

**STEM PBL  
Implementation Stories  
Fall 2010 – Fall 2011**

## Introduction

The STEM (Science, Technology, Engineering, Mathematics) PBL (Problem Based Learning) project has developed a series of six multimedia problem-based learning case studies called “Challenges,” with a focus on sustainable technologies. The project introduced high school and college instructors from across the country to the Challenges using professional development activities. NEBHE's previous PHOTON PBL project developed eight Challenges that focused on optics and photonics. Both the STEM PBL and PHOTON PBL Challenges are located at <http://www.pblprojects.org>.

The goal of both projects is to increase the number of college and job-ready STEM graduates by engaging high school and college students with stimulating learning materials and innovative teaching methods. Using the Challenges, students are prepared for the real world by working in teams to solve an authentic industry technological workplace problem where multiple solutions are possible. The instructor facilitates and acts as a consultant as students learn to balance technological issues, and budget and time constraints while devising and testing their solutions.

Instructional resources provided for students include scripts to the multimedia modules, technical background, and a series of questions called Whiteboards — tools that guide students through the problem solving process. Teachers are provided an implementation manual, how-to video, technical background, assessment strategies and standard alignment.

The Challenges can be implemented at three levels of difficulty (Structured, Guided and Open) depending on the students' level of content knowledge and their familiarity with STEM concepts and problem-based learning.

During the 2010 – 2011 academic year, STEM PBL instructors field-tested five different STEM PBL Challenges. Students field-testing the Challenges presented their solutions to their peers and evaluated the implementation experience by filling out a survey. The instructors also filled out an implementation survey and responded in a narrative to a series of questions about the implementation process. The Implementation Stories are a summary of these reports.

### **How to Use the At-A-Glance Matrix**

The following matrix is a quick guide to the educational level, grade level, and the level of difficulty employed for each Challenge field-test.

The New England Board of Higher Education's STEM (Science, Technology, Engineering, Mathematics) PBL (Problem Based Learning) Project (DUE #0903051) is funded by the Advanced Technological Education (ATE) program of the National Science Foundation (NSF).

**At-A-Glance  
STEM: PBL Implementation Stories  
Fall 2010 - Fall 2011**

<b>Page Number</b>	<b>Challenge Name</b>	<b>Secondary Education</b>	<b>Post-secondary Education</b>	<b>Course</b>	<b>Grade Level</b>	<b>Level of PBL</b>	<b>State</b>
<b>4</b>	<b>Cape Cod Cranberry Growers Association</b>	X		Problem Based Learning	Freshmen	Open	MD
<b>6</b>	<b>Cape Cod Cranberry Growers Association</b>		X	Principles of Environmental Science	Sophomores	Open	MA
<b>8</b>	<b>FloDesign</b>	X		Physics	10, 11 & 12th graders	Guided	MI
<b>10</b>	<b>FloDesign</b>	X		Digital Electronics and Principles of Engineering	9-12 graders	Open	TX
<b>10</b>	<b>FloDesign</b>		X	Electrical Engineering	Juniors	Open	TX
<b>10</b>	<b>RSL Fiber Systems</b>	X		Digital Electronics and Principles of Engineering	9-12 graders	Open	TX
<b>10</b>	<b>RSL Fiber Systems</b>		X	Electrical Engineering	Juniors	Open	TX
<b>12</b>	<b>RSL Fiber Systems</b>	X		Problem Based Learning	Sophomores	Open	MD
<b>8</b>	<b>SPG Solar</b>	X		Physics	10, 11 & 12th graders	Guided	MI
<b>14</b>	<b>TTF Watershed</b>	X		Integrated Science	Freshmen	Structured	CA

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<b>16</b>	<a href="#">TTF Watershed</a>		X	Biology	Sophomores	Structured	MA
<b>8</b>	<a href="#">TTF Watershed</a>	X		Physics	10, 11 & 12th graders	Guided	MI
<b>18</b>	<a href="#">TTF Watershed</a>	X		Woodworking Technology	9, 10, 11 & 12th graders	Structured	RI

## **Cape Cod Cranberry Growers' Association (CCGA)**

**Institution/Grade level:** High school freshmen in Maryland

**Course:** Problem Based Learning Course (stand alone 0.5 Credit Course)

**Class size/group size:** 121 students

**Challenge level:** Open

### **Details of Implementation:**

This was not the first STEM PBL Challenge I field-tested – I field-tested the RSL Fiber Systems Challenge with grade 10 (see page 9). I implemented the CCGA Challenge in my Problem Based Learning Course, which is a stand-alone course.

I facilitated the class by introducing the Challenge. Students were randomly assigned to working groups. I monitored student discussions and answered questions by redirecting students to ask each other within their own group. The students were “acting as consultants” and had to create a “bid” for the redesign of the cranberry bog. I showed the select pieces of the Challenge as appropriate.

As freshmen, this is their first year in their PBL Course. Our main focus is working on collaboration, as many of our 9<sup>th</sup> grade students confuse this with cooperative and/or group work. Therefore, constant monitoring, and at times direct intervention, was necessary to redirect students and/or groups to stay in collaborative mode.

There were numerous problems within several teams, and other teams had few problems, if any. Constant monitoring, and occasional verbal redirects were necessary. There were no problems with the Challenge itself, but in assisting students in understanding our program’s goals for the module within the course. Anecdotal records were kept and these were reviewed with students.

Our students had access to computers with Internet access and all of the software programs accessible within our STEM program.

Our 1<sup>st</sup> year PBL course has 3 main foci:

1. Acclimating our students to working with professionals in a professional manner (soft skills).
2. Working with peers in randomly selected groups – getting over the “like/don’t like” aspect and focusing on the professional approach.
3. Collaborative skills.

Presentation is not the main emphasis in the 1<sup>st</sup> year course. Thus, students were asked to create a media and or model/poster and then to present

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their ideas to their classmates. Students were permitted note cards as necessary. These presentations were not videotaped and were not peer reviewed. However the product/plan itself was reviewed and students were permitted to ask presenters questions regarding their product or plans.

**Assessment:**

The groups were asked to self-evaluate their presentation in terms of important points, not presentation skills or style. Team participation was assessed via journal entries on self-evaluation/reflection and peer evaluations and teacher observations. Collaboration checklists were also implemented.

**Instructor Comments:**

This was the students' 3<sup>rd</sup> Challenge in their 1<sup>st</sup> course. They were excited to be able to use some of the skills they were learning in other classes. The experience was a positive one. The students would have loved a chance to have a webinar with the parties involved, to ask questions and then to present their ideas.

**Student Comments:**

"[This project increased my confidence in my science skills] by making me think more inventively."

"It helped with my understanding of the scientific process and solving problems."

"The Challenge had nothing to do with our science class. Chemistry doesn't deal with cranberry bogs."

"It has shown that the science and engineering skills we have learned are actually paying off."

## **Cape Cod Cranberry Growers' Association (CCGA)**

**Institution/Grade level:** College sophomores in Massachusetts

**Course:** Principles of Environmental Science

**Class size/group size:** 22 students

**Challenge level:** Open

### **Details of Implementation:**

I field-tested the TTF Watershed Challenge in January 2011. Based on feedback from that first experience, in which the students indicated they preferred less direction, I provided very little direction and made this an Open Challenge. Also, given that I was doing the Challenge toward the end of the semester, I thought these students could definitely do this without much guidance.

There were no group problems. The students all seemed quite engaged in the work. I find small teams help: in this case, I broke the students into teams of three, with one team of four. I incorporated this Challenge into my curriculum during one 2.5-hour class period, with a little more class time a week later. The students were broken into teams that they were already working in for a semester-long environmental health research project. I created these teams taking their strengths and weaknesses into account. One team did not perform to the level of the others, but this was not surprising. Students used laptop computers and the Internet as their resources.

I left the method of presentation open. In the last Challenge, I required the students to present their solutions via PowerPoint. Some students created short PowerPoints, others spoke and/or used the whiteboard in the classroom to explain their solutions.

### **Assessment:**

Students were assessed based on their concept maps and presentations.

### **Instructor Comments:**

Students seem to like problem-based learning. I found that they were nervous about defining the problem incorrectly, but that they got past this trepidation as they dug deeper into the possible solutions. Implementing this Challenge was a good introduction to PBL, something we are doing on a LARGE

scale in my upcoming travel course to the Everglades in which the students will be redesigning South Florida to sustain a high quality of life for all, human and nonhuman. This was a great way to prepare them for understanding agricultural impacts on waterways.

**Student Comments:**

“Learning about bogs on my own made me feel a little better about doing research to solve a science-related problem.”

“I feel like a better researcher and presenter of information.”

“It helped me understand hypothesizing and finding solutions to real-life problems.”

“I feel more apt to use STEM skills to approach scientific problems.”

## **FloDesign, SPG Solar, TTF Watershed Partnership**

**Institution/Grade level:** High School sophomores, juniors & seniors in Michigan

**Course:** Physics

**Class size/group size:** 28 students

**Challenge level:** Guided

### **Details of Implementation:**

This was the first STEM PBL Challenge I implemented in my classroom. The Challenges were implemented as a stand-alone supplemental activity to a group of sophomore, junior and senior high school students who worked over the summer during a period of 1-2 weeks.

I split the students into teams and gave them the choice to work on the STEM PBL Challenge of their choice (students chose the Challenges FloDesign, SPG Solar, and the TTF Watershed Partnership). I guided the students through the process, which included a section on finding proper sources for their research, as well as how to document those sources. Students used computers and the media lab each day as their resources. We also had a short discussion period each day in order for students to get help with the direction they were taking on their project. I had only one team where there was a personality problem, and they seemed to be able to work out their problems on their own.

### **Assessment:**

Students were required to prepare PowerPoint presentations and to present their solutions to their classmates. The students self-assessed and I graded their presentations.

### **Instructor Comments:**

I like introducing the Challenges because my students need to learn how to research and problem-solve. I see by many of their evaluations that this type of work is not something they hold a great deal of interest in. Some students seemed to like problem-based learning, and some did not enjoy the problem-solving process at all. It seems they like the “spoon feeding” method of learning best.

I enjoy this method of instruction, but as with another method of instruction that I use, called "Modeling Physics," it seems that I really have to focus the student energy at first because they are used to a more passive method of learning. This is probably one of the most frustrating things for me. I find only a small percentage of my students each year really like to dig into a problem and solve it.

**Student Comments:**

"I like the participation part because it gives me a better idea of how the group aspect of research goes."

"My participation has increased my confidence in science skills because it helped me understand how to problem solve and figure things out on my own."

"It wasn't really difficult for me to complete the science aspect, the research was the worst!"

"I feel like I can understand something I was too scared to try on my own. I lost some of my fear of science through the Challenge."

## FloDesign and RSL Fiber Systems

**Note:** As part of our Alliance Schools Program, which connects secondary and post-secondary institutions by geographic region to create a student pipeline to higher education, these Challenges were taught jointly by a high school teacher and a university professor.

**Institution/Grade level:** Freshman through senior year high school students and university students in Texas

**Courses:** Digital Electronics and Principles of Engineering (high school; after school); Electrical Engineering (university)

**Class size/group size:** 14 students (6 from high school and 8 from university)

**Challenge level:** Open

### **Details of Implementation:**

This was the first time a STEM PBL Challenge was field-tested jointly by high school and university students in Longview, TX. Two Challenges were tested: RSL Fiber Systems and FloDesign. Four groups combining high school and college level students were assembled (6 high school students and 8 college students in total). The groups were presented with open-ended Challenges, which they completed over a 6-week period. The high school and university students connected for 2 hours once a week after school with the instructors, alternating campuses over 6 weeks.

Students utilized the Whiteboards for 4 weeks and had two weeks to build and test their prototypes, and to implement their solutions. Electronic labs and computer labs were available to students at both the high school and university level to use as resources. Instructors made themselves available to students over the 4-week period during which students completed their Whiteboards. The instructors encouraged students to work on their own during the last two weeks of the Challenge, which was used for prototype building and implementation.

Students designed, built and tested their solutions. They prepared PowerPoint presentations, which were presented to the class, and technical reports based on the results of their research and prototype testing.

**Assessment:**

Assessment was based on students' PowerPoint presentations and technical reports. The university students were graded for their participation in the Challenge. The high school students, who participated in the Challenge as an extra-curricular activity, did not receive a letter grade.

**Instructor Comments:**

Our experience has been a positive one. We could tell that both groups of students gained from the experience: the high school students were energized by working with their older, more experienced peers, while the university students were eager to lead and include the high school students in the Challenge.

We found that students like to be presented with problems that are real, not a textbook experiment. They like to feel that their solutions can make a contribution to society. At the same time, students somewhat resisted the open-ended format in that they did not like the idea of having several possible solutions to one problem.

**Student Comments:**

The following comments were obtained from participating high school students.

"Honestly, no [it did not increase my confidence in my science skills] because I realize that there is so much that I still need to learn."

"I feel like I can research and take care of some things on my own, without having to ask for help as often. Also, it let me strengthen my reasoning and deduction skills."

"It did help me a lot because I learned key aspects about energy conversions, mechanical advantage calculations, and energy storage methods, which before I didn't know anything about."

## **RSL Fiber Systems**

**Institution/Grade level:** High school sophomores in Maryland

**Course:** Problem Based Learning Course (stand alone 0.5 Credit Course).

**Class size/group size:** 101 students

**Challenge level:** Open

### **Details of Implementation:**

This was the first STEM PBL Challenge I field-tested. I implemented the Challenge in my Problem Based Learning Course, which is a stand-alone course. I introduced the Challenge by telling the students they were creating “top secret bids” for the US Navy. I randomly assigned students to working groups, monitored student discussions and answered questions by redirecting students to ask each other within their own group. I showed the select pieces of the Challenge as appropriate. As sophomores, our students are used to PBL challenges and collaborative projects, so little was needed in terms of redirects. I did not show the students the solution provided as each group had to formally present their “bid.”

As these students are in their 2<sup>nd</sup> year of the PBL course, there were few problems with teamwork to be addressed. Smaller issues within the groups, such as absent group members, were resolved within the peer groups themselves. The students are used to “live” guest instructors and at first had issues with the “canned” feeling of the Challenge. However, as they became engrossed in the Challenge itself, the complaints ceased.

Students had access to computers with Internet access and all of the software programs accessible within our STEM program to use as their resources.

Our 2<sup>nd</sup> year PBL course focuses on presentation. Therefore, our students were required to dress professionally and to present to their peers for peer evaluation. Any media, tech, or prop supplements were permitted. Note cards and reading from the presentation (if PowerPoint or Prezi) was not permitted. Presentations were video recorded for students to self evaluate presentation skills and to hone those presentation skills.

### **Assessment:**

Team participation was assessed via journal entries on self-evaluation/reflection, peer evaluations and teacher observations.

**Instructor Comments:**

Implementing a STEM PBL Challenge was a positive experience. The students really enjoyed employing the skills they have learned in their other courses. It also aligned with their current topic in their Systems Science course, so it was timely placed into the curriculum.

**Student Comments:**

“Yes, [it increased my confidence in my science skills] because it gave me a chance to apply knowledge and research to a real-world problem. Additionally, completion shows me what I can accomplish with my current knowledge.”

“It made me understand the process of solving a problem, and it also taught me things to do and not to do while presenting the solution.”

“I did not learn anything new in the field of science. It has improved my project skills, though.”

“I felt this was mostly research and presenting. I would have liked to collect data as well.”

“This only increased my confidence in my problem solving skills.”

## **TTF Watershed Challenge**

**Institution/Grade level:** High School freshmen in California

**Course:** Integrated Science

**Class size/group size:** 15 students

**Challenge level:** Structured

### **Details of Implementation:**

This was the first STEM PBL Challenge I attempted and I chose the "structured" method in order to train the students how to solve problems on their own. I chose to implement this Challenge as a stand-alone supplemental activity during the last 15 minutes of class, with an additional hour at lunchtime. I also made myself available after school for committed students. Most students that completed the Challenge successfully were students that took advantage of either the lunch or after school opportunities.

The greatest team problems we encountered were when students had to begin partitioning workloads and defining the depth of research that would be required for those workloads. This caused the "lone ranger" type students to be on edge and to develop a worst-case scenario mentality (having to do the work on their own if their teammates failed to participate). I let them fail whenever it would bring about learning. To keep failure at a minimum, however, I encouraged students to clearly identify what specific questions would need to be answered and by whom. The students learned that when they had clear assignments (goals), they were extremely embarrassed when they were the only person in their group with no answers the following day.

Students used our local water district, Internet, classroom, and library as their resources. None of the students constructed analog devices for testing theories or for measuring microscale results.

### **Assessment:**

Students presented their solutions two weeks after being introduced to the problem. Student presentations included a speech in front of the class. The use of Whiteboards and PowerPoint were suggested, but not required or implemented. Team participation was assessed by the team itself, and by the feedback I received from students verbally. Teamwork was easy to assess because attendance was mandatory and those who did not show up at lunch or after school were never ready to present information during class collaboration.

**Instructor Comments:**

The overall student reaction was initial shock, tempered by curiosity driven research. When I originally implemented this in my classroom, I found that there was an immediate schism that occurred between those that wanted to participate, and those that did not. I did not allow non-participation, and allowed natural leadership to train others.

I am excited to continue with the model of PBL, given that the students are now more mentally prepared to find real-world solutions. The key is in knowing how to be a good "Question Asker"!

**Student Comments:**

"I learned that if I want to find things out, I can do it by myself."

"I felt like I learned a lot about issues with stormwater causing problems in towns, but I don't feel like I learned any of the standards I learn in class."

"It shows me I can teach myself science too."

"The project increased my confidence in my science skills because I have never been challenged like this before."

## TTF Watershed Partnership

**Institution/Grade level:** College sophomores in Massachusetts

**Course:** Biology

**Class size/group size:** 20 students

**Challenge level:** Structured

### **Details of Implementation:**

This was my first time implementing a STEM PBL Challenge, which I implemented over one 4-hour time slot. Students performed their research in the library and used multiple study rooms to break out into smaller group discussions. I gave the students a checklist of Challenge-related concepts with which they were to check off “Know/Don’t Know/Think I Know” prior to watching the Introduction, Organizational Overview and Problem Statement videos.

I showed the videos mentioned above and established the teams. I gave the students their Whiteboards and study rooms to work in, then circulated to ask and answer questions, though the students actually needed very little guidance/prompting from me.

We reconvened for the Discussion video after which I sent the students back to revise their work. Students were asked to use a different colored pen to revise their Whiteboards post Discussion. We ended the day with the students’ PowerPoint presentations.

During the next class I asked the students to go through the “Know/Don’t Know/Think I Know” checklist a second time once they completed the Challenge so they could self-evaluate what they learned. Students were also asked to create a concept link, rather than an entire concept map, during the first class (there was not enough time to complete an entire concept map). I asked them to revisit this concept link in the second class, so they could see what they learned. I also assigned an individual project report, which was due a few days later.

Overall, the teams worked well. I think the time crunch helped to keep students focused. Some students clearly did better quality research than others, but they all contributed. I allowed the students to use laptops with wireless Internet, the library facilities (though few used these), and reference librarians (no one accessed this service).

**Assessment:**

I graded the students' individual project reports, but did not assess team participation. I plan to work team assessment into the next Challenge.

**Instructor Comments:**

My reaction was that students seemed to like problem-based learning! They were engaged in solving the problem, and most pushed themselves and their teammates to better understand the issues. I was impressed with the solutions the student teams developed. I taught these students zero environmental science. In fact, we had only met once when I introduced this Challenge.

**Student Comments:**

"Simply being able to come up with solutions and understanding how they work has definitely increased my confidence."

"This has made me use my science skills to get at a conclusion and as a result has made me more confident in myself."

"The experiment didn't feel very scientific. Mostly, I looked stuff up on Google and discussed it, which I do a lot of anyway."

"Seeing the research side of science helped me to remember that science is not just results. There is a lot of work put in before results are obtained."

## **TTF Watershed Partnership**

**Institution/Grade level:** Freshman, sophomore, junior and senior high school students in Rhode Island

**Course:** Woodworking Technology

**Class size/group size:** 20 students

**Challenge level:** Structured

### **Details of Implementation:**

This was the second time that I introduced the TTF Watershed Partnership Challenge to my students. I ran the Challenge with a group of advanced seniors at the end of the 2010/2011 school year. This year, I implemented the Challenge with a mixed group of students and ran the class as a structured Challenge over a period of 1-2 weeks, guiding the students through the process of problem solving. This group of students had never done anything like this before.

I split the twenty students into groups of two. This seemed to give them enough work throughout the Challenge process, and I found that the students worked through the Challenge without group problems. Students had access to a computer lab in school where there were enough computers for each student to work on a computer individually. I projected the videos onto the wall enabling the students to watch the Challenge videos together.

Students used the information that they had gathered in their Whiteboards to prepare their PowerPoint presentations, and delivered their presentations in front of the class to their peers.

### **Assessment:**

Students were responsible for gathering information in order to complete their Whiteboards. Additionally, students were required to fill out their own final Challenge reports. Presentations were delivered as a group effort and each member of the team presented information. This presentation was graded as a group grade using the high school's school wide presentation rubric.

**Instructor Comments:**

Though I enjoy using the PBL Challenges in my classes, I received mixed feelings from the students. Students in this class really like to work with their hands. They like challenging projects. This project provided a challenge to the students, and the students liked the challenging parts of it. However, we did not have time to test the solutions. I think if we had the time to test the solutions the students would have enjoyed the PBL experience even more.

I enjoy using PBL in my classes because I can see how it gives the students a good framework to solving any problem they encounter. I like having the Whiteboards for the students to use as an organizer for all the information they need. I really enjoy watching the students present their solutions to the class. I have had a positive experience with the PBL Challenges and I plan on using and developing more of them in the future. I intend to have this year's advanced group work on the Solar Challenge.

**Student Comments:**

"I feel that I know more about pollution problems and the environment."

"Yes [my participation in this project has increased my confidence in my science skills] because I think if we did another Challenge I would be able to get it done faster and better."

"I prefer learning through regular school work and working alone."

"Yes [my participation in this project has increased my confidence in my science skills]. It helped me explore many solutions and ideas."