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Please visit our websites: www.ampbl.org and www.pblprojects.org

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NEW ENGLAND **BOARD OF** HIGHER EDUCATION

AM PBL Partners with Industry to Develop "Challenges"

recent study prepared by the New England Council and Deloitte Consulting entitled "Smart Infrastructure in New England: An Investment for Growth and Prosperity," indicates that a skilled workforce is fundamental to economic growth. The report states that a "21st century infrastructure supports collaboration among communities, businesses, and educational institutions (especially community colleges and vocational schools) — a collaboration that links 'learning with earnings' by preparing people for gainful employment."

The underlying concept of the New England Board of Higher Education's (NEBHE) Advanced Manufacturing Problem Based Learning (AM PBL) project is that in order to develop effective curricula NEBHE must partner with advanced manufacturing companies in the development of its six multimedia instructional modules called "Challenges." In



An associate engineer (seated) described the FastCAP Systems problem statement to a summer intern at the company's lab in Boston, Mass.

doing so, the AM PBL project team spends a day with each industry partner's engineering team, touring the advanced manufacturing facility and recording the retelling of how the company identified and solved the Challenge problem. The entire process is photographed and video recorded. Audio from the video recording is used to write the Challenge scripts,

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AM PBL Educator Recruitment Opens October 1, 2013

n October 1, 2013, the New England Board of Higher Education (NEBHE) began recruiting New England secondary and postsecondary in-service STEM educators, as well as teacher education faculty, to participate in the Advanced Manufacturing Problem Based Learning (AM PBL) curriculum and professional development project.

To foster collaboration between secondary and postsecondary institutions, the AM PBL project is recruiting participants in pairs, called Alliances, which are composed of a secondary and a postsecondary partner. The goal of the Alliance model is to support instructors' professional development, build an academic pipeline from high school to college, and cultivate students' aspirations to participate in

STEM and higher education. The application process appears later in this article.

The AM PBL project will develop six authentic multimedia PBL Challenges (case studies) focused on critical areas of advanced manufacturing in collaboration with industry partners across New England. Based on the previously developed STEM PBL and PHOTON PBL Challenge model (see article above), these instructional materials will bring real-world problems solved by companies in advanced manufacturing fields such as aerospace, composite materials, medical devices, nanotechnology, precision measurement and semiconductors into the classroom to promote the development of student problem-solving and critical thinking skills, and to

Educator Recruitment continued on page 3

Teach a Man to Fish: A Guide to Creating PBL Challenges

By Nicholas Massa, Ph.D.

6 6Give a man a fish and he'll eat for a day. Teach him to fish and he'll eat for a lifetime." The same is true for problem-based learning. Over the past six years, NEBHE's PBL Projects have created 14 PBL Challenges in photonics and sustainable technologies and provided professional development in their use to hundreds of STEM educators across the country.

But teaching educators to use existing PBL Challenges only provides limited opportunities for students to engage in real-world problem solving, thus limiting the enormous potential to develop the critical thinking skills desperately needed in the 21st century workplace.

To help teachers move beyond the use of pre-packaged PBL curriculum materials (i.e., giving them the fish), one of the goals of the PBL Projects is to teach educators how to create their own PBL Challenges customized to address the specific needs of their students. Building on the knowledge and experiences gained in creating the 14 PHOTON PBL and STEM PBL Challenges, Co-Principal Investigators Nicholas Massa, professor of laser electro-optics technology at Springfield Technical Community College, Mass., and Judy Donnelly, program coordinator of laser and fiber optic technology at Three Rivers Community College, Conn., created a "PBL Challenge Design Guide," focused on helping teachers identify "good" PBL problems and a template for producing a PBL Challenge that aligns with their specific learning outcomes and assessment requirements.

The guide was initially field-tested in a graduate level Technology and Engineering Education (TEE) course in PBL methods at Central Connecticut State University (CCSU) during the spring of 2012. After completing three PHOTON PBL and STEM PBL Challenges to introduce and acclimatize graduate students to the PBL method, the 22 in-service high school teachers were asked to use the PBL design guide to create their own PBL Challenges.

Teachers worked in teams to research and identify potential problems that would both address the learning outcome requirements for their courses and engage students in meaningful real-world problem solving. One of the Challenges created involved the redesign of the I-95/I-84 interchange in Hartford, Conn., to be used as part of a transportation technology course. Another team of teachers created a PBL Challenge focused on identifying methods and personal strategies for carbon dioxide sequestration to be used in an environmental science course. Another Challenge involved developing strategies for recycling and composting school cafeteria waste for use in the school's greenhouse garden. Yet another challenged students to develop a device or strategy for rescuing dogs stranded on the thin ice of a frozen pond.

Over the past year, the PBL Projects team has conducted a number of PBL professional development recruitment workshops to introduce participants to PBL and to recruit participants for the AM PBL project including: Connecticut Science Center;



AM PBL Co-PI Jim DeLaura discussed a potential Challenge problem with instructors at Kennebec Valley Community College (KVCC) as part of KVCC's new NSF ATE project. The project will use the PBL Challenge Design Guide to create a series of PBL Challenges that will be used to train technicians for Maine's mechanical services industry.

University of Connecticut; Pathways Academy of Technology and Design, Conn.; Rhode Island College; Middletown High School, Conn.; International Technology and Engineering Educators Association, Ohio; EASTCONN, Conn.; EASTEC, Mass.; Keene State College, N.H.; Central Connecticut State University; Massachusetts Association of Vocational Administrators; Southern Regional Education Board, N.C.; Wesleyan University, Conn.; Waterbury Public Schools, Conn.; and the Education and Training in Optics and Photonic conference in Porto, Portugal.

The workshops gave attendees an opportunity to work with the existing PBL Challenges and to learn about the PBL Challenge Design Guide to develop their own Challenges.

The PBL Projects team is also currently working with faculty from Kennebec Valley Community College's Energy Services Technology program on a new NSF ATE project to create a series of PBL Challenges aimed at training a new generation of technicians for Maine's mechanical services industry. Overall, teachers found the PBL Challenge Design Guide extremely helpful in developing their own PBL Challenges. Like their students, teachers were initially apprehensive about the new open-ended instructional format, but once acclimated, questioned whether they would ever go back to the traditional "chalk and talk" method. They have learned to fish!

Please visit the Teachers' Resources page at **www.ampbl.org** to learn more about the PBL Challenge Design Guide.

Nicholas Massa, Ph.D. is a Professor of Laser and Fiber Optic Technology at Springfield Technical Community College and a Co-Principal Investigator of the AM PBL project. He can be reached at massa@stcc.edu.

Educator Recruitment continued from page 1

provide career awareness in advanced manufacturing and other STEM fields. Each Challenge will be aligned to K-12 national Common Core State Standards and industry competencies. To see examples of the previously developed STEM PBL and PHOTON PBL multimedia Challenges, please visit www.pblprojects.org.

The application period, which opens October 1, 2013, includes two separate application forms and deadlines. Application A, due November 1, 2013, is an electronic questionnaire for secondary and postsecondary educators and STEM teacher educators. Application B, due November 22, 2013, requires signatures from the applicant's supervisor as well as information about and signatures from the applicant's proposed Alliance partner. All partnering institutions must submit their own Application forms A and B. Teacher educators are not expected to form an Alliance partnership. Both applications are located at **www.ampbl.org**. Participant slots are limited. Applicants are encouraged to apply early. Notification of selection will take place in December 2013.

Participation in the AM PBL project will include:

- * A comprehensive one-week AM PBL Institute in Boston, summer 2014.
- * Pre-workshop webinars to introduce participants to PBL pedagogy and the PBL Challenges.
- * Field-testing AM PBL Challenges in the classroom.
- * Ongoing technical support and mentoring.
- * An online learning community for participants, PBL practitioners and mentors.
- * A capstone showcase in year three (2015) to disseminate best practices and exchange ideas for future collabortion in PBL.



SAVE THE DATE! AM PBL Summer Institute Boston, Mass., 2014



AM PBL Summer Institute Professional Development Opportunities

Opportunities for Teachers

As a result of taking part in this Institute and the follow-up activities, participants will:

- * Learn how the web-based AM PBL Challenges can be used in the classroom.
- * Be trained in student assessment and PBL evaluation.
- * Learn to design their own PBL Challenges.
- * Gain access to the PBL curriculum materials developed by the AM PBL, PHOTON PBL and STEM PBL projects.
- * Receive stipends for field-testing Challenges.
- * After the Institute, continue to network and share knowledge with fellow project participants in a capstone showcase in 2015.

Opportunities for Teacher Education Faculty

In addition to the above, STEM teacher educators who join in this Institute will learn how to implement/adapt the following courses in teacher education programs:

- * Teaching Technology and Engineering Education, a preservice undergraduate PBL course developed by Central Connecticut State University (CCSU).
- * STEM PBL Applications for Science and Technology Teachers, a graduate course developed by CCSU.

The cost of registration, lodging, transportation and most meals associated with the AM PBL Institute in July 2014 will be provided by the NSF ATE AM PBL project DUE#1204941.

Questions? Please contact Project Coordinator Nicole Schepker for more information at nschepker@nebhe.org or 617-357-9620 ext. 113. ■

Disseminating AM PBL

During the first half of 2013, the AM PBL project team provided a series of introductory recruitment workshops and presentations on problem-based learning (PBL) pedagogy for secondary and postsecondary science, technology, engineering and mathematics (STEM) educators throughout New England. They also presented the work of the PBL Projects in workshops and conference sessions across the United States. The project's workshops and presentations reached more than 300 STEM educators, including middle and high school teachers, college professors, administrators, and other educational professionals.

Top takeaways from the outreach activities as cited by participants included the introduction and access to the projects' resources, such as access to the authentic industry-based multimedia case studies called Challenges and their real-world applications, teachers' resources, assessment strategies, concept mapping tools, and the Whiteboards, a problem-solving tool for students developed by the PBL Projects team. In addition, the implementation strategies for PBL and the opportunity to network and collaborate with STEM instructors from schools, districts and disciplines outside of their own were noted. Participants also said that the workshops provided a better understanding of PBL pedagogy and methodology, the effects of PBL on students' self-directed learning and engagement, and an interdisciplinary approach to teaching and learning.

"I was very impressed with how accessible the activities were. I can imagine high school students engaging at many levels with the topics. Problem-based learning can be relevant no matter who the learner is or at what level they are," said one educator.

"This concept is a great starting point for teaching a grade level theme across disciplines. The workshop is an excellent springboard for introducing staff to performance tasks required by Common Core," a STEM administrator said.

Another workshop participant commented, "PBL allows students an opportunity for collaboration and problem-solving that will develop critical thinking skills, reading and research skills, argumentation and presentation skills. Awesome projects!"



A group of STEM educators discussed possible solutions to a PBL Challenge at an AM PBL workshop hosted at the Society of Manufacturing Engineers' EASTEC Eastern States Exposition in May.

The project's Principal Investigator, Fenna Hanes, Co-Principal Investigators Jim DeLaura, Michele Dischino, Judy Donnelly, Nick Massa and Project Coordinator Nicole Schepker facilitated the following AM PBL workshops and presentations during the spring and summer of 2013:

May 8, 2013 Workshop

Problem Based Learning in the Classroom Using STEM Topics Central Connecticut State University, New Britain, Conn.

May 23, 2013 Conference Session

Problem Based Learning Implementation Strategies for STEM Courses The 48th Annual National Association for Workforce Improvement (NAWI) Conference, Indianapolis, I.N.

June 29, 2013 Workshop

Problem Based Learning in the Classroom Using STEM Topics Central Connecticut State University, New Britain, Conn.

July 19, 2013 Conference Sessions

(I) STEM Problem Based Learning (PBL): An Introduction
(II) Experiencing Problem Based Learning (PBL) as a Student
(III) Designing Your Own Problem Based Learning Case Study
The 27th Annual Southern Regional Education Board's (SREB)
High Schools That Work (HSTW) Conference, Charlotte
Convention Center, Charlotte, N.C.

July 31, 2013 Workshop

Problem Based Learning in the Classroom Using STEM Topics PIMMS Center of Wesleyan University, Middletown, Conn.

August 22, 2013 Workshop

An Introduction to Using STEM PBL Challenges and Methods – A Professional Development Workshop for Secondary Instructors Waterbury Public Schools, Waterbury, Conn.

Previous recruitment workshops are featured in the Spring 2013 edition of AM PBL News. Please check **www.ampbl.org** for details on upcoming professional development opportunities, or contact the AM PBL Project Coordinator (see back cover).



High school STEM instructors engaged in developing their own Challenge at the Southern Regional Education Board's (SREB) High School's That Work (HSTW) conference in July.

PBL Challenge Implementation Video

Teacher and student resources are a key component of the transition from a lecture-based approach to a student-centered approach to teaching and learning, and are therefore a critical part of the PBL Projects. To address this pedagogical transition, NEBHE's STEM PBL project developed a five-minute PBL "How To" video containing a step-by-step description to show instructors how the Challenges are structured and how they can be implemented with students. The video is hosted at **www.pblprojects.org**. However, this video did not show students actually solving a Challenge problem in the classroom.

To address this issue, a 30-minute video, entitled "PBL in the Classroom," was developed featuring Springfield Technical Community College professor and AM PBL Co-Principal Investigator Nick Massa. Massa led a class of high school math and science students from the St. Bernard School in Montville, Conn., through a Challenge. The students, who were used to learning in the traditional lecture-based format, had no experience with PBL prior to participating in the video.

The students were instructed in the use of the Challenge "Whiteboards," a tool that guides students step-by-step through the problem-solving process. The Whiteboards help students to capture and reflect upon their current state of understanding, thought processes, and problem-solving strategies. The video also shows the students presenting their solutions. In addition, Professor Massa provided the students with information on how their learning would be assessed. The video will be available at www.ampbl.org.

The students' teacher, Matthew Donnelly, was interested in having his students participate in this video for two reasons. First, he wanted them to experience real-world applications for the math topics they had learned in class, since his students' most frequent complaint was that they don't understand how math is applied. Second, he wanted his students to experience a manner of education other than lecturing.

Both goals were met and exceeded. Several students requested that Donnelly start using PBL in his classes. The biggest lesson he said he learned was that when using PBL, a teacher has to focus on asking the right questions of students (somewhat akin to the Socratic method) in order to guide students to where they need to go without simply telling them.

This year he will implement PBL in his pre-calculus classes (he teaches three sections). Donnelly also plans to use the PBL Challenges as quarterly projects, and to create some of his own Challenges using the "PBL Challenge Design Guide" draft template that will be introduced to AM PBL participants during the summer 2014 professional development workshop (see page 2 for details on the draft template).



Nick Massa, AM PBL Co-PI and a professor at Springfield Technical Community College, leads a group of high school students in a structured PBL Challenge at the St. Bernard School in Montville, Conn.

The PBL Curriculum Redesign Project for Differentiated Instruction

n July, AM PBL Co-Principal Investigators Jim DeLaura and Judy Donnelly led five middle school science teachers from Connecticut in a four-day pilot project entitled the "Problem Based Learning (PBL) Curriculum Redesign Project" at the University of Connecticut's Neag School of Education. The teachers modified existing PBL instructional materials for use in middle schools and differentiated learning environments that provide students with different avenues to acquiring content knowledge. The PBL Curriculum Redesign Project was designed to help retain students' interest in STEM education from an earlier age, while infusing problem-solving and critical thinking skills into both middle grades and differentiated STEM curricula.

The science teachers made revisions to the Teachers' Resources and assessment tools, as well as to the additional resources specific to the STEM PBL FloDesign and Tookany/Takony Frankford (TTF) Watershed Partnership Challenges, focused on wind power and storm water management, respectively. Both Challenges were aligned to middle school science curricula and standards in Connecticut. These revisions will be incorporated into the Teachers' Resources and Additional Resources sections of those Challenges.

The teachers also revised the student Problem Solving Toolbox, adding new components to the Whiteboards such as a "Share" directive that incorporates team sharing throughout the Challenge process, a drawing component, a solution revision process and a scoring rubric. A stipend was given to participating instructors upon completion of the curriculum revisions.

Curriculum modifications to the Teachers' Resources, assessment tools, and Problem Solving Toolbox will be available at **www.pblprojects.org**.

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and photos and videos are integrated into the multimedia modules that will be available on the web. The project's industry partners provide support materials that will help teachers and their students find solutions to the Challenge problems.

In May 2013, the AM PBL project team traveled to IBM's advanced semiconductor manufacturing facility in Essex Junction, Vt., to record the first Challenge. IBM identified a problem with its semiconductor manufacturing process. A process designed to uniformly etch a film on a substrate was intermittently resulting in a localized area at the edge being significantly under-etched. This was causing expensive delays in production.

Dale Miller, semiconductor manufacturing & operations director of the Microelectronics Division stated, "IBM's future depends on highly skilled workers, including both technicians and engineers. We fully support programs like AM PBL and are eager to do our part to ensure a well-prepared workforce."

"If we can hire graduates with strong problem-solving skills," said Stewart Foster of IBM's Fab Lean Core Team, "they can help us get to the root cause of the problem so it won't reoccur."

Miller and Foster are featured in a brief video recorded during the visit that shares their experiences developing their careers in advanced manufacturing.



Stewart Foster (standing) discussed IBM's problem statement with team members at the company's semiconductor manufacturing facility in South Burlington, Vt.



Sound Manufacturing's President and CEO Kelli Vallieres (far left), led her team in a reenactment of the problem statement at the company's sheet metal manufacturing facility in Old Saybrook, Conn.

In August, the AM PBL team collaborated with Boston, Mass., advanced manufacturer FastCAP Systems to record the second Challenge. FastCAP is an energy company that makes a novel type of energy storage device called an ultracapacitor. FastCAP has broken four performance records related to the power and energy density of its cells and has achieved a world record related to its work in geothermal energy system development.

FastCAP ultracapacitors incorporate nanotechnology, specifically carbon nanotubes (CNTs), as an internal component. Growth of CNTs require use of a technique called "sputtering" – where a thin film of metal is sprayed onto a surface. In its research of new sputtering techniques and processes, FastCAP found that it was unable to spray a perfectly uniform and smooth thin film layer onto its substrate materials. Instead, the thin film bunched into clusters. This problem impacted FastCAP's ability to grow carbon nanotubes with the characteristics that it wanted.

This young entrepreneurial company demonstrated quite dramatically the diversity of skills and backgrounds necessary in today's advanced manufacturing workforce. The project team that worked on this problem consisted of a Ph.D. scientist and an engineer, both educated abroad, as well as a young graduate with an associate degree in engineering technology, and a second-year summer intern who started with FastCAP in his junior year of high school, and who is entering college this fall.

Teamwork and diversity of skill levels are essential in the advanced manufacturing workplace. A short video featuring the FastCAP team as well as Director of Operations and attorney Jamie Beard will be included in the Challenge's additional resources section.

The third Challenge was recorded in September at Sound Manufacturing in Old Saybrook, Conn. Sound Manufacturing, established in 1984, is an ISO 9001:2008 certified precision sheet metal contract manufacturer, offering an innovative array of technical capabilities and expertise to service commercial and industrial sheet metal applications.

Sound Manufacturing's Challenge involved the fabrication of a new telecommunications patch panel for a customer of over 20 years. In order to double capacity, the customer recently designed a panel with many more connectors in the same space, resulting in less material between the openings while the tolerance on the cut outs needed to remain the same. Can metal be cut and bent beyond existing metal and machine standards without increasing the fall out rate?

The company also illustrates other changes in the advanced manufacturing workplace. President and CEO, Kelli Vallieres, holds a Ph.D. in Education from the University of Connecticut. Her understanding of adult experiential learning has enabled her to innovate and expand business in spite of the recent economic downturn. A video of her thoughts on the changing workplace will also be included in the Challenge resource materials.

All videos will be accessible at **www.pblprojects.org**.

NEBHE's Developmental Math Demonstration Project (DMDP)

ast fall, the New England Board of Higher Education was awarded a three-year, \$356,200 grant from the Lumina Foundation to support a new project—the Developmental Math Demonstration Project (DMDP). Through DMDP, NEBHE supports community colleges across the region in investigating the impact of Khan Academy materials in developmental and gateway math courses as well as in math placement test preparation. Community college DMDP sites are located in five of the six New England states.

This project comes at a crucial time for community colleges. NEBHE estimates that between 50% and 70% of all incoming community college students in New England lack college-level math skills and are required to take one or more remedial courses. While many institutions across the region have implemented developmental math reforms, DMDP aims to further these efforts across New England colleges. This will be accomplished through leveraging Khan Academy's free, online math content (conceptual videos, practice exercises and an adaptive assessment environment) for use by community college faculty and students in conjunction with NEBHE-led research efforts demonstrating Khan Academy's impact on student performance.

Participating community colleges plan to integrate Khan Academy into placement test preparation courses, traditional developmental math courses, and gateway technical courses.

Delivery models include modular-based instruction, online instruction, and flipped classroom methods. In summer 2013, participating colleges piloted Khan Academy in "Jump Start" programs designed to prepare students for taking the Accuplacer placement test.

Although most of Khan Academy's work to date has focused exclusively on K-12 schools, this project marks the beginning of the organization's shift to better serve students in postsecondary education. DMDP will also support better understanding of how no-cost open educational resources might impact and accelerate college student learning.

More information about the project, including project resources and an alignment of Khan Academy materials with the Accuplacer Exam and Common Core State Standards, may be found at **www.nebhe.org/devmath**.

Please address questions and comments to Stafford Peat, project director, at speat@nebhe.org.

PBL Challenges Aligned to Khan Academy Mathematics Resources

Math skills are critical to today's technologically intensive workplace and key to the design and implementation of advanced manufacturing processes. Yet, as stated in the DMDP article, NEBHE estimates that between 50% and 70% of all incoming community college students in New England will need one or more developmental math courses.

NEBHE's PBL Projects Program, which consists of the National Science Foundation-funded PHOTON PBL, STEM PBL and now AM PBL projects, recognized an opportunity with the start of the DMDP project to help close the math gap with its multimedia PBL Challenges, which contain many math concepts. Consequently, the 14 existing PBL Challenges have been aligned to the Khan Academy modules as well as other online math practice sets to support students whose math skills need reinforcing. The alignment documents are being added to the Challenges at **www.pblprojects.org**. The AM PBL Challenges will also be aligned to the online math materials.

The PHOTON PBL Challenges		The STEM PBL Challenges	
Real-World Application	Industry Partner	Real-World Application	Industry Partner
Laser Safety	International Laser Display Association	Green Chemistry	Johnson & Johnson
Precision Laser Micromachining	PhotoMachining, Inc.	Lighting Design	RSL Fiber Systems
DNA Testing	Boston University Photonics Center	Solar Power	SPG Solar/City of Tucson
Manufacture of High Power Lasers	IPG Photonics	Stormwater Management	TTF Watershed Partnership
Phototherapy	Drexel University, Southern Methodist University, Photodigm Onsite Neonatal Partners	Sustainable Agriculture	Cape Cod Cranberry Growers' Association
Energy Conservation/Lighting	California State Polytechnic University at Pomona	Wind Power	FloDesign
Non-contact Precision Measurement	McKay Orthopaedic Research Laboratory, University of Pennsylvania	For more information on the STEM PBL and PHOTON PBL Challenges, please contact PBL Projects Coordinator, Nicole Schepker, at 617-357-9620 x 113 or <u>nschepker@nebhe.org</u> .	
Thermal Imaging	Penn State Electro- Optic Center		

Please visit **www.pblprojects.org** to view the STEM PBL and PHOTON PBL Challenges, and **www.photonprojects.org** to learn more about the AM PBL, STEM PBL and PHOTON PBL projects of the New England Board of Higher Education.

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