Developing a Photonics and Laser Technician Education and Training Program

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Abstract

Photonics is the science and technology of using light to generate and control energy, and transmit and detect information. Photonics is an enabling technology, supporting a wide variety of industries and fields. The National Photonics Initiative[1] has identified five key areas where photonics plays a critical role in allowing the United States to regain global competitiveness and maintain national security: advanced manufacturing, communications and information technology, defense and national security, energy, and health and medicine. While photonics plays such an important role in enhancing the quality of our lives, higher education programs to prepare technicians to work in this area are few across the country. The existing programs do not produce a sufficient number of graduates to fill the current and projected industry needs for photonics technicians in our state and region as well as nationally[2]. Baker College has started addressing this gap by developing and introducing a two-year Photonics and Laser Technology program, the only such program in our state. This initiative has received enthusiastic support from the photonics industry in the state, and is also supported by a National Science Foundation Advanced Technological Education[3] (ATE) Grant. The goals of the grant project are to: a) create and implement a new Associate of Applied Science Photonics and Laser Technology (AAS PLT) program; b) fully equip an Optics and Photonics Laboratory for education and training; c) train faculty to teach core courses in the AAS PLT program; d) perform outreach activities to local high schools to promote the new program; e) educate 30 or more students or workers by the end of the project.

The paper discusses the efforts and activities performed towards achieving the project goals, and the results and outcomes obtained in the first year of the grant. Activities included convening an Advisory Board with industry participation to provide guidance towards a current, high quality photonics program; developing new photonics courses with labs; building a state-of-the-art Optics and Photonics educational laboratory; providing professional development to faculty members in photonics topics including experimental skills; training and certifying a faculty member to act as Laser Safety Officer; holding an Open House and visits to the Optics and Photonics Laboratory; and offering a summer program introducing photonics to high school students in the area.

Introduction

Photonics encompasses the science and technology of using light to generate and control energy, and transmit and detect information. The 2012 Report "Optics and Photonics: Essential Technologies for Our Nation"[4] from the National Research Council discusses the current state of the art and the economic impact of optics and photonics technologies, and provides recommendations to ensure that the United States remains competitive in this field as many other countries are investing heavily in their optics and photonics industries. The Report called for the formation of a National Photonics Initiative[1] that will seek to raise awareness about photonics and its impact on our everyday lives; increase collaboration and coordination among U.S. industry, government and academia to advance photonics-driven fields; and drive U.S. funding and investment in areas of photonics critical to maintaining U.S. competitiveness and national security. The National Photonics Initiative, formed in 2013, has identified five key areas where

photonics plays a critical role: advanced manufacturing, communications and information technology, defense and national security, energy, and health and medicine.

Concurrent with photonics getting a brighter spotlight at the national level, state efforts are underway to promote the growth of photonics. Mi-Light[5], the Michigan Photonics Cluster, was formed at the end of 2012 to serve as the focal point for the photonics industry in Michigan. The ultimate goal of the Cluster is to expand the industry, attract funding and stimulate innovation in Michigan. In its first year of existence the Cluster has reached a total of 25 members including commercial companies and academic institutions.

Educational institutions have a key role to play in the growth of the optics and photonics industry. Numerous universities in the U.S. and throughout the world offer undergraduate and graduate programs in optics and photonics. The situation is different for community and technical colleges; few of these offer photonics programs. The National Center for Optics and Photonics Education, OP-TEC[2], is one of the National Science Foundation's Advanced Technological Education (ATE) Centers. The focus of the Center is on creating a secondary-to-postsecondary "pipeline" of highly qualified and strongly motivated students and to empower high schools and community colleges to meet the urgent need for technicians in optics and photonics. To achieve this, OP-TEC is providing numerous resources to help colleges introduce optics and photonics courses and programs of study.

The efforts undertaken and resources provided by the organizations above are creating a vibrant and rich environment for post-secondary institutions to investigate and introduce photonics in their portfolio of advanced technology programs of study. The paper describes the development and introduction of a two-year photonics program at Baker College, supported by a grant from the National Science Foundation's (NSF) Advanced Technological Education (ATE) program.

New Photonics Program Development and Introduction

The Principal Investigator (PI) for the NSF ATE Grant has started researching opportunities for introducing photonics at college level several years ago. The PI's background in optics and photonics, and her desire to contribute to the field's growth through educating college students acted as a catalyst throughout the process. With support from OP-TEC and from faculty and administration at the College, two photonics related courses were introduced in the curriculum of the existing Associate of Applied Science in Electronics Technology (AAS ET) program in winter 2011. Both courses have an experimental laboratory component which required equipment to be purchased. Winter 2011 thus also saw the start of the Optics and Photonics Laboratory, sharing space at that time with the Electronics Laboratory, located in the same room. The PI taught the two photonics courses the first time they were offered and one more time since.

The PI continued to research the opportunity of introducing a full-fledged two-year photonics program with a survey in fall 2011 that gathered data from several photonics companies in the state about their needs for photonics technicians. OP-TEC provided the PI guidance on running this state-wide survey. Additionally OP-TEC ran a national survey about needs for photonics technicians in summer 2012[2]. The latter survey obtained national data as well as regional data, which was helpful to determine needs in our region. Both surveys revealed there was a current and projected need for photonics technicians in the state, region and entire U.S., and the most appropriate education for photonics technicians was from a two-year program. The OP-TEC

survey also revealed that the number of graduating photonics students with two-year degrees from existing programs at community and technical colleges is considerably smaller than the projected technician needs.

The favorable results from the two surveys were utilized in fall 2012 as part of a proposal to introduce a two-year photonics program. Baker College has a formal new program process that needs to be followed, starting from a new program idea up to receiving full approval of the new program. Industry needs in the local area, the state, and beyond are an important consideration when evaluating a potential new program of study. For the photonics program, the new program process resulted in the program being approved in spring 2013, under the name of Associate of Applied Science in Photonics and Laser Technology (AAS PLT).

In fall 2012 while starting the new program process, the PI also wrote and submitted a grant proposal to the NSF ATE program requesting support for the development and introduction of a two-year photonics and laser technology program. The grant proposal was accepted and in summer 2013 the PI started working on the program introduction while also fulfilling requirements for the NSF grant.

The objectives of the NSF grant project are to: a) create and implement a new Associate of Applied Science Photonics and Laser Technology (AAS PLT) program; b) fully equip an Optics and Photonics Laboratory for education and training; c) train faculty to teach core courses in the AAS PLT program; d) perform outreach activities to local high schools to promote the new program; e) educate 30 or more students or workers by the end of the project.

The period for the NSF grant is July 1, 2013 - December 31, 2015. To support achievement of the project objectives the PI developed a set of activities and a time table for each activity together with responsible personnel. The activities that have taken place since the beginning of the grant are described below.

a) Formation and Meetings of the Program Advisory Board

One of the first activities was to form an Advisory Board to guide the new program throughout its development phase and continue with future improvements after the program is fully operational. The Advisory Board has representatives from five photonics companies in the state, as well as the state photonics cluster, in addition to program faculty, students, and college administration. The frequency of meetings is two times per year, and there have been two meetings of the Advisory Board up to the time the paper was written.

b) Development of the New Program Curriculum

The Grant PI and Senior Personnel, with support from a Baker College team, developed the program curriculum by looking first at the big goals for the program. Following the ABET[6] approach they listed four Program Educational Objectives (PEO), which are: “To prepare graduates who:

1. Demonstrate competence as photonics technicians in building, testing, operating and maintaining laser and electro-optical devices and systems.
2. Demonstrate critical thinking skills in applying basic photonics technology principles to solve technical problems.

3. Exhibit effective oral and written communication skills, team work, and ethical and professional behavior in the workplace.
4. Continue professional training and adapt to changes in the workplace through additional formal and informal education."

Achievement of the PEO's is supported by the Program Outcomes (PO) which capture what students should know and be able to do at the time of graduation. Both PEO's and PO's were discussed with the Advisory Board, who approved adopting the a-i ABET Student Outcomes described in the Engineering Technology Accreditation Commission Criteria for 2013-14[6] as Program Outcomes. A program specific PO was added to express outcomes related to the photonics and laser technology field: Program Outcome j. "graduates will demonstrate knowledge of and hands-on competence with various optical components and lasers, and their application to the safe building, testing, operation, and maintenance of laser and electro-optical systems".

The courses in the curriculum were fleshed-out next to provide students the fundamental knowledge in the discipline followed by applications and current technology examples. The PI has consulted for this purpose with grant partners OP-TEC and Indian Hills Community College. The latter has been offering a very successful Lasers and Electro-Optics Technology program for more than 25 years, with graduates working in photonics all over the United States in commercial companies and national labs.

The new AAS PLT program includes general education, mathematics and science, electronics fundamentals, and photonics and laser technology courses as described in Table 1 below. Please note that Baker College operates on a 10-week quarter schedule while the majority of colleges and universities have 15-week semesters. Table 1 shows the number of credits at our institution and also what these convert to for an institution operating on a semester schedule. An internship or co-op experience is required for all programs in engineering and technology. The majority of courses in the photonics specialty will have a laboratory component to provide students with the hands-on skills so important to technicians. The course descriptions for the photonics courses were discussed with the Advisory Board, whose suggestions on course content were incorporated. The new program has some overlap with the older AAS Electronics Technology program which creates an interesting opportunity for students who would like a double major in electronics and photonics to complete it in three years.

Table 1. Curriculum of the new AAS PLT program.

Area	**# Credits (Quarter)**	**# Credits (Semester)**
General Education	29	19
Mathematics and Physics	12	8
Electronics, CAD	24	16
Photonics and Lasers	36	24
Internship/Co-op	4	3
Total Credits	105	70

Out of the nine photonics courses that make up the Photonics and Lasers core of the program, two are already offered as part of the AAS ET program, leaving seven new courses to be developed during the grant period. The first one of these, Geometrical Optics, is being created and is planned to be offered in winter 2014 to a small group of students for the first time. The course includes three hours of lecture and three hours of laboratory. The development of the remaining core courses is scheduled to be completed by fall 2014.

c) Development of the Optics and Photonics Laboratory

In fall 2012 the College was able to assign a dedicated room to house the Optics and Photonics Laboratory, which was previously located in the same room as the Electronics Laboratory. This has been extremely helpful in preparation for adding the new AAS PLT program which requires more equipment and more space. Currently the equipment in the photonics lab consists of three sets of Optics Education Kits (OEK) from Newport Corporation with He-Ne lasers and optical power meters. Miscellaneous small items such as optical fibers, prisms, mirrors, diffraction gratings and simple spectrometers in addition to the ones in the OEK are available. The plans for expanding the lab call for more OEK to be purchased to increase the lab capacity. Other optical sources and test equipment will also be purchased, including various types of lasers, spectrometer, optical spectrum analyzer, CCD camera, and beam profiler.

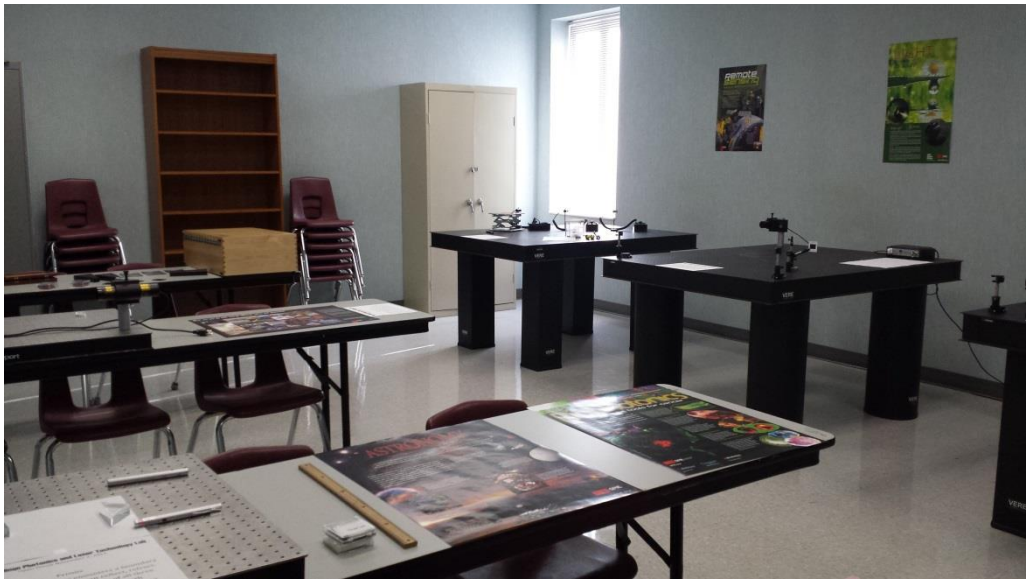

Fig. 1 The Optics and Photonics Laboratory

It must be noted that the lab has already benefitted from two generous donations from photonics companies in the state, one of three optical tables and the other of a fiber laser. To create a more attractive look for the lab we used posters from the SPIE[7], The International Society for Optics and Photonics, and OSA[8], The Optical Society professional organizations.

d) Faculty Training

Two faculty members have received training in photonics through OP-TEC, which offers courses in online format followed by a capstone experience in the laboratory. The faculty members have completed one course at the end of summer 2013, and are now enrolled in a second one. In

addition, the Grant Senior Personnel has received training in laser safety to enable him to act as Laser Safety Officer for the College.

e) Student Recruitment

The new program started in fall 2013 with a small group of students. Due to the aggressive timeline of bringing the program to life in less than one year, the time to advertise the program was very short. Recruitment efforts are expanding and it is hoped that new student enrollment for next academic year will be higher. At the same time, graduates of the Electronics Technology program are advised about the opportunity to earn a second Associate degree in one additional year. This approach seems promising to add students to the new program. A third avenue is to offer courses outside of the degree to currently employed technicians who need to further their education or refresh their knowledge.

f) Outreach activities

Outreach activities for high school students are planned for summer 2014 and summer 2015 in the form of a day camp where students learn about photonics and lasers. A "preview" activity has been introduced in July 2013 during the "Explore Engineering and Technology Summer Camp" for high school students that took place at the College. The Camp duration was one week, from 8:30am to 4:00pm with a break for lunch. Nine modules in different engineering and technology disciplines were offered to the participants, each 3.5 hours long. One of the nine modules was in optics and photonics, with a total of 27 students rotating through the laboratory and working on several simple experiments that introduced them to photonics and lasers. The module was well received and will be used as a starting point for developing the more extensive photonics camp that will be offered in summer 2014.

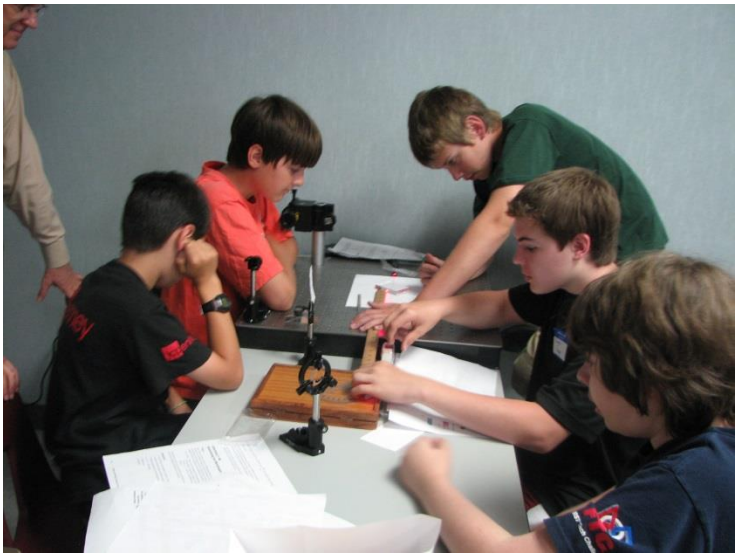

Fig. 2 Introduction to photonics as part of the "Explore Engineering and Technology Summer Camp", July 2013

Other outreach activities included an Engineering and Computer Technology Open House on Nov. 7, 2013 and visits to the Optics and Photonics Laboratory by high school students, teachers, counselors and parents.

g) Dissemination of Results

The new AAS Photonics and Laser Technology at Baker College is the only 2-year program dedicated to preparing photonics technicians in our state. As such, the program has received a lot of publicity in the state as well as at national level. The College worked with a marketing communications firm to create a release about the new program, which was then used by several national trade magazines to write their own articles about it. The PI was invited by two local radio stations to be interviewed about photonics as a field and about the new program. This provided a great opportunity to reach the general public and educate it about photonics, starting with what photonics is and what kind of jobs are there in this field. A local TV station aired a news segment about the new program and showed the Optics and Photonics Lab. The support from the NSF ATE Program was acknowledged in all articles and interviews.

As part of the dissemination activities the PI is planning to present the results of the grant project to several national conferences. These include the American Society for Engineering Education (ASEE) Annual Conference and Exposition, and HI-TEC, the High Impact Technology Exchange Conference. This paper is the first one describing results of the grant project and includes results from the first year of the grant. In addition to papers and presentations at conferences, the PI plans to host a regional conference at Baker College in the third year of the grant, to present information about the program to colleges in the region and state.

Results, Conclusions, and Future Steps

The first year of the grant project has seen the accomplishment of several important milestones: the AAS PLT program has started to be offered officially at Baker College, a first cohort of students has been enrolled, and the Advisory Board was formed, and met to approve the program curriculum and provide needed guidance. In addition, courses in the program are being developed, the Optics and Photonics Laboratory is fully functional and continues to expand, and faculty has received professional development in photonics and laser safety. Outreach activities included an Open House, visits to the optics and photonics laboratory, and an introductory photonics module offered during a high school summer camp in July 2013.

Year two of the grant project will see a continuation and expansion of the activities above, resulting in the curriculum being completely done, and the Optics and Photonics Laboratory being equipped with modern lasers and test equipment that will allow students to acquire up-to-date knowledge and hands-on skills. Professional development for the PI and Senior Personnel will continue with participation in several conferences.

The project to develop and implement a new Associate program in photonics at Baker College is entering its second year. With support from the NSF ATE program, the first year has been productive and successful. Moreover, efforts by several other organizations to promote the field of photonics have created a great environment for the project to succeed. The National Photonics Initiative, OP-TEC, Mi-Light - the Michigan Photonics Cluster have provided support for educational programs in optics and photonics, our program included. Leveraging all these resources has been an important element from the beginning of the project, continuing into the future. This is also a recommendation for colleges interested in introducing a photonics program, to bring together multiple groups and organizations to support the program and make use of the resources they offer.

Acknowledgement
This paper is based upon work supported, in part, by the National Science Foundation Advanced Technological Education program, under Grant DUE # 1304071.

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

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