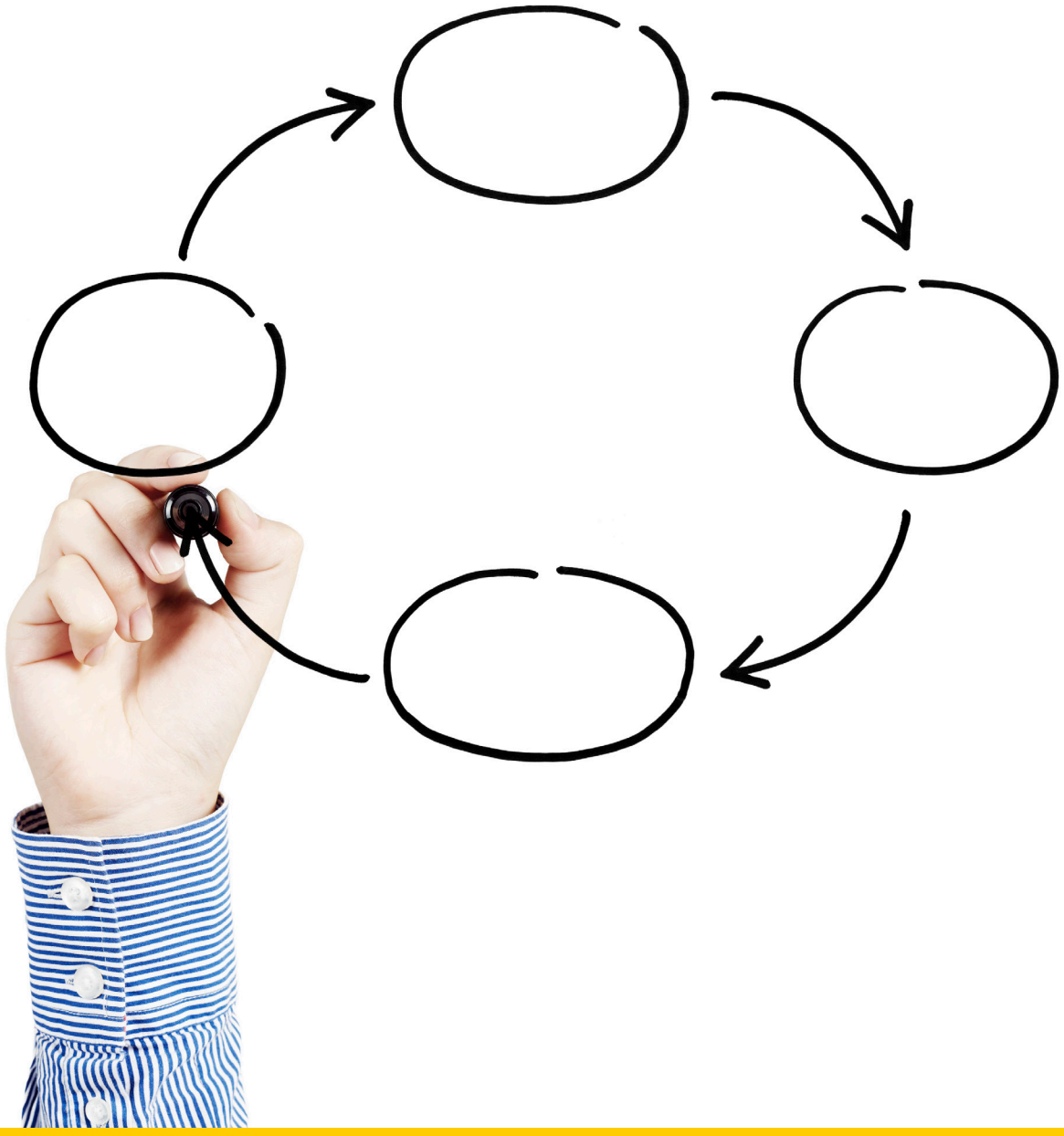


the **CHALLENGE DESIGN GUIDE**

creating pbl challenges based on **REAL WORLD PROBLEMS**

Problem Based Learning PROJECTS

The PBL Projects team of the New England Board of Higher Education has created a number of multi-media Challenges (case studies) available at www.pblprojects.org. Each Challenge represents many days of effort by several people, including pre-planning, partner visit with photo and video recording, script, resource and graphic development, audio recording and finally, video production. Because the PBL team has been funded to produce only a limited number of Challenges, teachers may find that there is not a Challenge in our online library covering a particular topic of interest. This guide assists you in creating your own PBL Challenges employing the two necessary elements of PBL:

- An authentic "real world" problem,
- The four-step Whiteboard approach to problem-solving.

I. Choosing a problem[1]

Solving "real world" problems provides students with an authentic and meaningful learning experience that promotes the development of skills critical for success in the workplace and in life (e.g., problem-solving, critical thinking, time management, resource allocation, self-regulation, etc.).

Suitable problems may be found:

- through discussion with local industry/agency contacts (e.g., program advisory committees).
- in scientific literature and technical journals.
- through government agencies.
- in media resources, such as newspapers, web sites and blogs.

Appropriate problems:

- are open-ended with several possible solutions.
- stimulate the interest of students.
- are ill-structured to challenge students and promote inquiry.
- are interdisciplinary in nature, and require collaboration and teamwork.
- address several topics normally covered by the course in question.
- have ideally been solved by "experts" so that students can compare and contrast their solutions to the expert solution.

Problems must be of sufficient complexity so that a solution isn't immediately available through a web search.

Criteria for Creating Good PBL Problems:

A. Determine the Purpose of the Problem

- Teachers who use PBL must ask a fundamental question: "What am I trying to accomplish by assigning this problem?"
- The chosen problem should promote knowledge and skills that have been clearly defined as intended course or program outcomes. Problem solving techniques may be one such skill.

B. Designing Problems to Promote Higher-Order Thinking

- Assess students' current knowledge of the content inherent to a problem and design the problem slightly beyond what students currently know. As a result, students will not be able to solve the problem without extending their knowledge base and their skills.
- If the goal in designing the problem is to foster higher-order thinking among students, then the problem should be relatively ill-structured, since that is often the case in the workplace.

[1] Excerpted from: Weiss, R. E. (2003), Designing Problems to Promote Higher-Order Thinking. New Directions for Teaching and Learning, 2003: 25–31.

- Design the problem for collaboration such that the group must synthesize their ideas and make decisions throughout the course of the PBL activity.
- Problems should be authentic. However, if a problem is too theoretical and out of touch with students' experiences and daily lives, they will not be engaged by the problem.

II. Creating the Challenge sections

Each PBL Challenge contains five main sections. The Challenge can be created in a Word document, the PowerPoint template available from emailing PBLProjects@nebhe.org, or a multimedia presentation if time and funding permit. No matter which format is used, the Challenge has five distinct sections:

1. Introduction - This is a general introduction to the topic area that sets the context of the problem.
   - References or links to additional resources may be print or web-based. Since website URLs change frequently, PDF documents are preferred for Challenges that will be used over the course of several years

2. Organization Overview-The organization that solved the problem is introduced in a few paragraphs to emphasize that the problem was solved by real people working as a team.
   - The organization's website is provided for reference.

3. Problem Statement – This is a re-enactment of an authentic real-world problem as originally presented to the organization's technical team. It may be presented as a simple text narrative (2-3 paragraphs) or it can be written in script form.
   - Enough resources are provided to get the students started in the right direction. These may be web or print. None of the resources provided at this point should give details of the problem solution, but they should provide general information to help focus students' research.
   - The Whiteboards are provided as a student resource. Students should be directed to fill out the Whiteboards as completely as possible. As further information is found, the Whiteboards will be revised until a solution is reached.

4. Brainstorming Discussion – This is a re-enactment of a brainstorming session by the technical staff, discussing what they know/have learned about the problem. The discussion is designed to provide further hints for students as needed, depending on students' technical and problem solving ability. If the problem statement is in narrative form, the "discussion" would also follow as a narrative that provides more information and guidance. If the problem statement is in script form, the discussion would be as well.
   - The discussion is shared with students if/when the instructor feels it is needed. The online videos are protected with passwords; in print form, the information is simply withheld.
   - Additional resources are provided to assist students to formulate their own solution.

5. Problem Solution – This section provides the organization's solution, indicating how it addresses each of the problem criteria. The solution is withheld until students present their own solutions for peer review. Students are encouraged to compare and contrast their solutions to the organization's: Is the student solution cost effective? Could it be accomplished in time to meet customer demands? Are there other (e.g., ethical social, political) considerations?

Creating a Challenge from a Printed Article

This is an example of a PBL Challenge created from an article found in a trade journal (Photonics Spectra, http://photonics.com/Article.aspx?AID=7552). Following the article is the text-based Challenge developed using the "Guide for Creating a PBL Challenge" instructions.

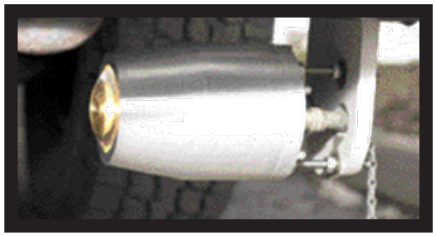
Sample Article for a PBL Challenge

Infrared Detector Sniffs Out Gas Leaks

Daniel C. McCarthy (Photonics Spectra 2004)

About 7000 miles of distributed gas pipelines wend their way beneath the Binghamton, N.Y., metropolitan area, home to more than 200,000 residents. New York State Electric and Gas Corp., also known as NYSEG, supplies gas to the city. As a safety precaution, the company routinely patrols the streets to seek out leaks in the pipelines. Optical sensing technology from Heath Consultants Inc. is helping to speed these patrols.

Most of NYSEG's patrol trucks carry a flame ionization unit, which uses sampling cones mounted in front of the vehicle's bumper to draw air into the flame ionization detector via a pump. If the air sample carries traces of any combustible hydrocarbons, it causes a chemical reaction in the detector chamber and signals the possibility of a leak. The technique has several dis-



advantages, including the need to carry several fuel bottles and a sampling pump. If water gets into the sample detector's chamber, performance suffers. Consequently, on rainy days, technicians must continually change the filters. Another disadvantage is that flame ionization can operate only while traveling below 7 mph. More importantly, it detects other combustible hydrocarbons including vehicle exhaust, resulting in frequent false-positive readings.

Truck-mounted optical methane detectors are speeding routine patrols for gas leaks in Binghamton, N.Y. Courtesy of NYSEG.

Heath Consultants' Optical Methane Detector is providing an alternative solution. Earlier this year, NYSEG mounted a single unit beneath the front bumper of one of its trucks. The unit comprises an infrared light source aimed at an optical filter and a photodetector. The filter transmits only the wavelengths at which methane is absorbed, so if traces of gas pass through the beam path, the detector signals an alarm in the truck's cab.

Both methods deliver sensitivity to 1 ppm, according to Mayra Castorina, marketing coordinator for Heath. However, the optical detector is specific to methane and detects propane and ethane at one-third the sensitivity, reducing false positives.

Unlike flame ionization, Heath's unit signals a leak immediately and, because it is digital, data can be stored for later analysis.

Also, the optical sensor allows the NYSEG truck to travel at 25 to 35 mph. "We did over 30 miles in under four hours with the [optical methane detector]," said Mark Cole, NYSEG's manager of gas engineering and project management. "We've never had that kind of success or production with flame ionization units."

Heath's optical detector complements ionization methods, which currently are the only portable option.

The Sample Challenge (Narrative Form)

INTRODUCTION

(The introduction highlights the general issue of gas leaks and what happens when they go undetected. Resources include links to stories on gas explosions and gas pipeline safety.)

More than two million miles of gas pipeline are used to deliver natural gas to homes and businesses in the United States. Although gas pipelines have an excellent safety record, leaks can and occasionally do have disastrous consequences. For this reason, gas producers add a harmless chemical, mercaptan, to add a distinctive "rotten egg" smell to otherwise odorless and colorless natural gas. The smell makes it easier to detect leaking gas, especially in enclose spaces such as homes. Gas distributing companies also routinely patrol streets where underground pipelines are located using specialized sensors in order to find gas leaks. It is important that leaks be promptly repaired before a disaster occurs.

INTRODUCTION RESOURCES

- American Gas Association http://www.aga.org/

See http://en.wikipedia.org/wiki/List_of_pipeline_accidents#United_States for a complete list of all kinds of pipeline incidents)

- A few gas pipeline explosions in recent years

W. VA: http://www.csmonitor.com/Environment/2012/1212/West-Virginia-gas-pipeline-explosion-just-a-drop-in-the-disaster-bucket

MA: http://www.masslive.com/news/index.ssf/2012/11/claims_for_losses_continue_to.html

ORGANIZATION OVERVIEW

(The organization web site is a good source of information that can be summarized for the organization overview.)

Heath Consultants is an international manufacturing and consulting firm that provides a variety of products and services for utility protection and damage prevention. The company was founded in 1933 with a focus on leak detection for the natural gas industry. Since then, Heath has expanded its products and services to include portable gas detectors, confined space monitors and pipe and cable locators. Heath Consultants employs a variety of engineers and technicians, including gas leak survey technicians and utility line located technicians, throughout the United States.

ORGANIZATION OVERVEW RESOURCES:

- http://www.heathus.com/_hc/index.cfm

PROBLEM STATEMENT

(In this case, the problem is stated in the first two paragraphs of the article. The city is not specifically identified in this summary to make the web search for this specific article more challenging.)

A large city in New York has about 7000 miles of gas pipeline buried under its streets. The local utility company regularly patrols the streets to search for leaks in the pipelines using trucks equipped with flame ionization units. These are very sensitive detectors of combustible hydrocarbons, but also fairly complex instruments requiring the truck to carry several fuel bottles and a sampling pump. Also, the units only work when the trucks travel slower than 7 miles per hour, and they do not work well in the rain. Since they are sensitive to hydrocarbons in the truck's exhaust they can give frequent false positive readings.

The gas company would like to find a sensor that is simpler to operate, gives an immediate alarm in response to a leak, has fewer false positives and operates at a higher truck speed, that is, can cover more length of pipeline in less time.

PROBLEM RESOURCES

- How a flame ionization detector works:

http://www.wisegeek.com/what-is-a-flame-ionization-detector.htm

- Gas Technology Institute:

http://www.gastechnology.org

DISCUSSION

(The Discussion includes more specific information on methane detection. The information can be as explicit as needed for the students' technical and problem solving abilities. For a longer term Challenge solved over several weeks, the Discussion and its resources may be omitted entirely. The reference in the resource below includes information on several types of detectors, including the one used in the article.)

A wide variety of commercial gas detector technologies have been developed including electrochemical, infrared and semiconductor, among others. Electrochemical detectors measure the amount of current produced when a gas undergoes a chemical reaction. Infrared sensors pass long wavelength (infrared) light through a sample and measure the wavelengths that are absorbed; these wavelengths depend on the properties of the gas being sampled. In semiconductor sensors, the electrical resistance changes when the sampled gas comes in contact with the sensor.

Discussion Resources

- Types of gas sensors:

http://www.intlsensor.com/pdf/infrared.pdf

ORGANIZATION'S SOLUTION

(The Organization's Solution is in the final paragraphs of the article. Students would be expected to explain how their detector of choice works, how it is mounted on the vehicle and how it is superior to previous methods.)

Heath Consultants' developed an optical methane detector that takes advantage of methane's absorption of infrared light around at a wavelength near 3.4 µm. The system consists of a light source, a filter and a photodetector. The filter only transmits the wavelengths at which methane is absorbed. If methane gas is present, the detector will signal a drop in the amount of light. This change in detected light is displayed on a monitor and also sounds an alarm to the operator. Because the filter is tailored to the absorption of methane, it is less sensitive to the presence of other gases resulting in fewer false positive alerts. The optical sensor is rugged and allows the trucks to travel at 25-35 miles per hour.

Solution Resources

- Paper on the detection of methane using light

http://www.heathus.com/_hc/res/InfoCenter/WorldConferencePaper.pdf

- The complete tracker system developed by Heath

http://www.heathus.com/tasks/sites/_hc/assets/File/survey_tracker.pdf

PBL PROJECTS

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