PHOTON PBL NEWS

A PROJECT OF THE NEW ENGLAND BOARD OF HIGHER EDUCATION (NEBHE)

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PHOTON PBL is a project of the NEW ENGLAND BOARD OF HIGHER EDUCATION (NEBHE) and is funded in part by the Advanced Technological Education (ATE) program of the National Science Foundation (NSF).

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www.photonprojects.org.

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Field-testing Across the Spectrum

PHOTON PBL Challenges are designed for three different educational levels: high school, community college and four-year institutions. This flexibility is possible because the multimedia Challenges can be implemented at a structured, guided or open-ended level. Increasing responsibility for solving the Challenges is placed on students as they progress from the structured level (entirely instructor-led) to the guided level (moderately structured) to the open-ended level (instructor acts as a facilitator).

Between fall 2007 and fall 2008, six of the seven Challenges produced to date were field-tested in 16 different educational institutions – eleven high schools, three community colleges and two universities.

Field-testing continues during spring 2009. Case studies from three field-testing schools are profiled below. All PBL Challenges will be available at *www.photonprojects.org* after field-testing is completed.

Boston University Academy
Two Challenges were presented in a one-semester elective short course, *Photonics*, taught by Boston University Academy physics teacher Gary Garber. The class had twelve 9th and 10th grade students and met for two hours a week. The students were divided into three four-person teams to devise a solution. Each team gave an oral PowerPoint presentation and then performed lab experiments to test their ideas.

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Creating Problem Based Learning Labs for Math Class

June Decker, Professor of Mathematics at Three Rivers Community College (TRCC) in Norwich, CT, has long been interested in using concepts from other disciplines to teach math in a problem-based manner. In August 2007 she attended a PHOTON Problem Based Learning workshop to better understand the process.

Afterwards, Decker partnered with PHOTON PBL co-principal investigator Professor Judy Donnelly, who is a photonics professor at TRCC, to try and create Problem Based Learning labs for Decker's math students. Together they designed and presented two photonics labs, *Point Sources of Light* and *Filters*, to Decker's intermediate algebra class. Their goal was to teach the math concepts of inverse variation and exponential functions while also building student interest, motivating student learning and increasing conceptual understanding of mathematics. They anticipated that seeing how another discipline views a problem or activity would deepen the students' understanding. The labs were a hit and the highlight of the semester.

June Decker, (C), sightseeing in D.C. with students Waldemar Cruz Jr. (L) and Bryan Manchester (R).

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Developing the Final PHOTON PBL Challenge

Problem Based Learning (PBL) is an instructional method that challenges students to "learn how to learn" by collaborating to solve genuine real-world problems. Research shows that compared to traditional lecture-based instruction, PBL improves student understanding and retention of ideas, critical thinking, communication and problem-solving skills, as well as students' abilities to adapt their learning to new situations. These are the cornerstones of lifelong learning, skills critical in a 21st century environment.

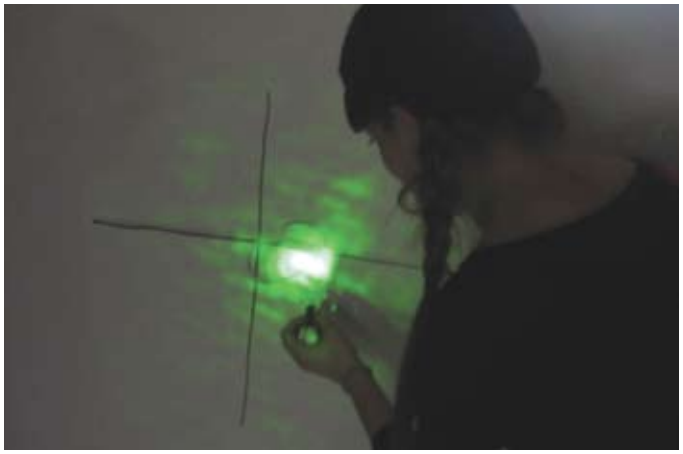
Over the last three years, the PHOTON PBL principal investigators (PIs) developed seven multi-media problem-based Challenges in collaboration with industry and research universities. The development of the Challenges is funded by the National Science Foundation's Advanced Technological Education program.

In PBL, students learn the process of solving real-world open-ended problems that have a number of possible solutions. They come to see that a good solution to a problem is what would be most appropriate in that particular context. As the PI team developed the initial seven Challenges, it became increasingly clear that the eighth and final Challenge should in fact become the first Challenge presented to students. It would focus on the critical topic of Laser Safety.

The *Blinded by the Light* Challenge is based on an actual news story. In January 2005, CNN reported that a green laser beam shone from the ground entered an airplane cockpit, temporarily blinding the pilot of a US Airlines flight on route to New York's Kennedy Airport. Soon after, police arrested a man at his home in a densely populated area in New Jersey approximately 12 miles from the airport and accused him of shining a green laser pointer at airplanes during their landing approach. The Challenge is to determine whether or not a standard green laser pointer on the ground is capable of posing a danger to airline pilots. The Challenge will contain ample teaching resources about general laser safety provided by the International Laser Display Association.

Co-Principle Professor Nick Massa and his students in his *Introduction to Light and Lasers* class at Springfield Technical Community College produced the Challenge. Working in teams, they were photographed and video-taped as they set up the scenario and followed the Challenge problem-solving process. They started by identifying the problem scenario, brainstormed to analyze the problem, conducted research, reconvened to brainstorm the solutions, tested possible solutions and selected the final problem solution that was the most appropriate in that particular context. •

STCC student Andrae Tate tests the accuracy of a typical laser pointer.



Fellow STCC student Samantha Bullard checks to sees if Andrae hits the mark.

The other seven Challenges are:

Photomachining's *Stripping with Light, Fantastic!* – How to develop a process to strip the coating off 50-micron wire?

Boston University's *DNA Microarray Fabrication* – How can graduate students determine the appropriate exposure time for a DNA microarray fabricator?

IPG Photonics' *High Power Laser Burn-In Test* – How to run a 100-hour unattended burn-in test on a 2-kw laser?

Photodigm and Drexel University's *Shining Light on Infant Jaundice* – Can technology provide a safe and effective portable home treatment for newborn babies with jaundice?

California State Polytechnic University at Pomona's *Watt's My Light?* – The package says a 26-watt fluorescent has the same light output as a 100-watt incandescent. How can students verify this statement?

University of Pennsylvania Medical School's McKay Orthopaedic Research Lab's *Of Mice and Penn* – Can lasers provide a non-contact measurement method for a project studying tendon healing?

Pennsylvania State University's Electro-Optics Center's *Hiking 911* – Two boys are lost in deep woods in rough terrain. How to determine the best technology to locate them?

For more information visit www.photonprojects.org.

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The class spent three weeks on *Hiking 911* and then six weeks on *Watt's My Light?*. *Hiking 911* was taught at the structured level while the second Challenge, *Watt's My Light?*, was initially introduced at the guided level. However, Garber soon realized that the young students needed a more structured approach, and subsequently offered more hints and tips to steer them in the right direction. Students also requested additional informational resources.

For *Hiking 911*, the students used an infrared camera to photograph a person with and without camouflage and compared the heat signatures. For *Watts My Light?*, all three teams used the same Vernier light sensor to take readings of the compact fluorescent bulb from a distance of 50 cm, and all had different readings. This became a "teachable moment" when the students realized the light coming from the bulb was not uniform because they had made the measurements at different positions relative to the bulb. To test this, Garber and his students built and tested their own integrating sphere.

Garber's class student-made intergrating sphere.

Garber observed that motivated students asked questions and gained much from problem-based learning.

North Carolina State University Photonics Xplorers Program for High School Students

Pamela Gilchrist directs the Burroughs Wellcome Fund Photonics Xplorers program at North Carolina State University. Two dozen ninth graders participate in a year round science and technology program.

In November 2008, the students investigated the *Hiking 911* Challenge at the structured level. Students had much less time than in Garber's class – only two 65-minute in-class sessions at NCSU's Science House with a two-hour virtual meeting in between. During the first classroom session, students learned about problem-based learning and began working on the Challenge. The students were introduced to *Hiking 911* by viewing three video clips and were given instructional materials to work with a partner to analyze and solve the problem. Participants reviewed and discussed the Challenge resource materials and completed self-directed whiteboard activities. Two weeks later the student groups participated in a virtual meeting to brainstorm solutions. They then reconvened at The Science House for a second 65-minute class session where they discussed their hypothesis and created group PowerPoint presentations of possible solutions.

Pam Gilchrist works with student Brandon Smith.

Gilchrist found that 85 percent of the students really enjoyed the PBL instructional method. Most were very enthused by the independent learning approach; however, 15 percent of the students who were conditioned to more structured instruction had difficulty adjusting to this design. Gilchrist concluded that because students had increased responsibility for their own problem solving they tended to learn more using the PBL format. Gilchrist suggested that more hands-on lab-based components, as Garber had done, would help to engage students further. Like Garber's students, the Xplorers also requested more informational resources in order to solve the problem.

Central Connecticut State University

During the spring 2008 semester, CCSU Professor of Computer Electronics and Graphics Technology Olusegun Odesina field-tested the *High Power Laser Burn-In Test Challenge* with his students at CCSU. In Fall 2008, Odesina presented the *Laser Wire Stripping Challenge* as a class assignment worth 15 percent of the class grade. Four classes (10 hours total) were devoted to class discussion and work on the project. The students worked in teams using computers and the library for reference. Odesina presented the Challenges at the open-ended level acting as a facilitator and explaining the desired outcome and encouraging his students to work together in teams to find solutions. All students were required to give an oral presentation at the end of the semester.

Olusegun Odesina in a fall 2000 PHOTON workshop.

Professor Odesina found that his students liked the fact they could apply previous learning to solving a real-world problem. They were very engaged, deliberative and highly motivated by the PBL format of learning. Including a PHOTON PBL Challenge has now become a permanent instructional component of the *Photonics Principles* course in the Computer Engineering Technology program.

Like the other instructors profiled above, Odesina recommended that more informational resources be added. These suggestions and others gained in the field-testing process will be considered and implemented by the PI team to improve the educational experience of the Challenges. •

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Decker noted many benefits of collaborating with a scientist: access to world-class lab equipment, scientific assistance for the photonics section, and learning the trick of how to fix the dependent variable and vary the independent variable in an experiment to make data collection neater. She also did an assessment of how the different learning style impacted her students. Professor Decker's results showed that the interdisciplinary project-oriented instructional approach significantly increased student retention in her algebra class.

As reported in the fall 2008 issue of PHOTON PBL News, the New England Board of Higher Education received a grant from the Electrical, Communication and Cyber Systems Division of the National Science Foundation to provide mini-grants to PHOTON PBL participants to present papers at local, regional and national conferences. Professor Decker applied for and received a Conference Experience for Educators (CEE) grant.

Because of the unique opportunity that this CEE grant offered, Decker worked with two TRCC undergraduates from her class to write a paper and present their findings to a conference. Decker said, "Working on the presentation with the students reinforced …the importance of reiterating math skills and concepts that arise in the real life projects and problems done in math class. The students honed their public speaking skills as they spent several hours rewriting and rehearsing the presentation."

Professor Decker and her two students, Waldemar Cruz Jr. and Bryan Manchester presented the paper *A Math Teacher Sees the Light: Photonics Labs in an Algebra Class* at the Joint Conferences of the 2009 Joint Mathematics Meetings of the American Mathematical Society (AMS) and Mathematical Association of America (MAA) the largest math conference in the country. It was held in Washington, DC January 5-8, 2009. Mathematicians presented approximately 2,000 papers, met colleagues and saw a wide range of exhibitors. Nearly 6,000 attendees came from all over the US and several foreign countries. Student Bryan Manchester, who grew up in a small town in Connecticut, said "There were so many people, I couldn't believe they were all here for this meeting."

Waldemar Cruz, a computer science major, was fascinated by one session he attended. It showed an artwork display of strips of color that at first seemed random but actually was an algorithmic encryption of Pi. This meeting opened up a new way of understanding mathematics for him.

Both Decker and her students found the whole experience to be intellectually invigorating. The students said they had no idea how vast and diverse the field of mathematics is. They were very encouraged by the more than 25 professors attending their presentation who also received literature about the NEBHE PHOTON PBL Project.

Besides presenting at the session *College Algebra: Focusing on Conceptual Understanding, Real-World Data, and Mathematical Modeling*, Decker, Cruz and Manchester attended a variety of other talks including a special lecture on geometry by noted author and mathemetician Ivars Peterson. Professor Decker also attended a four-hour mini-course *Taking Symbols Seriously: Teaching Form and Function in College Algebra* by world-renowned math educators Deborah Hughes Hallet and William McCallum.

Both students were inspired by the continuing professional development at the conference and the wide world of mathematics it showed them. Said Cruz, "Attending the Mathematics meeting has put some things in perspective for me. Seeing how [the attendees] are greatly contributing to the math, science, and technology fields showed me that there is still a lot of things to be discovered and worked upon." Manchester agreed, saying, "I personally have learned a lot from this trip and it wasn't only the mathematics." •

View the power point presentation "A Math Teacher Sees the Light" at www.photonprojects.org, then click on "Conference Papers".

Upcoming 2009 PHOTON PBL Dissemination Activities

April 2009
12th Annual Massachusetts Community College on Teaching, Learning and Student Development
Springfield Technical Community College, MA
Problem Based Learning: A Practical Approach for STEM Education

May 2009
American Association of Physics Teachers New England Chapter Meeting
Northeastern University, Boston, MA
PHOTON Problem Based Learning Challenges for Photonics Education

New England Fiberoptic Council's *FiberFest* Trade Show
Holiday Inn, Boxborough, MA
Exhibit table

July 2009
ETOP (Education and Training in Optics and Photonics)
Wales, United Kingdom
Creating and Using Industry-Based Problem Based Learning Challenges in Photonics: Lessons Learned

Problem Based Learning in Photonics Education: Assessing Student Learning

HI-TEC (High Impact Technology Exchange Conference)
Scottsdale, AZ
Problem Based Learning in Technology Education

August 2009
SPIE Optics & Photonics Annual Conference, San Diego, CA
An Optics "First Year Experience" Course for Community College Students

Recent PHOTON PBL Dissemination Activities

PHOTON PBL principal investigators and participants have been busy spreading the word about the project at conferences and workshops across the country. Unless otherwise noted, the PHOTON PBL principal investigator team of Dischino, Donnelly, Hanes and Massa authored and delivered the presentations listed below. All listed authors were participants in the PBL program.

June 2008
American Society for Engineering Education (ASEE)
Pittsburgh, PA
Fiber Optics Communications Educational Toolkit
Author: Abu-aisheh, et al, University of Hartford, CT

Bridging Health and Food Science to Electronic Engineering
Authors: Moussavi and students Randy Gomez, Ben Garcia, Erick De Guzman, Cal State Polytechnic University, Pomona

August 2008
SPIE Optics & Photonics Annual Meeting
San Diego, CA
Interdisciplinary Optics Course for Technical High Schools
Authors: Goyette, et al, H. H. Ellis Regional Technical High School, CT

Laser Camp: Shining a Light on Optics Careers

Problem Based Learning in Photonics Technology Education

November 2008
National Educators' Workshop at EASTCONN
Hartford, CT
Optics Magic: Easy Explorations from the PHOTON Projects

January 2009
Joint Mathematics Meetings of the American Mathematical Society (AMS) & Mathematical Association of America (MAA)
Washington, DC
A Math Teacher Sees the Light
Authors: Decker and students Waldemar Cruz and Bryan Manchester, Three Rivers Community College, CT.

Association for Science Teacher Education (ASTE) International Conference
Hartford, CT
Problem Based Learning in STEM Education
Presentation and Posterboard

March 2009
National Science Teachers Association (NSTA) National Conference on Science Education
New Orleans, LA
Problem Based Learning: A Practical Approach for STEM Education

Teachers for a New Era Workshop
University of Connecticut, Storrs, CT
Problem Based Learning in STEM Education

SPIE Recognizes Hanes & Donnelly

Fenna Hanes has been selected as the winner of the international SPIE 2009 Educator Award for her contributions to photonics and optics education. And Judith Donnelly has been named as one of the first Senior Members of SPIE. They will be recognized at SPIE's annual meeting *Optics & Photonics* in San Diego this August.

Fenna Hanes

SPIE's annual Educator Award is granted in recognition of outstanding contributions to optics education by a SPIE instructor or educator in the field. Hanes' award citation states "in recognition of her leadership in several NSF-ATE (National Science Foundation-Advanced Technological Education) projects, and her unfailing enthusiasm for optics/photonics technology. Ms. Hanes has fostered the growth of optics education in secondary schools and colleges throughout the United States."

Prof. Judith F. Donnelly of Three Rivers Community College states, "Among Fenna's most enduring accomplishments are the dozens of educational/industry alliances she facilitated during more than ten years involvement in optics/photonics education. She has worked closely with scores of companies, recruiting participation in educational conferences and workshops ranging from serving as the host site to providing guest speakers and plant tours."

Hanes' nomination was a group effort. "It was Fenna's idea that teachers and industry could learn from each other to the benefit of both... This nomination of Fenna for the SPIE Educator award is, in fact, made on behalf of the twenty PHOTON2 teachers and counselors who met in San Diego [for the 2007 SPIE Optics & Photonics conference] and wished that Fenna Hanes be acknowledged for her contributions to optics education at their institutions," said Donnelly, who submitted the nomination on their behalf.

Judith Donnelly

Judith Donnelly is also being recognized by SPIE for her years of activism in optics/photonics education and in SPIE itself. This year SPIE has initiated a new honor, the Senior Member program, awarded annually to just 20 members worldwide. Requirements for the honor include more than 10 years of significant professional achievement in industry or academia, SPIE participation, and outstanding leadership in educational outreach, project management and/or entrepreneurial operations.

Donnelly's nomination is "for specific achievements in optics education and outreach" during her 31 year career at Three Rivers Community College. She co-founded TRCC's *Laser and Fiber Optics Technology Program* and was instrumental in the conception and design of TRCC's new high-tech optics lab. 2008 SPIE President Kevin Harding stated, "SPIE is a member-driven organization that relies on such people to achieve the mission of the Society. By distinguishing these important contributions… we recognize the hard work that has grown our industry into a wide-reaching and influential discipline. •

PHOTON Projects' Sustainability

In 1994, the National Science Foundation (NSF) awarded the first Advanced Technology Education (ATE) grants with the goal of improving technician education at two-year colleges and forming partnerships between academic institutions and industry. In 1995, the New England Board of Higher Education (NEBHE) received its first ATE grant, FOTEP (Fiber Optics Technology Education Project), a project to prepare teachers and faculty to introduce fiber optics technology to secondary and postsecondary students in the six New England states. The work of the first grant was adapted and expanded by three subsequent ATE grants: PHOTON, PHOTON2 and the current project PHOTON Problem Based Learning (PBL).

Over the years, the impact of these projects has grown in technical breadth by covering not only fiber optics but also other aspects of photonics technology and in geographical outreach by including teachers and faculty from Maine to Hawaii. During the past 14 years, more than 140 science and technology educators from more than 100 high schools and colleges from across the country have participated in the PHOTON projects and introduced photonics technology curricula to thousands of students. The projects have produced an array of curriculum materials that can be used in existing courses or to develop new ones. (Available at www.photonprojects.org) Professional development activities have also provided science and technology teacher with opportunities to develop relationships between academia and local industry.

In January 2009, NEBHE began to research whether former project participants were still teaching in their original institutions. And if so, were they still teaching fiber optics and photonics? In this article, we summarize our findings from four schools that continue to teach fiber optics and photonics. They include three FOTEP (1995 – 1998) participants: Bryant Abbott from **Cheshire Career Center** at Keene High School in Keene, NH; Jeff Schall from **White Mountains Community College** (WMCC) in Berlin, NH; Bill Dolan from **Kennebec Valley Community College** (KVCC) in Fairfield, ME; and PHOTON (2000 – 2003) and current PHOTON PBL (2006-2009) project participant Olusegun Odesina from **Central Connecticut State University** (CCSU), New Britain, CT.

Curriculum Development and Implementation

For the three FOTEP participants, fiber optics is still a curriculum component at their schools, in courses such as *Industrial Communications* at the Cheshire Center; *Semiconductor Fundamentals*, *Digital Data Communications* and a *Networking Applications Lab* at KVCC; and *Computer Networking* at WMCC. None of the FOTEP schools developed a full-semester course in fiber optics. However, Professor Odesina, who participated in both the PHOTON and PHOTON PBL projects, developed two completely new courses at CCSU: *Photonics Principles and Fiber Optics Communications.*

All of the PHOTON projects supplied participating instructors with industry-quality laboratory kits. Each of the instructors continue to use the kits, and two have bought additional lab equipment. At WMCC, enough additional materials were bought to support 12 students terminating fiber cables at one time. Schall shared that he "owed the skills I learned to FOTEP. These skills have allowed me to introduce hands-on fiber optics training to college and high school students in the applications of fiber optics computer networks."

Jeff Schall's workshop students at Groveton H. S. in NH: (L-R) Matt Burt, Liz Dorr, Josh Curtis and Matt Cook.

Student Impact

Over the years, many students in the PHOTON projects instructors' classrooms have had a chance to learn fiber optics and photonics technology. Abbott has an average of 20 students per year at the Cheshire Career Center over a period of 12 years. At WMCC, Schall teaches about 50 students a year. Over the past ten years at KVCC, Dolan has taught three courses that include fiber optics that reach about 70 students per year. At CCSU, Professor Odesina teaches about 25 students per year in the two new photonics courses that he developed.

We asked these instructors how they recruit students. High school teacher Abbott works with guidance counselors to recruit students for his classes. The community college instructors present fiber optics workshop to local high schools to create interest in the subject. Dolan offers a *Fiber Optics Road Show* at two local high schools. Schall has been holding fiber optics workshops for three area high schools for many years where students come to the college for a day long workshop to

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terminate multi-mode fiber patch cords. Odesina holds open houses and makes recruitment visits to local high schools and community colleges.

Bryant Abbott's student Anthony Carbonaro learns how to install patch cables at the Cheshire Career Center at Keene High School in NH.

These recruitment strategies have led to articulation agreements between high schools and colleges. Abbot collaborates with fellow PHOTON participant David Miller, an instructor in the *Information Systems Technology Program* at Great Bay Community College in Portsmouth, NH. Both institutions offer the Cisco Academy curriculum that includes fiber optics. At KVCC, Dolan has developed articulation agreements with two nearby high schools in Maine.

All these programs reported many students either go on to higher education or go to work in the telecommunications and related technology fields. Dolan reported that he has at least two to four students each year who go directly to the University of Maine's electrical engineering technology degree program.

All of the instructors agreed that fiber optics and photonics are cutting-edge technologies critical to the nation's technological competitiveness, and that there are many career opportunities for college graduates with these skills. •

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