PHOTON PROBLEM BASED LEARNING NEWS

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

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NEBHE Awarded New Problem Based Learning Grant

The New England Board of Higher Education (NEBHE) has won funding for a new three-year project, titled *Problem Based Learning (PBL) for Sustainable Technology: Increasing the STEM Pipeline.* Funding will be provided by the National Science Foundation's Advanced Technological Education (ATE) program to improve science, technology, engineering and math (STEM) education to help America develop homegrown sustainable technologies.

According to an August 19, 2009 *New York Times* article titled "Sustainability Field Booms on Campus," numerous colleges have begun offering continuing education and courses on sustainability in building, transportation, energy and economic policy. STEM PBL Principal Investigator Fenna Hanes said, "This project will develop two courses for teacher education, for both pre- and in-service teachers, plus six problem-based Challenges to meet the need for instructional STEM materials for use in college and high school classrooms."

The project's goal is to prepare both current high school and college educators and pre-service education college students enrolled in Technology & Engineering Education (TEE) programs to introduce problem-based learning into STEM subject courses. The grant will also fund development and production of multi-media instructional ma-

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Midwest Partners Collaborate on PBL Challenge

Students from both schools celebrate the successful conclusion of their work.

Columbia Area Career Center (CACC) of the Columbia Public Schools, in Columbia, Missouri, and Indian Hills Community College (IHCC) in Ottumwa, Iowa, joined the PHOTON PBL (Project Based Learning) Project as alliance partners—partners across educational levels.

The faculty and staff of the two schools have worked together for a number of years for the benefit of students. Together they established articulation agreements to provide regional science and technology students with a seamless transition from secondary to post-secondary education. For example, CACC high school photonics students can earn eight semester hours of college credit in general photonics and geometric optics in the IHCC Laser/Electro-Optics Technology AAS Degree program, providing a natural transition from secondary to post-secondary study.

Midwest Partners, continued on page 4

Greening PBL: Using Sustainability to Increase STEM Pipeline

By Nicholas Massa, PhD

As a new generation of American students moves through the education pipeline, it is inundated with information on global climate change, sustainability, and all things green. But what exactly do we mean by *sustainability* and what does it mean to be *green*? Moreover, what are the environmental, societal, economic, and geopolitical implications of these issues?

The US Environmental Protection Agency defines sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs". The implications of sustainability are far-reaching and pervasive. They affect all aspects of life including how we generate energy, provide clean drinking water and grow food, manufacture goods and provide services, heat and cool our homes, and get to work and school each day. From energy generation to manufacturing, agriculture to biotechnology, transportation to construction, both business and industry are beginning to embrace the idea that taking care of the environment for future generations is a responsibility for all of us.

A famous 1970s TV commercial featured a Native American actor, Iron Eyes Cody, with a tear running down his face as he gazed upon the trash strewn landscape. The image reflected the powerful emotions of the time, focused studies and organized action by that student generation to publicize the dangers of pollution and promote a clean environment. The energy and climate situation in today's world has captivated a new generation that has passionately embraced the cause of clean renewable energy and environmental sustainability.

However, even with all of the attention by policy makers and the media about the importance of sustainability and green technologies, student enrollment in STEM fields in the U.S. continues to lag behind other industrialized nations. One reason for the lag is the lack of engaging teaching materials that bring these real-world concerns into the classroom. STEM educators lack topical instructional materials and resources that engage and motivate students' natural creativity, imagination, and passion for saving the planet. These instructional materials and resources must develop students' problem solving and critical thinking skills needed for lifelong learning, while at the same time promoting societal and environmental responsibility with a global perspective.

Real-world problems are interdisciplinary. They require thinking that transcends traditional STEM curricula in which each subject matter (i.e., chemistry, physics, mathematics, technology, etc.) is taught in isolation. Utilizing the highly successful PHOTON Problem-Based Learning (PBL) project's model, students learn how to adopt a "big picture" approach to problem solving. Students must look at a problem situation from many different perspectives and apply concepts from different disciplines. PBL also requires teamwork and collaboration, bringing to bear the expertise and insight of different individuals so that solutions represent the collective knowledge of the team. Encouraging the spread of problem-based learning is the goal of the new STEM PBL project. (See page 1 for more details.)

Over the next three years, the new STEM PBL project will work with business, industry, government and universities to identify real-world problems focused on sustainable technologies, and then create a series of multi-media instructional materials and resources aimed at capturing the hearts and minds of students in an effort to increase the number of students entering STEM fields. Professional development for teachers and faculty in PBL instructional methods will be provided through an online course created for in-service STEM teachers and a classroom-based course created for pre-service STEM teachers.

The new STEM PBL project will collaborate with six companies and universities which are breaking new ground in sustainable and green technologies to develop new educational materials: a set of six multi-media real-world Challenges for classroom use. A leading biotechnology company in Cambridge, MA, has expressed interest in being an industry partner with a Challenge exploring how biotechnology supports sustainable technologies. Another possible industry partner is a start-up company in Wilbraham, MA for a Challenge focused on harnessing wind power. Other industry partners are still being sought in the areas of clean water technology, nanotechnology, solar energy and agricultural science.

The STEM PBL project will also expand the reach of the existing Photon PBL Challenges by updating them to incorporate issues of sustainability. For example, in the PBL Challenge *Watts My Light*, hosted by California State Polytechnic University's (Cal Poly) Lighting and Illumination Center, students are tasked with determining whether the energy efficiency claims of energy-saving fluorescent light bulbs is true. This Challenge will be enhanced so that students must also consider issues like the environmental impact of disposing mercury-filled fluorescent light bulbs as well as the health risks associated with mercury – real-world issues with real-world implications. The multifaceted approach of the Challenges will allow them to be easily incorporated into different subject courses and disciplines, leading to a more holistic approach to STEM education.

For more information about becoming a Challenge industry partner or an educator participant, visit **www.stempbl.org**.

Nicholas Massa is a professor in the Laser Electro-Optics Technology Program at Springfield Technical Community College (MA).

Professor Massoud Mousavi (R) at Cal Poly Pomona works with his students on the *Watts My Light?* Challenge.

PHOTON PBL Dissemination Activities

Note: All papers and presentations listed are available at **www.photonprojects.org** in the *conference papers* section.

Patrick Straight (L) and Matthew Rajock (R) demonstrate at their APS/AAPT conference presentation.

May 2009
New England Sections of the American Physical Society and the American Association of Physics Teachers
APS/AAPT

PHOTON PBL participant Gary Garber, a physics teacher at Boston University Academy, and two of his students, Matthew Rajock and Patrick Straight, presented *Optical Integrating Sphere and Measuring the Intensity of Light Bulbs*, their experience with implementing the *Watt's my Light?* PHOTON PBL Challenge, at the 2009 Joint Spring Meeting of the New England Sections of the APS and AAPT. The May 8 and 9, 2009 meeting offered 50 presentations and was attended by more than 125 educators. It was held at Northeastern University in Boston, MA. Garber and his students' participation in the conference was funded through a Conference Experience for Educators (CEE) grant (see page 6 for more information about the grant) from the Electrical, Communications and Cyber Systems Division of the National Science Foundation.

July 2009
Education and Training in Optics and Photonics
ETOP

PHOTON PBL Principal Investigators Fenna Hanes, Judy Donnelly and Nick Massa presented three of the 77 papers delivered at the ETOP conference held July 5-7, 2009, at Technium OpTIC in St. Asaph, Wales. United Kingdom. ETOP is a joint event organized by SPIE, OSA, IEEE/LEOS and ICO. Donnelly's presentations included: *Optics in Eastern Connecticut*, and *Creating and Using Industry Based Problem Based Learning Challenges in Photonics: Lessons Learned*; Massa presented *Problem Based Learning in Photonics Technology Education: Assessing Student Learning*.

The biannual international conference brings together leading optics and photonics educators to discuss, demonstrate and share new developments and approaches. In all, 95 educators from 23 countries attended. Countries represented included:

Algeria	France	Russia
Australia	Germany	Spain
Brazil	India	Thailand
Canada	Ireland	Tunisia
China	Korea	United Kingdom
Czech Republic	Portugal	USA

More than 70 presentations were given and 10 poster sessions were displayed, including the winning posters submitted by U.S., Greek and Romanian middle and high school students who participated in a *Light in our Life* competition. The contest asked students to combine both their science and art competencies and was organized by an international committee including Professor Donnelly.

Fenna Hanes (L), Nicholas Massa (C) and Judith Donnelly (R) at ETOP in Wales.

Dissemination Activities, continued on page 5

Challenges and Support Materials Now Available on Website

Eight PHOTON PBL Challenges are now available on our website, **www.photonprojects.org**. The multi-media Challenges are teaching materials for student-centered, real-world problem-solving instruction in optics and photonics units for both high school and college classes.

The Challenges have been aligned to the U.S. national science, technology and mathematics content standards for grades 9 to 12. These benchmarks provide teachers greater flexibility in incorporating the Challenges into existing curriculums. Each Challenge's benchmark report is on the website.

Also available for downloading is a 24-page *PHOTON PBL Challenge Implementation Guide* which explains how the Challenges are designed and advises how teachers can utilize them in their classroom.

Midwest Partners, continued from page 1

Student team of high school and college students working together in the IHCC Photonics lab.

The PHOTON PBL Project encouraged the two schools to take their collaboration to the next level. Field-testing a PHOTON PBL Challenge together would provide an opportunity for both the high school and college photonics students to interact during a real-world learning experience. The Missouri high school photonics students experienced a two-day field trip and a joint field-test on the IHCC campus. Funding was provided by OP-TEC (**www.op-tec.org**), the National Center for Optics and Photonics, also funded by the Advanced Technological Education program of the National Science Foundation.

Frank Reed and Bill Gray, IHCC Laser/Electro-Optics Technology instructors, and Rick Shanks, CACC Laser/Photonics instructor, planned the event with Columbia Area Career Center Counselor Sharon Nelson and assistance from both schools' staff. Seventeen high school and 22 college photonics students participated. The instructors chose to field-test ***Of Mice and Penn***, one of the Challenges introduced at the NEBHE's 2008 PHOTON PBL professional development summer workshop at Boston University, which all three instructors attended.

The instructors used an *open-ended* method, as compared to a *structured* or *guided* problem-solving method. Only an introduction and problem statement were provided to the students to reflect real-world problems encountered in industry. The high school and college students worked together in teams to research the problem and propose solutions. At the end of the process, each team presented their solution, responded to questions and comments from other teams and defended their implementation strategies before the entire group. Students from both programs benefited from the social interaction. The CACC high school students brainstormed, analyzed and solved a problem with college students who have chosen photonics as a career. And the IHCC students were impressed by the level of the CACC students' photonics knowledge and technical skills.

CACC teachers felt the open-ended approach to solving the Challenge required the high school students to use a more analytical style of problem solving. It was very satisfying for them to see their students rise to this level of problem-solving and to observe their sense of accomplishment. The IHCC educators were pleased with the problem-based learning curricula and the ease with which it could be utilized.

Establishing timelines was critical for the overall structure of the campus visit to ensure that students had time to fully complete the Challenge and receive maximum benefit from the learning experience. The instructors also recommended that the Challenge should take place early in the semester so there is time afterwards to integrate follow-up activities into the existing curriculum of both programs, such as planning for the critical collaborative components to be accomplished at the time of the visit. Other components, such as testing of solutions, can be done later at each school, perhaps sharing results via ITV.

Educators at both schools found this year's PHOTON PBL collaboration to be an exciting and valuable opportunity for high school and college students to interact and learn together. They hope to provide future collaborative learning opportunities, including future joint Challenges, to utilize problem-based learning as part of both schools' ongoing commitment to the advancement of photonics education.

A second student team working on a possible solution.

Dissemination Activities, continued from page 3

Michele Dischino shows an excerpt from a Challenge during a presentation at HI-TEC.

July 2009
High Impact Technology Exchange Conference
HI-TEC

PHOTON PBL Co-Principal Investigator Nick Massa of Springfield Technical Community College (MA) and consultant Michele Dischino from Central Connecticut State University co-presented a session titled *Problem-Based Learning in Technology Education* at HI-TEC, held July 19-22, 2009 in Scottsdale, AZ.

HI-TEC is the first national conference on advanced technological education where both the faculty who teach technicians and the technicians themselves meet to update skills and knowledge. There were 18 workshops and pre-conference sessions as well as 34 presentations, 38 exhibits and three industry tours for the more than 500 educators. HI-TEC is offered by a consortium of NSF Advanced Technological Education centers and projects, with contributions from corporate and industry partners.

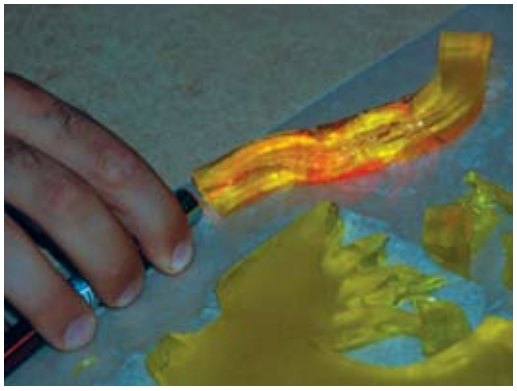
August 2009
SPIE Optics & Photonics Conference
SPIE

PHOTON PBL Principal Investigators Fenna Hanes and Judy Donnelly attended SPIE's annual *Optics & Photonics* conference held in San Diego, CA, from August 2-6, 2009.

Donnelly presented *Outreach Magic*, a hands-on workshop attended by an international group of students and educators. She also presented her paper *An Optics "First Year Experience" Course for Community College Students* during an Education session on August 3.

Three PHOTON PBL participants also presented during the education session. Pamela Gilchrist, a science-technology specialist at the University of North Carolina at Raleigh's Science House, presented *A Case Study Findings of PHOTON Problem Based Learning (PBL) with Photonics Outreach Programs*. Presentations by Gary Beasley and Brian Belcher were funded by CEE travel grants. (For more on the CEE grant, see page 6.)

Fenna Hanes received the Educator of the Year award "in recognition of her leadership in several NSF-ATE programs, 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."



An educator in Donnelly's *Outreach Magic* workshop gets hands-on experience with the *Exploring Refraction* exploration for future classroom use. (Photo used with permission of Ryan Hannahoe.)

Fenna Hanes (R) is presented the SPIE Educator Award by Dr. Ralph James (L), SPIE president elect for 2010.

SPIE Awards Outreach Grant for Challenge Training Video for Educators

NEBHE has received funding from SPIE's Outreach Grant program to create a 10- to 15-minute ***Introduction to the PHOTON PBL Challenges*** video presentation to educate instructors how to implement the Challenges and use problem-based instructional strategies.

The training video will complement other instructor materials that have been developed to assist teachers in adapting and utilizing Challenges in their classes. The training video will cover material previously presented at on-site workshops. It will recreate the classroom experience of a PBL Challenge using students as actors.

The training video will be available at **www.photonprojects.org** in the *Teacher Resources* section. For more information about SPIE, please visit **www.spie.org**.

CEE Grantees Present at SPIE Annual Meeting

As reported in the fall 2008 and spring 2009 issues of *PHOTON PBL News*, NEBHE 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 attend conferences and present papers.

This spring both Brian Belcher and Gary Beasley received grants to present at SPIE's *Optics and Photonics* annual conference in San Diego, CA, in August. They had a booth on the exhibit floor presenting their schools' photonics programs and also attended plenary and breakout sessions.

Belcher, a science teacher at Plainfield High School (CT), presented his paper *Restarting a High School Photonics Program* in collaboration with PHOTON PBL Co-Principal Investigator Judy Donnelly. Beasley, who teaches in the Laser and Photonics Technology program at Central Carolina Community College, presented with his student Jamie Yeatman *Teaching Photonics Students to Think: Methods*. Both presentations were made during a special education session.

Belcher stated this was his first conference presentation and that he felt like "a real professional" keeping up with technical sessions and asking meaningful questions. He also purchased new items for future classroom use. Belcher plans to disseminate his experience with fellow high school educators and encourage them to present in the future.

Gary Beasley found the most significant part of participating in the SPIE conference was bringing Jamie Yeatman, one of his top students, to co-present with him. Yeatman said her most significant experience was learning more about real-world applications and career opportunities. She plans to share her experiences with fellow classmates.

Beasley and Belcher both stated they would not have been able to attend this SPIE workshop without the CEE grant support since the registration, travel and accommodation costs are prohibitive for their schools. To view their conference papers and presentations, visit: **http://www.nebhe.org/content/view/257/190/**.

Jaime Yeatman (L) and Gary Beasley (R) at SPIE.

New Grant, continued from page 1

terials for use in high school and college STEM classes.

The overall goal of the project is to increase the number of American students completing studies in STEM subjects, especially in engineering technician programs. Technicians are the "hands-on" side of an engineering or scientific team, responsible for designing experiments, building and troubleshooting prototypes, analyzing and interpreting data, and presenting experimental results. Technicians apply their knowledge of science, technology and mathematics to solving real world problems.

Problem-based learning is an instructional approach that challenges students to "learn how to learn" through collaborative real-world problem solving. Research shows that compared to traditional lecture-based instruction, PBL improves student understanding and retention of ideas, critical thinking and problem-solving skills, motivation and learning engagement and the ability to adapt their learning to new situations—skills deemed critical to lifelong learning.

The U.S. Bureau of Labor Statistics predicts that by 2010 the number of jobs in STEM-related occupations will grow at three times the rate of all other occupations. However, the U.S. lacks homegrown talent to fill these occupations and must rely on foreign workers. One reason for declining American enrollment in engineering technician programs is that students who have natural talent for problem solving are turned off by traditional education methods: dry classroom lectures followed by cookbook laboratory experiences that provide little engagement or interaction. The STEM PBL Project will develop a series of multi-media industry-based Challenges designed to stimulate problem-based learning and increase interest in STEM programs.

Key issues limiting the use of PBL in engineering and technology education include: an overall lack of instructional resources; a lack of professional development opportunities for teachers and faculty to learn how to effectively incorporate PBL into their existing courses; and most crucially, an overall lack of teacher education programs which cover PBL instructional methods.

To help address these issues, the goals of the STEM PBL Project are:

1. Design, develop and field-test six interdisciplinary multi-media STEM Challenges to provide instructional materials for classroom use. These Challenges integrate problem-solving skills with practical subject knowledge by focusing on sustainable technology problems faced by real researchers and businesses. The goal is to both engage the students and provide them with critical job skills.

2. Recruit 25 high school and college educators to participate in a two-year professional development program to prepare instructors to integrate PBL methods and Challenge materials into their STEM classes. This intensive program includes an initial on-site workshop, three sessions of five-week online distance learning courses, field-testing Challenges and a final capstone showcase workshop.

3. Develop a one-semester college course for education students in PBL instructional methods. This course will be field-tested during the project, and the results will be disseminated through academic conferences and papers.

4. Conduct research on the efficacy of PBL instruction in STEM education, produce papers analyzing this data and disseminate this information through academic conferences and other venues.

NEBHE is recruiting businesses and researchers to collaborate in development of the STEM PBL Challenges as well as educators to participate in the professional development programs. For further information, contact Principal Investigator Fenna Hanes at 617-357-9620, ext. 129 or **fhanes@nebhe.org**, and check our website at **www.stempbl.org**.

Invitation to Educators to Participate in NEBHE's New STEM PBL Project

The *Problem Based-Learning (PBL) for Sustainable Technology: Increasing the STEM Pipeline (STEM PBL)* project (see page 1 for details) is an intensive professional development opportunity. Participants are eligible for CEUs and graduate college credit after successful completion of the distance-learning course.

Who is eligible?

- Both high school and college educators in STEM disciplines.

What will I learn?

- What problem-based learning is.
- How to introduce students to PBL.
- How to guide students to become self-directed, motivated and work well in teams.
- How to engage students in technical topics.
- How to implement the STEM PBL multi-media Challenges regardless of students' level of content knowledge.

What are the program commitments?

- Participate in the *Introduction to STEM PBL* two-day professional development on-site workshop in summer 2010.
- Participate in a 15-week professional development web-based distance-learning course, divided into three 5-week sessions during academic year 2010-2011.
- Field-test and report outcomes for two or more Challenges between fall 2010 and spring 2012. Stipends are provided.
- Participate in a Capstone Showcase workshop during academic year 2011-2112.

The STEM PBL educator participant application form as well as detailed information about the project are available online at **www.stempbl.org**. Please note that space is limited.

Applications are due by November 30, 2009.

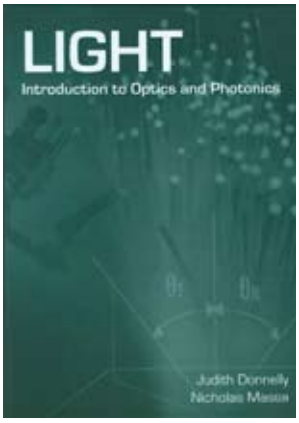
PHOTON Projects Longitudinal Survey

Since 1995 more than 200 teachers and faculty have participated in NEBHE's four NSF projects: FOTEP, PHOTON, PHOTON2 and PHOTON PBL. Last spring, NEBHE began a longitudinal follow-up study of the 160 participants in the first three projects. The goal was to learn if they or their schools are still teaching fiber optics or photonics components in their science and technology courses. A short four question survey was emailed to all prior participants.

A recent respondent was Adrian Sebborn, a technology teacher at the Southwest Vermont Career Development Center in Bennington, VT. He participated in the PHOTON2 project and still uses photonics/optics related units and labs in his Artificial Intelligence course.

However, the follow-up has turned into a detective story. Some teachers have retired since their participation or moved to another school. Additionally, many older email addresses no longer work. So far, we have achieved a 25 percent response rate but hope to hear from more people this fall.

We ask all former participants to please contact Program Coordinator Lisa Goldstein at **lgoldstein@nebhe.org** for a copy of the short survey. We want to hear from you!



LIGHT: Introduction to Optics and Photonics

By Judith Donnelly, Three Rivers Community College, and Nicholas Massa, Springfield Technical Community College.

This 15-chapter text gives an introductory overview of optics principles and photonics applications suitable for beginning college students, and high school juniors and seniors at the algebra/trigonometry level.

Written with the student in mind, the text features:

- plentiful illustrations
- a wide variety of optics/photonic applications in nature and technology
- three chapters on industrial applications written by industry experts
- questions and problems after each chapter

The book is available in full color (both hard cover and paperback), as a black & white paperback, or as a PDF download.

For sale at: http://stores.lulu.com/PHOTON2

All profits go to a fund to advance optics and photonics education.

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