PHOTON PROBLEM BASED LEARNING 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). Please visit our website: www.nebhe.org/photonpbl. You may also contact the program staff at:

Fenna Hanes
Sr. Director, Professional & Resource Development
617/357-9620 x129
fhanes@nebhe.org

Vanessa Goldstein
Newsletter Editor & Program Coordinator
617/357-9620 x140
vgoldstein@nebhe.org

45 Temple Place ■ Boston, MA 02111

Summer Workshop Held In Rhode Island

Roger Williams University (RWU) was the site of this summer's PHOTON PBL professional development workshop. Twenty-three of the project's 27 secondary and postsecondary educators traveled from across the country to scenic Bristol, Rhode Island, to learn how to introduce their students to optics and photonics science and technology using problem-based learning (PBL) strategies.

PHOTON PBL PI Fenna Hanes (far left) with Co-PIs and participants at Roger Williams University in Bristol, Rhode Island.

The workshop goals were to:

- Introduce project participants to the first three PHOTON PBL Challenges.
- Gain feedback from participants to guide project principal investigators (PI) in editing the first three and developing the remaining five Challenges.
- Create a community between the secondary and postsecondary partners who will be working together to implement the PBL Challenges in their home institutions.
- Build a network of educators who will become resources to one another as they introduce their students to the PBL Challenges.
- Provide the educators with the tools to build their own PBL Challenges.
- Provide a stimulating professional development experience in an attractive higher education learning environment.

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NEBHE Launches PHOTON PBL

In September 2006, NEBHE launched Project PHOTON PBL, funded by the Advanced Technological Education (ATE) program of the National Science Foundation (NSF). Now, one year later, the project team has made great strides toward its goal: to address the lack of PBL resources in photonics technology education by developing a curriculum of eight multimedia photonics Challenges and solutions to engage students in the process of solving open-ended problems.

With three of the Challenges under their belt, project PIs have already selected the 27 instructors who will field-test the curriculum between the fall 2007 and spring 2009 semesters. At the PHOTON PBL summer workshop in July 2007, project PIs presented the first three Challenges to instructors and received helpful feedback on how to make the materials more accessible and relevant for students.

One of the intricacies of capturing the Challenges is releasing information to students to enhance critical thinking and problem-solving skills, both consistent requests from members of the photonics and optics industry.

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Problem Based Learning: A Primer

By: Nicholas Massa, PhD

Photonics technicians are problem solvers – individuals who must skillfully apply their knowledge of lasers, optics, electronics and related technologies to solving real-world problems. Working side-by-side with engineers and scientists, photonics technicians are the hands-on side of an engineering team; they are responsible for designing experiments, building and troubleshooting prototypes, analyzing and interpreting data and presenting experimental results to peers, supervisors and customers. Given the broad scope of duties required of the photonics technician, why do many photonics technician educators continue to teach in a traditional instructor-centered manner that provides little opportunity for students to actively engage in real-world problem-solving? This approach to education too often results in graduates who enter the workforce inadequately prepared to adapt to the complex and ever-changing demands of the 21st century high-tech workplace.

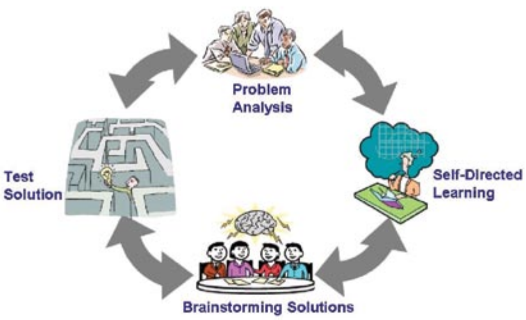


Figure 1: The problem solving cycle.

PHOTON PBL addresses this challenge through problem-based learning (PBL), an instructional method that challenges students to "learn how to learn" by collaboratively solving 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 ability to adapt learning to new situations – the cornerstone of lifelong learning.

In PBL, students learn the process of solving real-world, open-ended problems that may have a number of possible solutions. PBL involves a recursive problem-solving process that begins with a problem scenario presented in the context in which it is to be solved (see Figure 1). Student teams collaboratively analyze the problem by identifying relevant facts and learning issues, activating prior knowledge, generating hypotheses, reflecting on their beliefs about the problem and generating learning objectives needed to solve the problem. This phase is followed by a period of self-directed learning whereby each student engages in learning specific content identified as relevant in the initial problem analysis phase. During this process, the instructor serves as a consultant, guiding the student as they seek required resources and providing additional information as needed, thereby shifting the responsibility for learning onto the student. Upon completion of the self-directed learning phase, students reconvene to brainstorm, assessing and evaluating their problem solutions based on their new understanding of the problem. Possible solutions are then tested and reformulated if needed. This process may repeat itself several times when solving a single problem. Student evaluation in Continued on page 8

PHOTON PBL Meets with National Advisory Committeee

As with other NEBHE NSF/ATE projects, a National Advisory Committee (NAC) composed of leaders in industry and education has been selected to guide the PHOTON PBL project.

Committee members have been asked to provide guidance for 1) curriculum requirements and skill set needs for photonics technicians in industry; and/or 2) strategies for including PBL principles in the case study Challenges.

Issues that were discussed at the first annual NAC meeting held in Boston from December 6 – 7, 2006 included: considerations for selecting the Challenge partners; pedagogical considerations; assessment issues; resources the NAC can bring to the project; and what the PIs can do to assist the NAC.

NAC members include: Robert Breault, President of Breault Research Organization, Inc., Tucson, Arizona; Robert Douglas, Applications Engineer, Zygo Corp., Middlefield, Conn.; Wendy Gilpin, Director of Education, Penn State Electro-Optics Center; G. Groot Gregory, NAC Chair and Technical Business Analyst at Optical Research Associates, Westborough, Mass.; Jim Johnson, Dean of Information & Engineering Technologies, Nashville State Community College; Linda Jordan, Tennessee Department of Education; Mark Kahan, Chief Electro-Optical Systems Engineer, Optical Research Associates; Mike Ruane, Associate Professor of Electrical and Computer Engineering, Boston University; Ronald Scotti, Science and Technology Specialist, SPIE, Bellingham, Wash.; Margaret Sullivan, Inside Sales Manager, Verrillon, Inc., North Grafton, Mass. ■

PBL Launch, continued from page 1

The 8 PBL Challenges, captured in academic and industry settings, will include numerous photonics applications such as:

- Environmental sensing
- Machine vision
- Optical science/systems
- Lighting & illumination
- Precision measurements
- Imaging
- Laser materials processing
- Laser beam diagnostics
- Renewable energy
- Medical diagnostics

While the Challenges are being field-tested from fall 2007 to spring 2009, the project team will complete the remaining five Challenges, write and revise the student and teacher resources, implement the assessment tools, collect and analyze the data from the school test-sites and disseminate the project activities.

When project PIs began recruiting instructors to field-test the new PHOTON PBL curriculum, they received an overwhelming response. Fourteen secondary and post-secondary educators who had participated in NEBHE's previous projects FOTEP, PHOTON and PHOTON2, as well as 12 educators from new schools, were selected based on their goals for teaching optics and photonics, plans for implementation and administrative support.

For instance, from NH, Kingswood High School's Ken Franson (PHOTON2 participant) and New Hampshire Community Technical College at Pease's Dave Miller (FOTEP, PHOTON and PHOTON2 participant) have a longstanding history of successfully collaborating on NEBHE's professional development projects.

Other New England PBL schools that have previously participated in NEBHE photonics projects include Connecticut's Greater Hartford Math & Science Academy, H. H. Ellis Regional Vocational School, Plainfield High School, Three Rivers Community College and the Southwest Vermont Career and Technical Center in Brattleboro.

An instructor's degree of interest and plans for implementation were central to the selection. Francis Takahashi of Kauai Community College in Hawaii is continuing his partnership with Al Carbonel at Kauai High School (both PHOTON2 participants). Takahashi also coordinates photonics efforts with Maui and Hawaii Community Colleges. Takahashi believes the PHOTON PBL curriculum will benefit the majority of his students who do not learn well from traditional lecture-style teaching methods. Takahashi also plans to use the PHOTON PBL materials to augment the community colleges' distance learning courses, the aim of which will increase enrollment in photonics classes among the three island community colleges.

At California State Polytechnic University (CSPU), PHOTON2 participant Massoud Moussavi is already implementing that curriculum. In addition, CSPU will be hosting one of the eight Challenges. The PHOTON PBL PI team will travel to Pomona to photograph and videotape a Challenge where students must find viable sources of alternative energy using solar power.

Educators new to the PHOTON projects include Betsy Banks from the Huntsville City Schools Engineering Magnet. She plans to use the curriculum to expand her photonics unit in her AP physics and engineering classes to a 1 - 2 semester course open to all students. The school will partner with the Center for Applied Optics at the University of Alabama, Huntsville.

Bill Pugh from Englewood High School in Jacksonville is partnering with professor Peg Greene at Florida Community College. Pugh, who is developing a photonics program, plans to build a Career Academy around the broad theme of optics for the 2008 school year. Professor Greene plans to use the curriculum in her precalculus class and STEM Club (Science, Technology, Engineering and Math). She also hopes to partner with and expose her students to local industry, as well as integrate PBL projects into the regional, national and international conferences at which she currently presents.

Georgette Meyer from Westside High School in Anderson, South Carolina plans to partner with Tim Brown from Tri-County Technical College in Pendleton, South Carolina. Meyer plans to develop student guides for optics and photonics lab activities in accordance with state guidelines, as well as develop a major project for the students in the physics course. She also plans on working with Brown to develop and instruct a dual-credit course in photonics. At his college, Brown intends to develop a capstone project and other student learning scenarios for a first-year level Introduction to Photonics course.

Please see a full list of the PHOTON PBL schools in the box on this page. Future issues of PHOTON PBL News will profile implementation activities as the project progresses. ■

Participating Schools:

Alabama:
Hunstville City Schools Engineering Magnet
University of Alabama Huntsville

Arizona:
Pima Community College
Toltecalli Academy

California:
California State Polytechnic University
Vista del Lago High School

Connecticut:
Central Connecticut State University
Greater Hartford Academy of Math & Science
H.H. Ellis Technical High School
Plainfield High School
Three Rivers Community College**
University of Hartford**

Florida:
Englewood High School
Florida Community College Jacksonville

Hawaii:
Kauai Community College
Kauai High School

Michigan:
Oakridge High School

New Hampshire:
Kingswood Regional High School/Region 9 Vocational Center
New Hampshire Community Technical College at Pease

New York:
Saunders Trades and Technical High School
Vaughn College of Aeronautics & Technology

North Carolina:
Central Carolina Community College

South Carolina:
Tri-County Technical College
Westside High School

Texas:
Collin County Community College District
Frisco Liberty High School

Vermont:
Southwest Vermont Career Development Center

**Participating in collaboration with Conn.'s NSF/ATE-funded Regional Center for Next Generation Manufacturing.

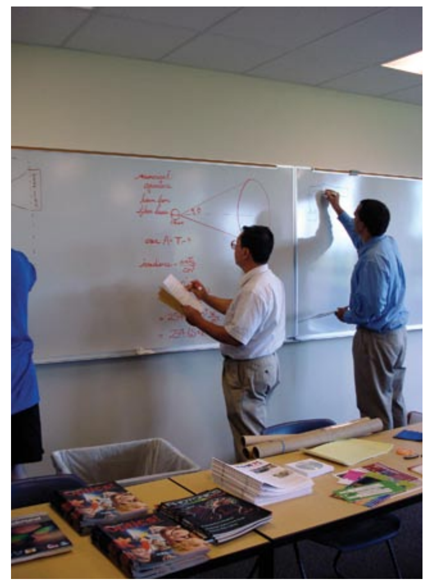
Workshop, continued from page 1

The workshop commenced with a Sunday evening welcome reception. RWU School of Education Dean Mieko Kamii welcomed participants: "I feel a special kinship with the important work you are doing in your problem-based instruction project, especially because it is based on a coalition of educators and businesses."

Workshop participants exploring PBL activities.

On Monday, Co-PI Richard Audet—a RWU science education faculty member—presented a comprehensive PBL overview. He introduced participants to a scientist's notebook that each participant would maintain throughout the workshop to track their learning experiences and to interactive activities that model PBL, defined as "a curriculum development and instructional system that simultaneously develops both problem-solving strategies and disciplinary knowledge bases and skills by placing students in the active role of problem solvers confronted with an ill-structured problem that mirrors real-world problems" Finkle and Torp (1995).

Chad Stark, Deputy Senior Director of the Optical Society of America's (OSA) Foundation, Membership & Education Services, joined the morning session and presented an overview of the educational activities of the organization. OSA is preparing a number of teaching aids and invited the PHOTON PBL instructors to participate in field-testing these materials before they go into final production.



L to R. Chien-Wei Han, Pima County Community College and Luke Burgess, University of Alabama Huntsville, recording their solutions to the IPG Challenge.

Next, Co-PI Judy Donnelly, a physics professor at Three Rivers Community College in Norwich, Conn., and Co-PI Nick Massa, professor of laser electro-optics at Springfield Technical Community College in Springfield, Mass., described the methodologies employed in developing the three PHOTON PBL Challenges to be examined during the workshop. Since the Challenges will be used at both the high school and college levels, each has been designed to include three levels of difficulty: structured, guided and open.

Participants would first examine the Challenge developed in collaboration with PhotoMachining, Inc., located in Pelham, NH. PhotoMachining is a leader in supplying high precision laser micromachining services and systems and is equipped with the latest in laser machining technology, including Excimer, Neodymium:YAG, CO2 and high powered fiber lasers.

The PhotoMachining Challenge is to choose the appropriate laser and develop the optical delivery system to strip wire in an automated system. Math concepts utilized include algebraic manipulations. Scientific concepts include lens and mirror properties and specifications, materials required for Infra-Red and Ultra-Violet optics, laser output characteristics, optical alignment and energy density. Other topics covered include material properties, reflectivity and damage thresholds and automated cutting/sorting.

Project PIs and participants assessing the three proposed solutions to the IPG Challenge.

Beginning on Tuesday, mornings commenced with a formative feedback session, the purpose of which was to review questions that had not been addressed or arose upon further reflection. Audet facilitated a discussion and activities that continued to explore PBL, teaching and tools. He introduced educators to a Problem Solvers Toolkit that teachers/faculty and students will use to solve the PBL Challenges. Tools include the use of affinity clusters, brain stormers, a "need-to-know" board, critical path analyzer and Gantt charts. The session also included tools for evaluating the outcomes of solutions to the Challenges.

The Boston University (BU) Electrical & Computer Engineering Department and Photonics Center provided the BU Challenge. One of its current research projects is the development of novel photo detectors and imaging biosensors for use with DNA and protein microarrays. The Challenge is to choose the correct wavelength to initiate photochemistry and determine the exposure time from the system losses and exposure curves. Math concepts needed to solve the BU Challenge include percent loss, interpreting graphs of data and exponential curves/half-life estimating. Optics concepts include imaging optics, UV sources, reflection and scattering, beam expanding optics and photochemistry. Other topics covered include DNA construction from chemical bases, microarrays for rapid assay and microarray applications.

Wednesday morning and most of the afternoon was spent viewing and analyzing the IPG Photonics Challenge. IPG Photonics, headquartered in Oxford, Mass., is a leading developer and manufacturer of high-performance fiber lasers and amplifiers for diverse applications in numerous markets.

Continued on following page

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The Challenge is to devise an unattended enclosed system to safely test and monitor high power laser wavelength and power for an extended period of time. Math concepts used in this Challenge include area calculations that describe power density and basic trigonometry. Optics concepts cover fiber laser output characteristics, beam expander/collimator optics, optical power meter operation, optical spectrum analyzer operation and fiber optic cable characteristics. Other topics covered include optomechanical couplers and assemblies, interlocks, mounting hardware, basic electric circuitry, temperature sensors, digital flow meters and control systems. IPG laser technician Heather Wade, who appears in the IPG Challenge video, is featured in the Career Profile article on page 7.

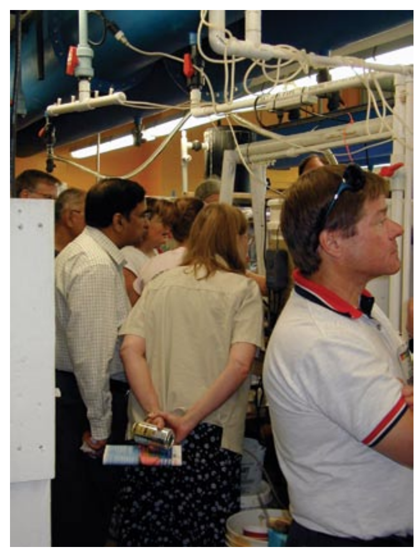
Center. Nicole Kessler-Snook, Toltecalli Academy, looking at the inside of her ear during one of Donnelly's demonstrations.

Wednesday afternoon, project PIs held a forum with participants to discuss the field-testing process. Each project participant will be expected to field-test two of the eight PHOTON PBL Challenges with their students. They will also be expected to assist the PIs in developing a Teaching Guide based on their use of the instructional materials. The Teaching Guides will include feedback from PHOTON PBL instructors in the areas of prerequisite skills/knowledge; uses of structured, guided and open Challenges; tips for student team building; useful student assessment tools; and other suggestions of value to other educators. Each PHOTON PBL instructor will receive a $500 stipend per Challenge after field-testing and assisting with the development of the accompanying Teaching Guide.

Once introduced to the 3 PBL Challenges, participants experimented with tailoring the Challenges for their classrooms.

Thursday and Friday were reserved for questions and discussions of how participants would implement the Challenges they had worked with over the previous three days. Issues that arose included suggested revisions to the Challenge scripts, questions about which level of structure to use with which students, what supporting resources are available to enhance student learning and assessment methodologies. In the afternoon, two separate focus groups were conducted by external project evaluator Carol Giuriceo to explore more deeply the concerns and questions the participants had with regard to introducing the Challenges to their students. While half the group participated in a focus group session, the other half enjoyed hands-on demonstrations provided by Pima Community College instructor Chien-Wei Han and his high school partner Nicole Kessler-Snook. Co-PI Donnelly also demonstrated a number of inquiry-based exercises to engage students in hands-on and problem-based learning.

Thursday night was a beautiful summer evening and a clambake was held on the lawn overlooking the bay. Special guests including Challenge partners from PhotoMachining, BU and IPG as well as members of the PHOTON PBL National Advisory Committee (NAC) and industry representatives interested in the project joined the participants and PI team. The moonlit evening was made all the more enjoyable by participant Dave Miller and PhotoMachining CEO Ron Schaeffer's guitar playing.



Participants during the tour of the Roger Williams University Aquaculture lab.

Friday morning PHOTON PBL media consultant and Central Connecticut State University professor Michele Dischino presented the electronic template used to create the Challenges. The long-term goal of the project is that each participant will be able to develop his/her own PBL Challenges using the prepared template.

NAC member Wendy Gilpin, Director of Education for the Pennsylvania State University Electo-Optics Center, joined the workshop for two days. Representatives from two other NSF/ATE projects also joined the workshop, including Jim Johnson, a NAC member and dean of information & engineering technologies at Nashville State Community College. Dean Johnson has been the PI for the ATE Case Files project and is the PI for a new ATE materials development project. He attended the meeting for three days and provided valuable feedback on the workshop to the PHOTON PBL PI team. Connecticut's ATE Regional Center for Next Generation Manufacturing PI Karen Birch and two of her senior personnel also joined the workshop for two days to learn more about the PBL that they will apply to the Center's work.

Participants were provided with two guided tours of the campus. The first on Tuesday was of the Marine Science aquaculture laboratory, where numerous shellfish and salt-water aquarium fish are raised. The second on Wednesday was of the library and academic facilities. Both tours were intended to give a more comprehensive understanding of what RWU offers its students. ■

PIs Develop the First Three PBL Challenges

When project PIs first sat down with the eight PHOTON PBL Challenge hosts in January of this year, the final Challenge products seemed like a distant point on the horizon. Just months later, three of the eight Challenges have been written, recorded and completed. IPG Photonics (IPG), Boston University (BU) Photonics Center and PhotoMachining, Inc. provided an ideal venue for the project's initial PBL experience.

From March 22 – 23, 2007 project PIs met with Q & A Technician Josh Chaffee, VP of Operations Dennis Leonard and others at IPG in rural Oxford, Mass. IPG is a leader in developing and manufacturing high-performance fiber lasers and amplifiers for diverse applications and markets.

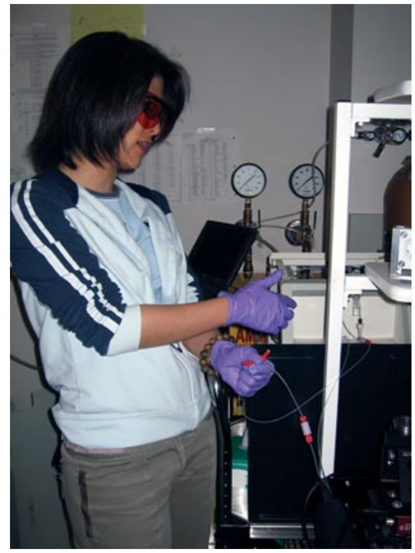
Videorecording the IPG Challenge discussion. L to R. Scott Morin, customer service manager; Heather Wade, laser technician; Jack Ward, operations manager; Mike Forrest, Q & A manager; Josh Chaffee, Q & A technician; Dennis Leonard, VP of operations; and Co-PI Nick Massa.

The facility is a multi-unit campus of large labs and offices with heightened security for entering and exiting each room. Walking through IPG is like stepping into Wonka Vision—big bright white rooms filled with people wearing white lab coats and large safety glasses. At the drawing board, the group discussed the Challenge: an engineering design team tasked with developing a burn-in test strategy for a high power fiber laser.

IPG's lasers are used in materials processing, communications and medical and advanced applications. Their lasers can be found in the micro-electronic, printing, automotive, medical device, shipbuilding and aerospace industries and are used in applications ranging from micromachining of medical stents and memory chips to deep penetration welding of heavy-walled pipe.

Less than one month later, the project team convened at the Photonics Center at BU with Professor Mike Ruane and two of his graduate students. The Center's Optical Characterization and Nanophotonics research group focuses on developing and applying advanced optical characterization techniques to the study of solid-state and biological phenomena at the nanoscale.

The Center itself sits on a concrete mat six feet thick to minimize vibration from the adjacent train and Mass. Turnpike. The facility contains a plethora of faculty and student artwork that celebrates light. One piece in particular is a series of holographic diffraction gratings that break sunlight into its spectral components, and a heliostat on the roof that deflects sunlight onto the gratings. Adjacent to this piece is a conference room and lab where the BU Challenge plays out: a university research team must develop the optical system for a DNA microarray fabricator. A DNA microarray, or "DNA chip," is a small piece of glass or other material with thousands of different attached DNA strands that can be used for genetic testing.



Graduate student Sunmin Ahn demonstrating the BU Challenge in the Center's lab.

In May, the PHOTON PBL team visited PhotoMachining, Inc. in Pelham, NH. PhotoMachining is a leader in supplying high precision laser micromachining services and systems, and its facility is equipped with the latest machining technology.

Most employees have been at the company since CEO Ron Schaeffer founded it in 1997 and have progressed in their careers because of the training they received there. Site labs vary in design—many are enclosed by plastic walls and ceilings; other stations sit behind closed doors.

In the PhotoMachining Challenge, an engineering design team must develop a strategy for the precision laser stripping of very delicate copper wires used in the medical device industry.

Photomachining CEO Ron Schaeffer and Materials Processing Manager Gabor Kardos giving the project team a tour of the facility. L to R. Ron Schaeffer, Michele Dischino, Gabor Kardos, Carol Giuriceo, Richard Audet, Nick Massa and Vanessa Goldstein.

Applications of PhotoMachining technology include manufacturing precision medical devices (i.e. stents and angioplasty catheters and balloons), as well as high speed drilling of printed circuit boards, cutting and scribing of ceramic substrates, removal of dielectric materials from flexible circuits, wire stripping and high speed marking for the microelectronics industry.

The first three Challenge visits have provided a tremendous problem-based learning experience for the PHOTON PBL PIs, and they are excited about implementing what they've learned in the final five visits.

To find out more about these Challenge hosts, visit IPG at IPGPhotonics.com, BU Photonics Center at BU.edu/Photonics and PhotoMachining at PhotoMachining.com. ■

Heather Wade

PHOTON PBL News spoke with Heather Wade of IPG Photonics, Inc. about her background, experiences in the fiber optics field and views on career paths in the industry.

What was your introduction to photonics?
My introduction to photonics was at H.H. Ellis Regional Vocational Technical School, where I studied electro-mechanical engineering. My physics teacher Donna Goyette introduced me to a photonics learning kit. I found it intriguing because I had never heard of photonics nor seen anything like the kit.

How did you get to where you are today?
During my senior year of high school I received a scholarship from the National Science Foundation to study photonics and electronics at Three Rivers Community College. While in my last semester of school, my Photonics Professor Judy Donnelly informed students of job opportunities at IPG Photonics and brought our Advanced Laser Topics class for an educational tour of the company. I thought it seemed like a good place to start because it's successful in the fiber optic laser business.

What were some critical turning points for you that made you into the successful laser technician that you are today?
The most educational moments of being a laser technician are when there are challenges or issues when repairing a module or if there are failures when operating a laser module during testing. I also learn new information every time we work on a type of unit that we haven't had before. My greatest learning experiences usually result from common mistakes, for example, breaking or damaging fibers or parts or not hooking something up correctly. Both are good examples of not properly handling equipment or product! It can be very time-consuming and costly to repair a laser when some of the fibers to be worked are too short from being broken or damaged. Making mistakes like those happen usually only once or twice and then never again. One learns fast to be very careful and pay close attention when dealing with delicate fiber optics.

What are your job responsibilities at IPG Photonics?
I test and assist in the repair of various types of fiber laser modules, ranging from 50-Watts to 800-Watts power output. These modules are usually combined together in a bigger laser in another department to achieve higher output powers. IPG sells these higher power lasers to customers for various applications including, but not limited, to metal cutting, rock blasting and even deploying land mines. I set up each laser I will test on a test bench, connect power supplies, align the power head, hook up the cooling system and run the laser. Then, using the power meter and a voltmeter, I take measurements and in some cases troubleshoot. I am also responsible for keeping the paperwork for each laser up-to-date and assisting with getting parts from stock and returning non-conforming parts.


Heather Wade testing a 100-Watt fiber laser in IPG's Laser Module Department's test lab.

What academic background do you think high school students need to be successful in a photonics technology associates degree program and the workforce?
A technical high school background helped prepare me for some of the program's equipment and terms, as well as the academic, scientific and technical concepts. If that's not an option, an introduction to physics and computer skills are a good start.

What advice would you give to young women thinking about entering this field?
I would say that more and more women are entering this field, so it's becoming more common to find them in photonics technology. Young women should not be discouraged when they seek employement if they find that there are only a few women compared to the number of males, because it creates more opportunity. Also, chances are that more women will follow in the next few years with the growing industry and education.

Where do you see the job opportunities for high school and community college students in this field?
Currently students who graduate with an associates degree or technical high school background have a likely chance of finding employment in production of photonic products. IPG most commonly starts new hires with associate's degress in assembly and technician positions. To pursue a higher position in engineering, for example, a person would need more schooling.

What do you see as the current economic climate in the field of photonics?
I see photonics as a growing field with endless possibilities.

Heather Wade's former instructor Judy Donnelly is a Co-Principle Investigator for projects PHOTON PBL and PHOTON2; Donna Goyette is a PHOTON PBL and PHOTON2 participant. ■

A Primer, continued from page 2

PBL takes several forms, from a final patient diagnosis in medical education to the generation and presentation of a formal proposal, including cost/benefit analysis and/or feasibility analysis in an engineering education application. In either case, the final problem solution takes the form of what would be most appropriate in that particular context.

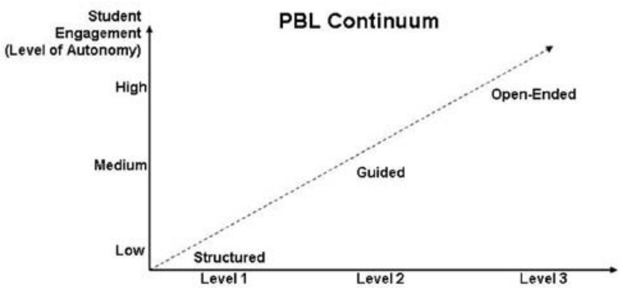


Figure 2: The Photon PBL Continuum.

After years of learning from classroom lectures, many students have difficulty adjusting to PBL. A common complaint among those introduced to PBL for the first time is the stress and anxiety associated with solving open-ended problems and self-directed learning. PBL thrusts students into uncertain learning situations where problem parameters are not well defined and the task at hand may be ambiguous – *just like in the real world*. To ease this transition, the PHOTON PBL Challenges are designed with three levels of structure: Level 1 (Instructor Led - Highly Structured), Level 2 (Instructor Guided - Moderately Structured) and Level 3 (Instructor as Consultant - Open-Ended) depending on the technical nature of the problem and ability level of the students. This format allows students (and faculty) to progress through the PBL Challenges along a continuum, from a low autonomy mode (highly structured) to high autonomy mode (open-ended) over time, improving the likelihood that both students and faculty will adopt and embrace this new mode of instruction and learning (see Figure 2).

Given the practical nature of photonics technology education where students must learn to apply their knowledge in solving complex, real-world problems, PBL appears well-suited for educating technicians capable of addressing the ever-changing needs of today's technological and multicultural society.

Dr. Massa teaches in the Laser Electro-Optics program at Springfield Technical Community College. He can be contacted at massa@stcc.edu. ■

NEBHE
45 Temple Place
Boston, MA 02111
617/357-9620

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