PHOTON PROBLEM BASED LEARNING NEWS

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

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BU Photonics Center Hosts PHOTON PBL Workshop

The 2008 PHOTON PBL professional development Summer Workshop participants and staff.

The PHOTON Problem Based Learning (PBL) project held its second summer professional development workshop from July 27 to August 1, 2008 at the renowned Boston University Photonics Center. More than 30 high school and college science and technology educators traveled to Boston from as far away as Romania and Hawaii.

The workshop introduced four new PBL Challenges to 12 of last summer's participants and 19 new participants. The week began Sunday evening with a welcome reception and dinner. Invited guests included BU faculty and representatives from the Optical Society of America (OSA), SPIE and the PHOTON PBL National Advisory Committee.

The next five days focused on the four new Challenges developed earlier this year in collaboration with industry and research universities. They are:

- *Shining a Light on Infant Jaundice* with Photodigm Inc. of Richardson, TX, Southern Methodist University of Dallas, TX and Drexel University, Philadelphia, PA.
- *Watt's my Light?* with California State Polytechnic University, Pomona.

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Photonics Education in Hawaii

by Francis Takahashi

Francis Takahashi (left) and Alfredo Carbonel (right) in Boston.

Photonics is the enabling technology of the 21st century just as electronics was in the 20th century. It is of critical importance that we stay abreast of this rapidly developing technology as we begin the confluence of photonics, nanotechnology, biomedical technology and information technology. In this millennium, we have to be prepared to educate students both for new photonics jobs and for jobs yet to be defined.

My goal is to develop photonics programs at Hawaii community colleges and local high schools that have chosen to partner with us in order to train technicians for photonics jobs on Kauai, Maui and the Big Island. I want to develop an awareness of this career option at the K-12 level. We need to stimulate interest at an early age so students are aware of the prerequisites and are prepared

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A Tale of Two Teachers: Initial Results of Photon PBL Field Testing

by Nicholas Massa, Ph.D.

In 2007, the PHOTON PBL project invited participating educators to a professional development summer workshop at Roger Williams University in Bristol, RI. Afterwards, participants field tested any two of the first three PBL Challenges. The goal was to obtain early feedback to improve the five PBL Challenges still under development. The field testers gathered data on implementation strategies, student reaction and student learning outcomes, and also gave suggestions for improving the forthcoming Challenges and Photon PBL Teachers' Guides.

Field testing took place during fall 2007 and spring 2008 with highly encouraging results. Thirteen teachers (8 high schools, 5 colleges) field tested *Laser Wire Stripping* (PhotoMachining, Inc.), six teachers (4 high schools, 2 colleges) field tested *Fiber Laser Burn-in Testing* (IPG Photonics, Inc.), and five teachers (1 high school, 4 colleges) field tested *DNA Microarray Fabrication* (Boston University Photonics Center). Participating educators answered the following questions:

1. Which PBL Challenge did you field test and how was it presented? Level 1 (Structured - Instructor led), Level 2 (Guided- Instructor guided) and Level 3 (Open-ended - Instructor as consultant).

2. Describe how the Challenge was introduced in your class.

3. How did your students react to the PBL instructional method?

4. What specific recommendations can you make to improve the next five PBL Challenges?

Responses were posted on a dedicated BlackBoard website discussion board used as a sounding board for the different implementation strategies. Lively discussions generated a wealth of ideas for how educators at different academic levels could adapt the PBL Challenges to a diverse array of academic settings. Overall, student responses to the PBL Challenges were reported as extremely positive. The following case studies illustrate the experience of two participating instructors.

Case Study I: DNA Microarray Fabricator

Problem: Boston University graduate students need to determine the best starting exposure time for a DNA microarray fabricator.

This case describes the experience of Dave Miller, instructor in the Information Systems Technology program at Great Bay Community College, NH. The PBL Challenge was presented to students in his college Physics II class. The Challenge was initially introduced using an open-ended format but was changed to a structured approach mid-Challenge.

The Challenge was delivered as a two-part laboratory activity conducted over four hour-long class sessions. The first lab period was used to introduce students to the problem and then let them explore the background information and develop ideas to meet the needs of the problem statement. During the problem-analysis stage, students either formed teams or worked individually according to the overlap between their ideas and those of other students. During the second lab session, students converged on their final designs and presented these to the class using PowerPoint, the whiteboard and other visuals.

Miller reported that the PBL method worked very well for most students. A few, however, were a bit shy and did not reach the level of excitement the instructor had hoped for. Miller found the *DNA Microarray Fabricator Challenge* was a little tougher to get off the ground than the *Laser Wire Stripping Challenge*, which he had implemented in a prior class. "It is more complex with a lot of distracters, which kept them [students] from gaining critical mass. The problem-solver toolkit helped to get them oriented and on track, but the enthusiasm was much less than that of the PhotoMachining module."

Miller echoed sentiments expressed by other field-testers, suggesting that the initial problem statement may have been too ambiguous for most students at the community college level. These suggestions were heeded and the introductory problem statement was revised. On-going field testing will continue to refine this Challenge.

Two Teachers, continued on page 3

Students Attend National SPIE Annual Meeting

by Judy Donnelly

Gregory Doyon and Daniel Spicer at their booth in the SPIE Exhibition hall.

In August, Co-PI Judy Donnelly, with two students from Three Rivers Community College (TRCC) in Norwich, CT, attended the SPIE Optics and Photonics Annual Meeting in San Diego. SPIE is an international society advancing an interdisciplinary approach to the science and technology of light. The student attendees were Daniel Spicer, TRCC's SPIE student chapter president, and Gregory Doyon, Jr., chapter vice president. They received a grant from SPIE that covered travel and accommodations for the week-long event.

The TRCC students joined 120 of their student chapter peers from 18 states and 22 countries for a week of leadership activities. They enjoyed free admission to many "Young Professionals" courses such as Optimizing Your Resume, Effective Scientific Papers and Strategies for Professional Conference Presentations. Students also networked with each other and with optics professionals from around the world through various student social activities. A special area in the Optics and Photonics Exhibition hall gave student chapters an opportunity to show off their school activities. According to Doyon, "It was a great experience that allowed us to explore the fields of optics and photonics as well as meet people from industry and around the world."

Donnelly was a guest of the Education Committee, where she made two presentations: *Professional Development in Photonics: The Advanced Technology Education Projects of the New England Board of Education* that described 12 years of optics/photonics related programs, and *Support for Community College Technician Programs* presented the challenges community college technical education programs have recruiting new students. She also presented several papers at the Novel Optical Systems Design session chaired by Groot Gregory, PHOTON PBL Advisory Committee chair. Presentations included *Problem Based Learning in Optics and Photonics*, co-authored by the PHOTON PBL PI team, and an interdisciplinary optics course for high school students, co-authored by Donna Goyette, a PHOTON PBL participant from H.H. Ellis Technical High School in Danielson, CT. ■

Two Teachers, continued from page 2

Case Study II: High Power Laser Burn-In Test

IPG Photonics needs a way to run 100-hour unattended burn-in tests on a 2-kw laser.

This case describes the experience of Ken Franson at Kingswood Regional High School in NH. The PBL Challenge was presented to students in a Physics I course entitled "Principles of Technology." The Challenge was introduced using a structured approach.

At Kingswood, the Principles of Technology course is divided into 12 units based on traditional concepts taught in a high school physics class. Three Challenges were used, including the *Burn-In Laser Test Challenge* presented at the end of the course. Students worked in both self-selected and randomly assigned teams. This process was dictated by the availability of lab equipment. Students worked in groups of two for brainstorming and researching the PBL Challenges and in larger groups to develop a final solution and present their problem solutions to the group. Students were given the opportunity to test their solutions by simulating their designs using the PHOTON2 lab kit. For example, students used a HeNe laser, two beam splitters and a power meter to demonstrate how a laser beam can be divided repeatedly until a safe level is reached. Following the group presentations, a "final" solution was developed by the entire class and compared to the company solution.

Throughout the semester, the PHOTON PBL problem-solving process was emphasized and applied to other topics, to which students responded very positively. Franson commented that the PBL method of instruction was very exciting, unpredictable and empowered the students to seek out information and experiment with their own ideas as opposed to following a standard lab outline and procedure. As a result of the PBL method, students began to develop their own Challenges for some of the more traditional labs in the PHOTON2 curriculum.

Franson felt that the PBL Challenges were well done and all the supporting materials and videos were very helpful and of high quality. The weakest part of the Challenge, however, was when students derived a possible solution but could not implement it to test it. He suggested it would be helpful if simulations demonstrating the concepts used to solve the problems could be developed by and shared among the participating teachers.

Additionally, Franson commented that one aspect of the PBL approach is a social rather than academic issue. It was difficult to create group sizes and dynamics to meet everyone's needs: for example, a group of four students where two students do the bulk of the work. When this situation happens it creates frustration for those who do the work because of inequity in assessment. Therefore, giving attention to creating student groups that function on a social as well as academic level was key to making the PBL approach more motivating and enjoyable. ■

Nicholas Massa is director of the Laser Electro Optics Program at Springfield Technical Community College, MA.

Workshop, continued from page 1

Photon PBL PIs (standing, from left to right) Fenna Hanes, Judy Donnelly and Nick Massa applaud donor gift drawing winners.

• *Of Mice and Penn* with the McKay Orthopaedic Laboratory at the University of Pennsylvania Medical School.
• *Hiking 911* with Pennsylvania State University's Electro Optics Center in Freeport, PA.

Using problem-based learning strategies, workshop participants worked in teams to solve the multi-media Challenges like their students would in the classroom. Each Challenge begins with an introduction and the problem statement, followed by a problem discussion and the solution. Each Challenge also contains comprehensive teacher resources.

A Challenge can be solved using different levels of complexity: *structured* for beginners who need to have as much information as possible; *guided* for those with some experience with optics and photonics and problem-based learning but still need to see the problem discussion; and *open-ended* for those with a greater level of experience who only need to see the introduction and problem statement. At the end of the problem-solving process, each team presented their solution. These were compared with the solution actually used by the Challenge partner organization.

Professor Michael Ruane was our host during the week. He is a member of the BU electrical and computer engineering faculty and also a member of the PHOTON PBL National Advisory Board. Prof. Ruane gave a tour of the BU Photonics Center and his own photonics lab. He also gave a presentation about another National Science Foundation summer program he was hosting, the six week Research Experience for Undergraduates. Prof. Ruane's research students participated in the Thursday evening barbecue so PHOTON PBL educators could learn more about this undegraduate research opportunity and then pass along the information to their own classes.

The participants were honored to have Executive Director of Admissions Kelly Walter give a presentation about the admissions process at BU. Participants took a field trip to the Massachusetts Institute of Technology (MIT) Museum in Cambridge for a special guided tour of the museum's holography collection – the world's largest – that illustrates the artistic and scientific facets of the medium. They also saw "Flashes of Inspiration: The Work of Harold Edgerton" a multi-media celebration of his development of the electronic strobe and his dedication to making the invisible visible.

After returning to their classrooms, participants will field-test the Challenges. Participants will share their various implementation strategies and results on a BlackBoard website. The project team will compile their feedback into a General Teaching Guide as well as a Teaching Guide for each Challenge. In addition, a new PHOTON PBL listserv has been implemented for participants to ask questions and exchange information about problem-based learning. This new listserv complements the existing PHOTON listserv for general photonics curriculum questions & discussion. For more information about the listserves or other activities, contact PHOTON PBL PI Fenna Hanes at fhanes@nebhe.org. ■

Summer Workshop Donors

Participants were asked to leave extra room in their suitcases for the many donations of literature and other giveaways from corporate and educational institutions and industry associations: **American Institute of Physics (AIP), Boston University Photonics Center, IPG Photonics, Laurin Publishing Co., Nufern, OFS, Optical Society of America, Pennsylvania State University Electro Optics Center, PennWell Corp., Polymicro Technologies, SPIE, Tessera, Three Rivers Community College and Zygo Corp.**

(From left) David Susuras, Gary Garber, and Leo Johnson enjoy a workshop presentation.

(From left) Richard Shanks, Feng Hong and JoAnn Flejszar discuss how to solve a Challenge.

Summer Workshop Participants

Arizona:
- Pima Community College
- Toltecalli Academy

California:
- California State Polytechnic University at Ponoma
- Independence High School
- Vista del Lago High School

Connecticut:
- Plainfield High School
- University High School of Science & Engineering
- University of Hartford

Hawaii:
- Kauai Community College
- Kauai High School
- Maui Community College
- Maui High School

Iowa:
- Indian Hills Community College

Massachusetts:
- B.M.C. Durfee High School
- Boston University Academy
- Bristol Community College

Michigan:
- Oakridge High School

Missouri:
- Columbia Area Career Center

New Hampshire:
- Great Bay Community College

New York:
- Colton-Pierrepont Central School
- Hermon-DeKalb Central School
- SUNY College of Technology-Canton

North Carolina:
- North Carolina State University

South Carolina:
- South Carolina State University

Tennessee:
- Nashville State Technical Community College

Texas:
- Frisco Liberty High School

Utah:
- Bridgerland Applied Technology College
- Utah State University

Romania:
- Center for Science Education and Training
- Colegiul National Vocational High School

Summer Workshop Sponsors

The workshop was made possible by funding from the Advanced Technological Education (ATE) program of the National Science Foundation (NSF). The Optical Society of America Foundation provided funding to bring the two Romanian educators to the workshop while SPIE provided funding to cover a portion of travel, food and accommodation costs for U.S. participants. In addition, the Connecticut Regional Center for Next Generation Manufacturing, an NSF/ATE regional Center of Excellence, provided funding to support six New England educators to participate in the project.

Hawaii, continued from page 1

Francis Takahashi (C) and fellow BU summer workshop participants Pam Gilchrist (L) and Bill Gray (R).

to enter our photonics program, graduate and then go on to high paying, high-tech jobs in Hawaii in this field.

Our professional development efforts began in 2004 when Alfredo Carbonel (Kauai HS) and I joined the PHOTON2 project. We participated in a four credit on-line course, internships at high tech companies on Kauai, the Hawaii High Technology Career Workshop on Maui, the PHOTON2 capstone at SPIE's annual conference in San Diego, and the Photon PBL 2007 summer professional development workshop at Roger Williams University in Rhode Island. We also attended the DEPS (Directed Energy Professional Society) Teacher Education Workshop in Huntsville, AL.

In summer 2008, Alfredo Carbonel, Keith Imada (Maui HS), Mark Hoffman (Maui CC) and I took advantage of another professional development opportunity to broaden our knowledge of photonics and methods of incorporating PBL into our courses to enhance student learning. We attended a week-long Photon PBL workshop at Boston University's Photonics Center. We gained a new perspective on photonics technology and a deeper understanding of PBL.

Last spring Alfredo and I both field tested the *Laser Wire Stripping* Challenge. This active learning gave our students the opportunity to work in teams and use their creativity and critical thinking skills to find a solution to the problem. We presented our results at the BU workshop. We will continue our efforts to develop photonics at the community colleges and high schools in Hawaii and hope to get additional high schools to partner with us. In total, the Boston workshop was a great professional development, cultural and culinary experience.

Our continuing association with NEBHE and the PHOTON projects has played a major role in developing our program at Kauai CC and our partnership with local high schools and industry. The PHOTON project developed our functional organization, and a DEPS grant provided funding for electronics and photonics equipment at all three Kauai high schools. Kauai HS is offering electronics this fall as a precursor to photonics in the spring. PHOTON has left an indelible stamp and nearly all that we are is the result of our association. The PHOTON projects enabled me and my colleagues, technology educators with no background in this field, to start photonics education programs in our schools. ■

Francis Takahashi teaches electronics technology at Kauai Community College, HI.

Porfirio Creque: Shining a Light on his Future

Optics and photonics and their applications are interdisciplinary, encompassing aspects of physics, chemistry, engineering and math as well as applications in the life sciences.

In the spring 2008 semester, PHOTON PBL Co-PI Nick Massa and Professor Peter Vangel, both instructors in the Laser Electro Optics Technology (LEOT) and Electronics Systems Engineering Technology (ESET) programs at Massachusetts' Springfield Technical Community College (STCC), decided to integrate this interdisciplinary quality into their programs. They combined course sections and team-taught the LEOT and ESET senior projects classes to provide students with an interdisciplinary learning experience utilizing the PHOTON PBL Challenges.

One of those students was Porfirio Creque who came to STCC through a displaced worker program after the company he worked for went out of business. He was enrolled in the ESET program and had taken both Laser Safety and Fiber Optic Communications as elective courses in the LEOT program.

When selecting a Challenge from a list of descriptions, he chose the Photodigm, Inc. Challenge, *Shining a Light on Infant Jaundice*. It intrigued him by presenting an opportunity to explore both his interest in lasers and optics as well as his experience with biomedical technology working at a local hospital for several years.

Porfirio worked with fellow student Zbigniew Olczuk as they followed the problem solving process incorporated in the PBL Challenges. Although it took them a number of brainstorming sessions to work through the problem, the problem-based learning experience motivated them to dig deeper into the electronics and laser technology involved in the Challenge. Because of their extra work, they began to better understand how the blue blanket system really works. Porfirio found himself becoming more proficient in a number of different areas that he had not studied before and both students started to master the problem solving process. They agreed that without the PBL process they would not have been able to solve the problem.

"The Challenge opened my eyes to a whole new world..."

Upon completing his first PBL Challenge, Porfirio realized that his experience with PBL was the single most rewarding

Porfirio Creque (right) and his partner Zbigniew Olczuk (left) collaborating on the Challenge in their senior project class at STCC.

experience in his two years at STCC. He said that as soon as Dr. Massa introduced him to this problem-solving approach, he recognized the advantages of implementing this form of learning. He saw a method whereby he could apply all the theory he had learned over the past two years, and he could see a real-world application of this knowledge. His only regret is that PBL is not incorporated in the curriculum for all first-year students. He said that he wonders how much more he could have learned if this method had been an integral part of the core curriculum of STCC.

As a result of the PBL Challenge experience, Porfirio began making plans to obtain his bachelor's degree and perhaps an advanced degree in biomedical engineering or computer science. The Challenge opened his eyes to a new world that can combine his previous work experience and interest in bioscience with skills obtained at STCC.

Prof. Massa stresses that a key take-away from Porfirio's experience is that not until he encountered a real-world problem did he learn what is his career interest: biomedical applications. Even though he had worked in a hospital before, he had not thought about biomedical engineering as a career possibility. Nor had he seen himself going on to higher education. But after completing the Challenge he has a burning desire to continue his education and learn more. ■

Conference Experience for Educators (CEE)

In June, Project PHOTON PBL received a supplemental grant from the Electrical, Communications and Cyber Systems Division of the National Science Foundation. The CEE grants will provide a number of mini-grants that cover travel, accommodation and registration costs for PHOTON PBL participants to present a paper or workshop at an association's regional or national conference.

The CEE grant is designed for a transformative professional development experience for participants. In addition to attending the conference, participants will have opportunities to network with colleagues, conference speakers and vendors and to expand their knowledge and understanding of the field of optics and photonics, as well as state-of-the-art education strategies.

Participants will submit conference grant proposals in alliance teams of PHOTON PBL participants, consisting of high school teachers and community college instructors. Teams can also include industry or university partners and students of the instructors.

Last spring, California State Polytechnic University at Pomona (CSPU) Professor Massoud Moussavi invited two students in his Electronic and Computer Engineering Technology class to join him in writing a paper and presenting it at the American Association for Engineering Education (ASEE) meeting in Pittsburgh in June.

Prof. Moussavi reported that most CSPU students are the first person in their family to attend college. Attending and presenting at the national conference raised the students' confidence. It also raised their aspirations to continue on to graduate work. Without the generous grant from CEE, they would not have been able to attend and have such an enriching experience. ■

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