier, according to the majority report of the Senate Health, Education, Labor and Pensions Committee released July 30." See the links below for relevant articles in

the US press.

- <http://www.tbo.com/news/education/colleges-gouge-vets-report-says-20140818/>
- <http://www.latimes.com/business/la-fi-university-of-phoenix-military-20151009-story.html>
- <http://chronicle.com/article/For-Profit-Colleges-Still-Cash/147977>

Although at a moderate rate, the number of veterans enrolling in LFO programs still has increased, as shown in figure 10 above.

Despite multiple efforts of the Center, the enrollment of veterans has increased at a moderate rate.

Goal 5. Develop, expand, and strengthen partnerships between LFO industries and all regional colleges.

RESEARCH QUESTIONS:

How does LASER-TEC influence developing relationships with business and industry?

Do these relationships have broader impact on the relationships between the college and local businesses?

What impact does LASER-TEC have on development of the incumbent LFO workforce?



EXAMINED AREAS:

- Development, implementation, and dissemination of continuing education and college-level training for incumbent LFO workforce

- Corroboration of local businesses with LASER-TEC college partners

- Timely supply of new talent to meet the industry hiring needs

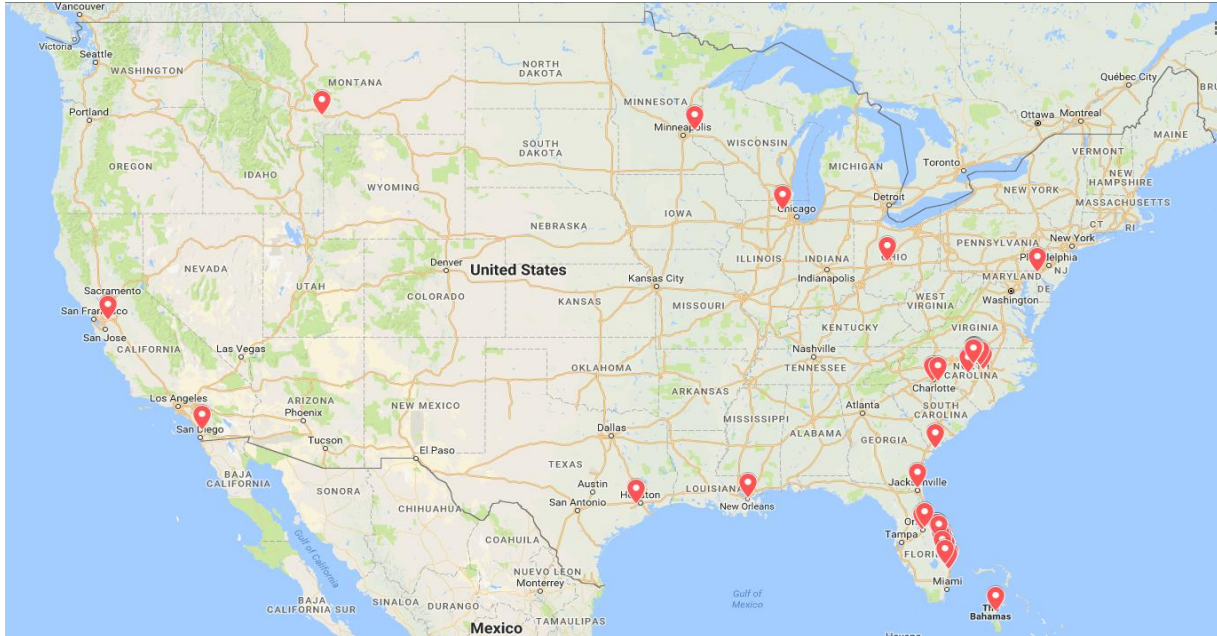
Findings:

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.

The LASER-TEC industry training has enabled the advancement of technical knowledge and skills in 141 of the LFO incumbent workforce. Exposure of the college faculty to the new technologies and techniques facilitated development of the curriculum which is better aligned to the industry needs.

The Center has organized and facilitated 51 on-campus or on-site hiring sessions for 18 LFO companies. This effort enabled industry to acquire qualified workforce, while providing graduates with opportunities for gainful employment. By the end of year five, 48 LFO companies have hired LASER-TEC graduates. See figure 11. 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.

Figure 11
LFO Companies that hired LASER-TEC graduates in Y1-Y5, total 48



The Center has worked closely with industry and has created college/industry collaborations at every partner college.

ACTIVITIES UNDER GOAL 5 HAD THE FOLLOWING LONG-TERM IMPACT:

Impact on the incoming workforce:

- ✓ Increased number of companies hiring LASER-TEC graduates.
- ✓ 15 companies routinely recruit LASER-TEC graduates before their graduation.
- ✓ Supplied qualified LFO technicians to 48 SE companies.

Impact on the existing workforce:

- ✓ Increased number of trained incumbent workers.
- ✓ Companies have trained workforce to the latest industrial standards.

Goal 6. Expand the membership of the Industrial Advisory Board (IAB) and monitor the supply, demand, and skillset needed by LFO technicians in the Southeast region through a strong IAB.

RESEARCH QUESTION:

How does LASER-TEC leverage the Industry Advisory Board to monitor the workforce supply and demand in the southeast?



EXAMINED AREAS:

- Communication effectiveness with IAB and the Industrial Network
- Dissemination of information among the stakeholders
- Implementation of IAB recommendations

Figure 12
Industry Network



Findings:

Since the beginning of the grant, LASER-TEC has engaged and strengthened the Industry Advisory Network. The network grew from 98 companies clustered in the southeast in year 1 in to 162 located nationwide in year 5. The primary college partners continue to reach out to LFO companies and sustain the academic-industry partnerships. Companies from the following states outside of the southeast region -California, Washington, Montana, Wisconsin, Illinois, Ohio, Delaware, and Texas - have joined the network.

Together with the evaluating team, the Center has developed, launched, and analyzed the results from 3 electronic surveys distributed among members of the network. The goals of the surveys were to identify the most needed LFO skills and knowledge for LASER-TEC graduate to secure a gainful employment with the industry. The results pointed to the most “sought after” skills (in no particular order):

- Math Skills
- People skills, including good communication skills, written and verbal in English in order to communicate well with engineers.
- Opto-mechanical alignment experience; laser centering of optical elements; interferometer experience
- Ability to align optical components/stations to required accuracies using not only simple alignment aids, but also optical metrology equipment and fixtures. The tech should be capable of understanding alignment techniques for both the visible and non-visible portions of the optical spectrum. Ability to design fixtures and procedures would be a significant advantage
- Basic trouble shooting skills
- Clean and inspect optical surfaces without damaging them
- Ability to read and understand detailed technical instructions
- Hands-on experience with lasers and fiber optic assembly and test equipment

The surveys have also revealed the looked-for knowledge of a LASER-TEC graduate (in no particular order):

- Knowledge of electromagnetics, lasers, basic geometric & wave optics including interference & diffraction, thin lens equation, basics of light propagation
- Strong math and science fundamentals such as physics, algebra, trigonometry, geometry as well applied fields such as electronics and geometric and ray optics. Some knowledge of calculus is desirable although not required.
- Competence in optics and physics that provides understanding of technical goals, performance metrics, and trouble-shooting/problem-solving skills.
- Understand the function of various optical components for assembly into laser systems or test set-ups.
- Understanding of different types of lasers
- Diligence in documenting procedures, measurements results, methods taken, and equipment/fixture layouts and locations. Documentation skills must be adequate for the tech or other team members to reproduce results and performance metrics.
- Just enough software skills to work with the EE and software engineers when developing and performing automated testing
- Responsibility in understanding risks and hazards, especially eye safety practices for lasers including laser classes, nominal hazard zones, and protective eyewear.
- Ability to use related computer tools such as MatLab, LabView, Excel and C++ or VB.

LASER-TEC has embedded the identified knowledge and skills in the developed courses and modules. The indicator of a successful infusion of the industry-identified competencies is a high job placement of LASER-TEC graduates. Many LASER-TEC students received several job offers even prior their college graduation.

To mobilize collaboration with the industry and ensure an effective advising and steering, the Center has formed the Industry Advisory Board (IAB), consisting of nine hiring engineering managers from various sectors of the LFO industry. The goals of the IAB were as follows:

- Provide information about industry needs for technicians with training in some aspects of LFO
- Provide information about industry needs for training of incumbent workers in photonics
- Review the current skill sets defining the industry needs for trained LFO technicians & recommend modifications or additions
- Review potential surveys to the industry network to help make them effective & to maximize the number responses
- Contact colleges in the proximity of company and encourage them to start an LFO course or certificate or degree program.

The evaluator finds the Center’s leverage of the existing professional communities, groups and societies to be an effective way to engage and communicate with the industry. The Co-Principal Investigator, Dr. James Pearson, currently serves as an Executive Director of the Florida Photonics Cluster, an association of nearly 100 photonics companies. FPC was “Formed to support the growth and profitability of the photonics industry through the strength of a unified voice”. Dr. Pearson efficiently serves as a liaison among colleges, LASER-TEC, and the industry. LASER-TEC has participated in all annual meeting of FPC briefing the cluster on the center’s progress.

To conclude, LASER-TEC has developed efficient ways to engage with the LFO industry, strengthened the college-industry partnerships, identified competencies for LASER-TEC graduates, and embedded them into the developed curriculum.

The Center has expanded its industry network. Its active industry advisory board ensures alignment between colleges and LFO industry.

ACTIVITIES UNDER GOAL 6 HAD THE FOLLOWING IMPACT:

Mid-term

- ✓ Active IAB.
- ✓ Improved LFO programs reflecting IAB recommendations.
- ✓ Improved quality of LFO graduates.
- ✓ Increased number of companies hiring LASER-TEC graduates.

Long-term

- ✓ Aligned skillset for LFO technicians with the industry needs.
- ✓ Reduced the supply and demand gap of trained LFO workforce.

PART IV

CONCLUSIONS

The final outcomes and impacts of the Center have been measured and assessed according to the logic model evaluation methodology.

LASER-TEC has achieved and surpassed the goals and objectives identified by the Center's mission to develop and sustain the pipeline of qualified laser and fiber optics technicians.

LASER-TEC has increased the member colleges' output of laser and fiber optics graduates, thereby reducing the gap between the supply and demand of qualified LFO technicians. LASER-TEC graduates found gainful employment in the LFO industry and many had multiple job offers. The employment with the LFO industry provides opportunities for workforce mobility and career advancement and versatility. Higher than average wages improve the overall socioeconomic status of graduates who enter the LFO workforce and have a broader positive impact on their families and communities. These new technicians now fill positions in the states where employers had difficulty finding qualified workers thereby strengthening the US economy and its global competitiveness.

The Centers' sustainability is achieved by supporting programs with analysis of local LFO employment market's supply and demand, curriculum alignment with local industry requirements, faculty development, facility improvement, and last, but not least- student enrollment and success. The center provided strong evidence that it has put a significant effort in all and each of these areas of academic sustainability.

Strong results have been achieved in the areas of incumbent workforce training. LASER-TEC leveraged partnerships with industry leaders in development and delivery of short-term training that upskill technicians in the laser and fiber optics technologies.

The Center has done a substantial work in preparing middle and high school students for LFO college programs. Multiple outreach events, students' camps, and fieldtrips brought awareness about LFO to students, parents, counselors and advisors.

The ongoing industry support is very strong, as evidenced by the monetary and in-kind contributions to LASER-TEC, which have been growing throughout the duration of the Center's operation. LASER-TEC has been effective in fostering industry partnerships and leveraging it for the LFO program design, course content, and updating technician skillsets. It is evident that the Center conducts a wide-spectrum strategy in engaging industry and building college/industry partnerships that enable strengthening of the nation's LFO workforce.

The Center has a strong IAB, consisting of members from not only southeast states, but other states such as California, Washington, Montana, Wisconsin, Illinois, Ohio, and Texas. The Center's management team is responsive to recommendations from the IAB, particularly in aligning training and college-acquired skillsets with industry needs.

It is the opinion of the evaluation team that a highly-qualified and experienced PI, set of Co-PIs and Center's personnel, have taken appropriate actions and established the necessary processes and mechanisms that created a successful ATE Center which will contribute to the strength of the US workforce for many years to come.