Science • Technology • Engineering • Math

STEM Problem Based Learning for sustainable technology NEWS

A Project of the New England Board of Higher Education (NEBHE)

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STEM 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.stempbl.org

Program Staff:

Fenna Hanes
Project Principal Investigator
Sr. Director, Professional & Resource Development
617-357-9620 ext. 129
fhanes@nebhe.org

Nicole Schepker
Newsletter Editor & Project Assistant
617-357-9620 ext. 113
nschepker@nebhe.org

NEBHE
45 Temple Place
Boston, MA 02111 USA

NEW ENGLAND BOARD OF HIGHER EDUCATION

Challenge Partners Collaborate to Develop Challenges

The STEM PBL project has created six multimedia Challenges in collaboration with industry partners. The Challenges are based on real-world problems linked to STEM course content, similar to a case study. They are designed to develop students' problem solving and critical thinking skills to prepare them for today's high technology workplace.

Through video re-enactment of problem situations recorded on location in industry and research organizations, the STEM PBL Challenges actively engage students in the problem-solving process by virtually "inserting" them into the environment in which the problem is to be solved. This is a major departure from traditional lecture-based instruction where end-of chapter problems with well-defined parameters produce artificial and uninteresting solutions.

Group at Soaring Heights' solar ground array located at Davis-Monthan Air Force Base. Pictured: Jim Switzer, Soaring Heights Communities; Sara Hummel-Rajca, solar outreach coordinator for Congresswoman Gabrielle Giffords; Nicholas Massa, Springfield Technical Community College; Judith Donnelly, Three Rivers Community College; Bob Breault, Breault Research Organization and Arizona Optics Industry Association; John Karelis, Soaring Heights Communities; Fenna Hanes, NEBHE; Chien-Wei Han, Pima Community College.

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STEM PBL Instructors Field-test Challenges

Emphasizing sustainability, STEM PBL Challenges introduce high school, community college, and university students to STEM fields through problem based learning initiatives. Instructors can choose from three approaches to PBL: *structured* (entirely instructor-led), *guided* (moderately structured), or *open-ended* (instructor as consultant).

Project participants are expected to field-test two or more of the six STEM PBL or eight PHOTON Challenges that were developed during the PHOTON PBL project (2006 – 2009). Field-testing requires instructors to respond to a survey and write a narrative describing the field-testing experience. Students are also asked to complete a survey outlining their experiences with PBL. The instructors receive a stipend for providing this information to the project team. The feedback is analyzed and synthesized into reports to the funder, the Advanced Technological Education (ATE) program of the National Science Foundation (NSF), and disseminated in journal articles and conference presentations illustrating the value and challenges of PBL.

During fall 2010, four of the six STEM PBL Challenges were field-tested in four high schools and one university. Field-testing will continue during the spring of 2011 and the 2011-2012 academic year. All PBL Challenges will be available at **www.pblprojects.org** upon testing completion. The following case studies come from schools across the country that field-tested Challenges.

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Assessing Student Learning in PBL

By Nicholas Massa, PhD

A good problem solver is someone who can approach any problem and systematically dissect, analyze, and formulate a coherent and viable solution strategy. Good problem solvers are patient and methodical, carefully considering all options before moving forward toward a solution. They break complex problems down into smaller, more manageable steps, making reasoned decisions on how to approach each step. Good problem solvers use metacognitive strategies to manage the problem-solving process by planning, monitoring, and evaluating their progress and strategies during problem solving, and adjusting their approach when necessary.

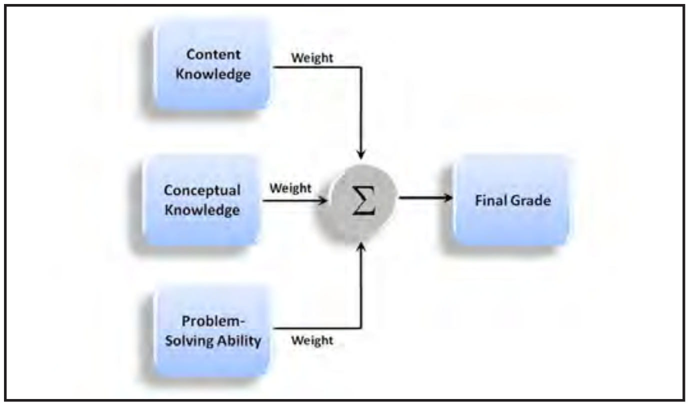
In problem-based learning (PBL), student learning is centered on solving authentic real-world problems that are inherently ill-defined with multiple possible solutions—problems that demand the use of higher order thinking skills and the ability to "think outside the box." The goal of PBL is to help learners develop the capacity to skillfully apply content and conceptual knowledge in solving complex problems in new and novel situations.

Assessing student performance in PBL, however, presents a unique challenge for educators accustomed to traditional assessment methods such as performance on homework, quizzes, exams and "cookbook" style laboratory activities. While these methods represent a convenient and effective way to measure students' content knowledge and ability to solve well-defined end of chapter problems, they do not adequately capture higher order thinking skills such as the ability to organize knowledge and understanding around key concepts and principles and synthesize knowledge in a way that creates new meaning. Assessing student learning in PBL requires authentic measures that capture not only content and conceptual knowledge, but also problem-solving ability, the process that students use in solving problems.

Based in part on the adaptive expertise model developed by the Vanderbilt-Northwestern-Texas-Harvard-MIT (VaNTH) Engineering Research Center, the STEM PBL approach for assessing student learning includes three separate measures: *content knowledge*, *conceptual knowledge*, and *problem-solving ability*. Student learning and performance on a PBL activity is determined through the summation of these three measures in which specific weights can be assigned by the instructor. This model, developed and field-tested during NEBHE's previous PHOTON PBL project, is illustrated at right.

Content knowledge refers to a student's understanding of key facts and principles within a specific domain of knowledge. To assess students' content knowledge, each PBL Challenge includes a test bank consisting of multiple-choice questions, closed-ended problems, and higher level thought-provoking questions centered on the specific technical content associated with the Challenge.

Conceptual knowledge refers to a student's understanding of the relationship between key concepts within a particular domain of knowledge and is assessed through concept mapping. Concept maps consist of groupings of circles labeled with key concepts, connected with lines and arrows labeled in a way that describes the relationship between concepts. Each pair of linked concepts produces a proposition that represents a measure of a student's understanding of the relationship between two or more concepts. Scoring is usually based on the number of connections formed and the quality and validity of the propositions generated. Each PBL Challenge contains a Teacher Resources section that includes a list of main concepts related to the Challenge topic, a "reference" concept map for instructors, detailed instructions on how to construct a concept map, and a concept map scoring rubric.



Student Assessment in PBL

Problem-solving ability is assessed through the Final Challenge Report, a reflective journal in which students reflect upon and provide a detailed summary of the problem-solving process in which they have engaged. As students work collaboratively to solve a problem, they complete four Whiteboards, a tool that guides them through the problem-solving process, helping them to reflect upon and capture their current state of understanding, thought processes, and problem-solving strategies. Research shows that verbalizing the thought process while engaging in problem-solving is essential for effective problem-solving and understanding. Upon completion of the PBL Challenge, students complete the Final Challenge Report, which represents a synthesis of the knowledge, skills, and strategies employed in solving the PBL Challenge. Researchers maintain that this final reflective exercise is essential in the development of effective problem-solving skills. A scoring rubric is used to grade the Final Challenge Report.

In short, the goal of the STEM PBL project is to produce strategic problem solvers who not only have gained content knowledge in sustainable technologies but who also have internalized skills and knowledge to apply to the process of problem-solving.

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

Introduction to Green Chemistry

Green chemistry is a revolutionary approach to the way that products are made; it is a science that aims to reduce or eliminate the use and/or generation of hazardous substances in the design phase of materials development. It requires an inventive and interdisciplinary view of material and product design. Green chemistry follows the principle that it is better to consider waste prevention options during the design and development phase than to dispose or treat waste after a process or material has been developed.

For a technology to be considered "Green Chemistry," it must accomplish three things:

- It must be more environmentally benign than existing alternatives.
- It must be more economically viable than existing alternatives.
- It must be functionally equivalent to or outperform existing alternatives.

Green chemistry presents industries with incredible opportunities for growth and competitive advantage. This is because there is currently a significant shortage of green technologies: we estimate that only 10% of current technologies are environmentally benign; another 25% could be made benign with known alternatives. The remaining 65% have yet to be invented! Green chemistry also creates cost savings: when hazardous materials are removed from materials and processes, all hazard-related costs are also removed, such as those associated with handling, transportation, disposal, and compliance.

Through green chemistry, environmentally benign alternatives to current materials and technologies can be systematically introduced across all types of manufacturing to promote a more environmentally and economically sustainable future.

The Twelve Principles of Green Chemistry

1. Pollution Prevention
2. Atom Economy
3. Less Hazardous Synthesis
4. Design Safer Chemicals
5. Safer Solvents and Auxiliaries
6. Design for Energy Efficiency
7. Use of Renewable Feedstocks
8. Reduce Derivatives
9. Catalysis
10. Design for Degradation
11. Real-Time Analysis for Pollution Prevention
12. Inherently Safer Chemistry for Accident Prevention

Courtesy of the Warner Babcock Institute for Green Chemistry, LLC. For more information go to: http://www.warnerbabcock.com/ ■

New Challenges continued from page1

Using video, Internet, print, technical and problem-solving resources, each Challenge includes the following segments:

1. A general overview of the STEM area of the Challenge to set the context for the problem.
2. An introduction to the industry or research organizations where the problem was solved.
3. A realistic presentation of the problem; for example, at a company meeting or through a customer request.
4. A brainstorming session by engineers, scientists and technicians at the partners' site that provides technical hints for the problem's solution.
5. The organization's own solution, which students can compare and contrast with their own.

Each Challenge also includes an innovative "Problem Solver's Toolbox" and additional "Teacher Resources." Four of the Challenges and their corresponding Challenge partners were described in the Fall 2010 issue of this newsletter. Below are reports on the final two Challenges.

City of Tucson

Tucson, AZ, located in sunny Pima County, has been steadily expanding its solar energy resources. As one of 25 Solar America Cities, Tucson is committed to improving the energy efficiency of city buildings and operations and to increasing the city's use of solar energy.

On September 24, 2010, STEM PBL Principal Investigators (PIs) Judy Donnelly, Fenna Hanes and Nick Massa visited Tucson to record the solar power Challenge and tour the site where the Challenge's subject is installed. The PIs met Bruce Plenk, Tucson city solar energy coordinator; Tim Christman, western regional coordinator for SPG Solar in Novato, CA; and Chien-Wei Han, an instructor and developer of Photovoltaic programs at Pima Community College (http://www.pima.edu/program/).

Thanks to PHOTON Project's Advisory Board member Bob Breault, founder of Breault Research in Tucson, the PIs were able to learn more about the city's solar activities. Breault arranged a tour of Solon, a leading solar panel manufacturer, and Tucson Electric's experimental solar power research facility. With the assistance of Congresswoman Gabrielle Giffords, he also organized a tour of Davis Monthan Air Force Base, home to one of the largest solar farms in the country.

THE CHALLENGE

The city of Tucson has identified a city building for installation of solar panels. The SPG Solar engineers have determined that this building's roof structure cannot support the traditional solar panels that are being placed on other buildings around the city. It's an older building and wasn't constructed with modern techniques. The challenge is to build a secure, productive solar system that produces at least 47 KW DC.

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Field-testing continued from page 1

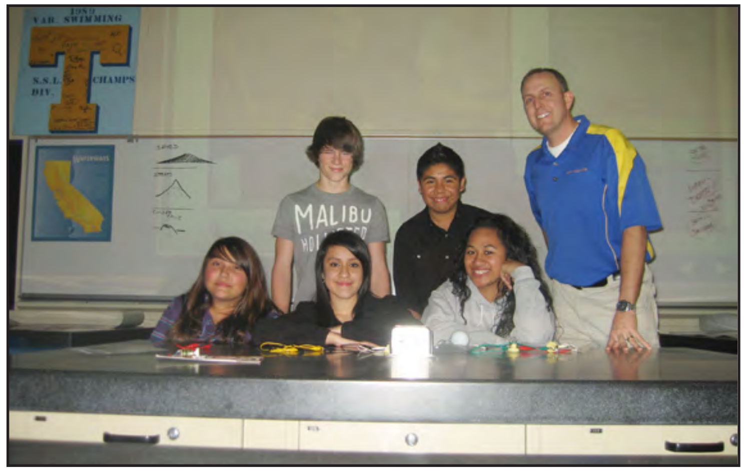
Taft Union High School, CA

After attending NEBHE's summer workshop held in Boston in 2010, Nathan Usrey, an integrated science teacher at Taft Union High School in Taft, CA, introduced a class of 15 ninth-graders to the Tookany/Tacony-Frankford (TTF) Watershed Partnership Challenge using the *structured* level of instruction, implementing PBL in his classroom for the first time. Usrey, like many teachers, found it difficult to find the time to fit the Challenge into his state-mandated curriculum.

In the fall, students worked on the TTF Watershed Challenge daily during the last 15 minutes of their integrated science class, with extra help offered during lunch and after school. Usrey found that students struggled to find relevant information related to the site's geographic location (Philadelphia, PA). In addition to needing time to acclimate to the PBL format, students also had difficulty preparing final technical reports and delegating workloads to one another. With guidance, however, Usrey found that success rates easily improved. For instance, when Usrey encouraged students to identify specific questions that needed to be answered, the students were better prepared for class discussion the following day. Usrey also found that students who took advantage of extra help opportunities had a greater rate of success in completing the Challenge. What Usrey hopes to teach his students is how to ask the right questions, not just for the Challenges, but also in real life.

Students used the local water district, Internet, classroom, and library as resources and were assessed based on their final presentations, technical reports, and team participation. Group participation was assessed by student feedback and peer review.

Based on his experience during the fall, Usrey made some adaptations to his implementation model for the winter term. To address classroom time constraints, he scheduled a special



Field-testing Watts My Light at Taft Union High School. L to R: (standing) Christian Hoffman, Carlos Santiago, and Instructor Nathan Usrey; (seated) Johndee Butler, Roxanna Barboza, and Tuttiana Tauta.

teaching segment called "STEM Time." Students are currently working on their second Challenge, the Watt's My Light Challenge. Because students now have some PBL experience, the second Challenge is being taught at the *guided* level. They are split into groups of four to engage in Whiteboard work (see page 2), discussion, and question development before beginning research and development that will solve the PBL Challenge question. To conserve time, the Challenges, which he conducts over a two-to-three-week period, are now given dedicated class time on Tuesdays and Thursdays during the last 15 minutes of class. Students are strongly encouraged to meet three times outside of class during the extra help hour and are given a full class period to execute their final designs before Challenge completion. At the end of the Challenge, students will verbally present their results and personal contributions to the class.

In the spring, Usrey intends to finish out the year with an *open-ended* Challenge, with plans of eventually "certifying" students with an award for their participation and issuing a prize to the most outstanding achievers.

"I have developed STEM Time as a para-educational personal case study to evaluate whether this model is an equivalent, or even superior alternative, to traditional teaching methods. Getting kids to be problem-solvers is the main focus right now. To expose them to STEM PBL, see how they respond, and reward the ones who really make it run," said Usrey of his goal.

Usrey intends to implement STEM Time in his classroom again next year, with hopes of introducing his own Challenges at that time. Currently, he is the only teacher utilizing STEM Time at Taft Union. In an effort to disseminate PBL, Usrey has invited teachers from every discipline to observe STEM Time in his class so they can get a feel for student participation.

"Teachers have been very impressed with the organized Whiteboard approach to the solving of problems," Usrey noted.

It is not uncommon for teachers who observed Usrey's class to relate the method to their own curriculum. One idea was to use PBL in "social experimentation" projects in a history class.

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Field-testing continued from page 4

And how is STEM Time impacting students? Katie Burrows said she "felt like an actual scientist instead of just a student in high school," while J. Martinez had "never been challenged like this before," and Mary Hazlewood learned "if I want to find things out, I can do it by myself."

Longview High School & LeTourneau University, TX

To foster collaboration between secondary and postsecondary institutions, the STEM PBL project recruited participants as partners, called an Alliance. The goal of the Alliance model is to support instructor professional development, build an academic pipeline from high school to college, and foster students' aspirations to participate in higher education. The following field-testing case study describes one Alliance experience.

In Longview, TX, students from Longview High School worked alongside engineering students at LeTourneau University to test two STEM PBL Challenges: Flo Design and RSL Fiber Systems. The Challenges were offered as a supplemental after-school activity for high school students by instructor Charles Mosley and as an in-class activity for college engineering students by Assistant Professor of Electrical Engineering Oscar Ortiz.

Mosley, instructor of Digital Electronics and Principles of Engineering—a part of Project Lead the Way, a national engineering program offered at high schools across the U.S.—offered his students a half-credit towards Problems and Solutions, a science and engineering research course, for their participation in the Challenge. Mosley connected his participating students with Ortiz's students for two hours once a week after school, with the instructors alternating campuses over six weeks.

Led by Professor Ortiz, university students were required to complete a PBL project of either NEBHE's or the university's design for 20% of their grade. Eight of 27 students opted to work on NEBHE's Flo Design and RSL Fiber Systems Challenges for the assignment. Students were instructed that working on a STEM PBL Challenge would require them to partner with Mosley's high school students.

Adam Sarhage (L) and Matt Larson of LeTourneau University present on the Flo Design Challenge.

A student prototype for the RSL Fiber Systems Challenge from Long View High School and LeTourneau University.

Although this was the first time the students were introduced to PBL, the group was asked to solve the Challenge using the *open-ended* approach, eliciting an array of possible solutions that many found daunting. In the end, however, students attributed the format to being one of the most valuable parts of the experience, teaching them how to sift through and test multiple solutions.

The 14 participating students (six from high school and eight from college) were split into four groups and asked to design, build and test a solution. The students spent four weeks working on Whiteboards and two on implementation and prototype preparation, using their teachers and the electronic and computer labs as resources. Based on these results, they prepared a technical report and PowerPoint presentation that they presented to the class. Students were assessed based on these assignments.

Ortiz noticed an eagerness among his college students to coach the high school students throughout the process, leading them in groups and eliciting participation. Students from Longview High School, in turn, were particularly energized by the opportunity to work with college students, raising their own aspirations to attend college. Learning to build a model prototype was another highlight for Mosley's students.

"It let me get a taste of college and independent research," said Andrew O'Connor, one of Moseley's high school students.

"Any topic would be nice to explore in [a] Challenge format. It is interesting and different," said Bee Gee Kavoossi, another student from Longview High. "I learned key aspects about energy conversions, mechanical advantage calculations, and energy storage methods, which before I didn't know anything about."

For Ortiz, whose university requires PBL be present in a students' final grade, implementing PBL in his classroom will remain a constant. At Longview High, however, where Mosley must complete his Project Lead the Way curriculum, STEM PBL will remain an after-school activity.

To access the Challenges, go to **www.pblprojects.org.** ■

New Challenges continued from page 3

Personal Care Products

Focusing on green chemistry, the STEM PBL project collaborated with Johnson & Johnson (J&J) to develop a personal care product Challenge. Johnson & Johnson was founded in 1886 and incorporated in 1887. It was a family owned business until 1944, when it was listed on the New York Stock Exchange (NYSE) under the symbol JNJ.

Today, J&J comprises more than 250 operating companies in 57 countries divided into three business segments: consumer, medical devices and diagnostics, and pharmaceuticals. It employs approximately 114,000 people. The company engages in research and development, manufacture and sales of a broad range of products in the healthcare field. Worldwide sales in 2009 were $61.9 billion, while total investment in research and development was $7 billion.

The consumer products segment includes a broad range of health and personal care products in the beauty, baby, oral care, over-the-counter medicines, nutritionals and women's health categories, as well as in wellness and prevention.

In January 2011, PIs Donnelly, Hanes and Massa traveled to J&J's Skillman, NJ facility to record the Personal Care Products Challenge thanks to introductions made by the Warner-Babcock Green Chemistry Institute, its non-profit arm, the Beyond Benign Foundation, and the U.S. Environmental Protection Agency (EPA).

L to R: J&J Challenge partners Glenn Nystrand, Frank Liebel, Susan Nettesheim, Vanita Srinivasan and Sunny Chen discuss the green chemistry Challenge at J&J's Skillman facility in NJ.

THE CHALLENGE

Eczema is a painful skin condition that affects numerous people across age groups. Patients who suffer from this condition have dry, sensitive, itchy, scaly skin on various parts of their body, affecting daily life. Left untreated and unattended, it can lead to serious infection and other complications. Regular cleansing and skin care products are not suitable for eczema sufferers due to the sensitivity induced by the condition. The challenge is to develop skin care products that will be safe for eczema sufferers yet meet their daily cleansing and skin protection needs without using steroids as active ingredients in formulations. ■

New England Green Chemistry Networking Forum at MIT

Overlooking the Boston skyline and pristine Charles River, once one of the country's most polluted waterways, green chemistry leaders and advocates joined together in the first New England Green Chemistry Networking Forum at MIT in Cambridge, MA on December 16, 2010. The forum was hosted by Curt Spalding, the U.S. EPA's region I New England regional administrator, and Paul Anastas, assistant administrator for the EPA's Office of Research and Development, in partnership with the non-profit organization Beyond Benign, a Warner Babcock Foundation. Approximately 300 green chemistry leaders from education, government, industry, investment and development, healthcare, advocacy, and non-governmental organizations were in attendance. The New England Board of Higher Education joined the conference as a presenter.

After a morning of networking followed by roundtable discussions, PI Fenna Hanes and Project Assistant Nicole Schepker attended an education focus group led by Beyond Benign Executive Director Amy Cannon for a discussion on the future of green chemistry in education. John C. Warner, president and CEO of the Warner-Babcock Institute for Green Chemistry, also joined the discussion emphasizing green chemistry's role in achieving sustainable chemistry. The goal, according to Warner, is to integrate green chemistry so completely into the sciences that the term green chemistry is one day obsolete (see Introduction to Green Chemistry, page 3).

STEM PBL PI Fenna Hanes (L) and Robert C. Howard, Principal, Weeset Advisors, Orleans, MA, at the Green Chemistry Networking Forum.

During the education focus group, participants discussed new ideas and existing barriers to integrating green chemistry into curricula. Several attendees expressed interest in developing workshops that bridge high school, undergraduate and graduate level educators to engage in green chemistry discussions and to create green chemistry models for dissemination. The group also discussed the need for job placement resources, the addition of green chemistry questions to standardized tests, and a desire to collaborate with industry groups. ■

Developing the TTF Watershed Challenge Calculations

Donald Gerwick is not a STEM PBL project participant but he is an assistant professor of civil engineering and teaches a Water Resources course at Three Rivers Community College (TRCC) in Connecticut, the home institution of Co-PI Judy Donnelly. The course is required in the Civil and Environmental Engineering Technology Associate degree programs.

After hearing about Donnelly's involvement with the STEM PBL project, Gerwick talked with her about developing and testing calculations for solving the TTF Watershed Challenge. This Challenge focuses on stormwater systems in an urban neighborhood that is part of the Tookany/Tacony-Frankford watershed district in Philadelphia, PA. An outdated pipe system blends stormwater and sewage refuse during heavy rainfall, dumping raw sewage into urban streams. Solving the Challenge requires developing and testing a series of calculations.

L to R: Civil and environmental engineering students Melissa Maciag, Evan LeBras, Ryan Desmarais, and Jill Brewer working on the TTF Watershed Challenge calculations.

college ready new england
a nebhe initiative

Continuing with the work of NEBHE's College Ready New England (CRNE) program, the New England 2025 initiative, in conjunction with the Lumina Foundation, employs a systematic and data-driven examination of postsecondary degree production in each of the New England states. Its goal is to achieve a significant increase in college attainment by the year 2025.

- Identify realistic, contextualized state goals for increased degree production.
- Provide support and assistance for state-based work on policies, programs and other change levers.
- Help states implement advanced data-mining and analysis techniques.

For more information, contact:
Matthew Crellin, Director of Policy and Research
mcrellin@nebhe.org • 617-357-9620 ext. 130

The class, largely comprised of second year students from each TRCC engineering program, was offered a chance to participate in the Challenge for extra credit during a "common hour" outside of class time. Out of 20 students, four to six participated in each of six common hour sessions during the second half of the fall 2010 semester.

In preparation for teaching the Challenge, Gerwick prepared plots of the watershed plans for students to pore over during their meetings, assessing what was proposed and what needed to be done. Since Gerwick is an expert on stormwater science and technology, Professor Donnelly asked Gerwick to assist her in writing the teachers' guide for the Challenge—a teachers' guide is produced for every STEM PBL Challenge. As Gerwick became more involved with the Challenge, he was inspired to write the entire teachers' guide, which includes a comprehensive description of the stormwater cycle, the impact of modern society, basic math concepts, and how to develop the calculations.

Gerwick's main goal was to get students to see how calculations are actually applied: to understand how to look at a site, think about the needs, develop calculations, and determine their audience. Developing the formula may be the easiest part of the equation, argued Gerwick, but diagnosing and dissecting a problem, producing a solution, and achieving results—these are questions that students must be able to answer upon entering the workforce. To that end, Gerwick encouraged his students to add PBL to their resumes, reporting that a student had recently emailed him requesting the course specifics to do just that.

"Students were very enthusiastic about working on this Challenge," said Gerwick, adding that it helped instill interest and excitement in class material.

"I also look at it in a rather devious manner," Gerwick added. "In the private sector I can influence one or two people at a time. But at TRCC, I can influence dozens of people in my Water Resource class…Some of [these students] are going to be in decision-making positions five, 10 years down the road. Some will be part of the design community, some will be part of the regulatory community, and both need to be going in the same direction. As far as I'm concerned you can't get enough of this into your course content. It is invaluable and should not be ignored."

Gerwick believes that the technology department at TRCC is open to adding projects of this nature to the program. After seeing the value that PBL brought to his course, in the future, Gerwick would like to test a Challenge during class time and include a final paper. "I would be happy to be an advocate for PBL," he said. ■

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ATE Principal Investigators Conference

From October 27-29, 2010, STEM PBL PI's Fenna Hanes and Nick Massa attended the 2010 National Science Foundation's ATE (Advanced Technological Education) Principal Investigator's Conference, "ATE Student Success: Building a Diverse and Entrepreneurial Workforce," in Washington, D.C. Hosted by the American Association of Community Colleges, the conference included three "showcase" sessions, numerous concurrent sessions, and round table "birds of a feather" discussion groups surrounding specific disciplines. Hanes and Massa hosted a showcase display describing the STEM PBL project and a round table discussion on problem-based learning.

The conference featured guest speakers including Dr. Freeman A. Hrabowski III president of the University of Maryland, Baltimore County; Charles Fadel, global education research lead, CISCO Systems; and Ann Higdon, president and founder of Improved Solutions for Urban Systems (ISUS).

ATE students highlighted their programs of study or career paths related to STEM, emphasizing the importance of building a diverse and entrepreneurial workforce. ■

STEM PBL Co-PI Nick Massa (R) talking with Department Chair of Biotechnology Linnea Fletcher, Austin Community College.