

Facilitating Problem-based Learning: An Engine and Authoring Tool for Building Web-based Learning-by-doing Environments

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Overview

- **Background**
- **Challenge**
- **Research**
- **Solutions**
- **Go public**
- **Future Work**

Background

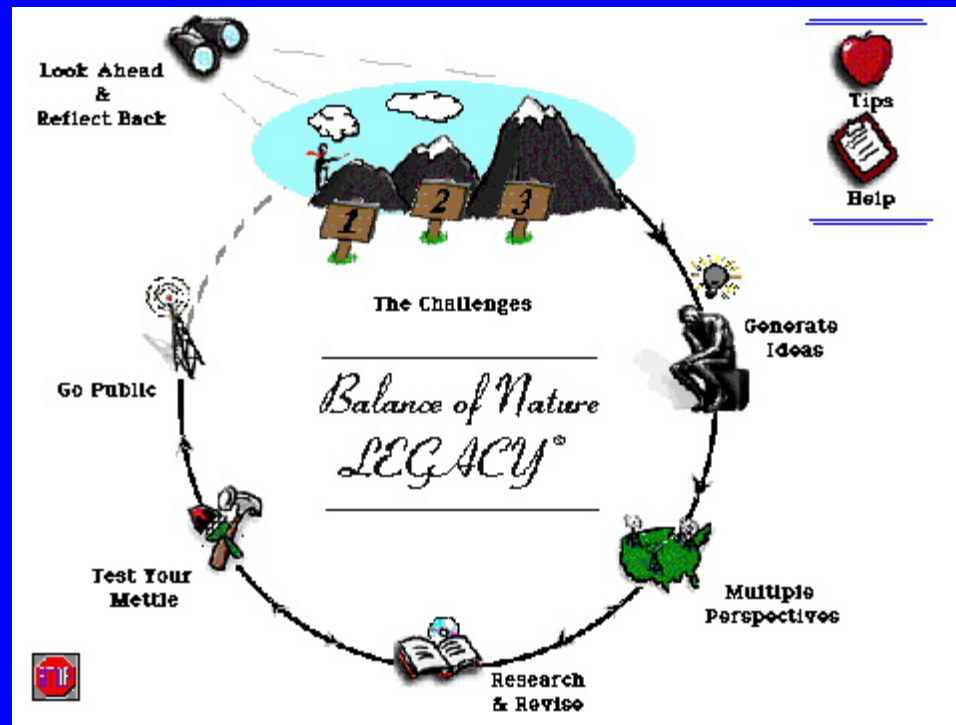
- **In a bioengineering course, students need to learn**
 - **Biological and engineering concepts**
 - **Adaptive expertise**
 - **Run experiments, research domain, analyze data (Investigate)**
 - **Make diagnoses based on relevant test results (Decide)**

Challenge

- **Educating adaptive experts**
- **Encouraging critical thinking**
- **Building a sense of science as inquiry rather than as answers**

Research

- Challenge-based learning helps students learn the context and utility of the domain knowledge when they are given the opportunity to experience the content in response to a challenge (Bransford, Brown, Cocking, 1999)
- The Legacy Cycle (Schwartz, Lin, Brophy, Bransford, in press) is a framework for designing challenge-based curriculum



Solution 1: Corrosion Investigator

- **Challenge**
 - Students take the role of consultants to help a company determine the cause of pipe corrosion
- **Research**
 - The instructor acted as a liaison between the students, the client, and various simulated commercial laboratories.
 - All communications were done via email
 - Test results
 - Domain background information
 - Scenario information

This is a module developed by Matthew Parsek, an assistant professor in Civil Engineering, and Ann McKenna, a post-doctoral fellow in the School of Education and Social Policy in Northwestern University.

Problem

- Running such a module by generating plausible data for each lab test manually is labor-intensive for the instructor
- Feedback to the students is often delayed
- Hard to deploy such modules to places where expert coaching and critiquing are not available

Time for more research. Can any of these be automated?

Research

- **The Goal-based Scenario (GBS) (Schank, 1994) framework for computer-based learn-by-doing (Dewey, 1916) environments is designed to engage learners in active purposeful learning (Bransford, Brown, Cocking, 1999).**
- **A software tool called Indie (Dobson, 1998) was developed by the Institute of Learning Sciences (ILS) at Northwestern University for building Investigate and Decide learning environments, a subclass of GBS's.**

A simulated computer-based Investigate and Decide learning environment seems a good solution...

Solution 2: A new version of Indie

- **Develop a new version of Inide**
 - **Written in Java for portability and web-delivery**
 - **Uses XML files to represent the domain content**
 - **Adds new functionality to support complex tests, random test result generation, and time and cost calculations.**

Problem

- **GBS's are closed world systems**
 - **Content is specified in advance**
 - **Learners can only do pre-defined activities**
 - **Significant upfront design, implementation, piloting are required to support potential learner actions**
 - **No easy way to add new content once deployed**

How to make GBS's open?

Solution 3

- **Create an architecture for hybrid Indie learning environments that provide the option for human coaching in the feedback loop**
 - **Open-ended inputs are handled by the human expert**
 - **New material can be introduced into the system during instruction time**



Expert

- Scenario challenge
- Experiment options
- Experiment result generation methods
- Domain background information



Content Authoring Tool



Content Knowledge

Indie toolkit

Authoring time

Instruction time



Indie Learning Environment



Instructor

- Role-play characters in the scenario
- Provide feedback on student work
- Track student working progress



Students

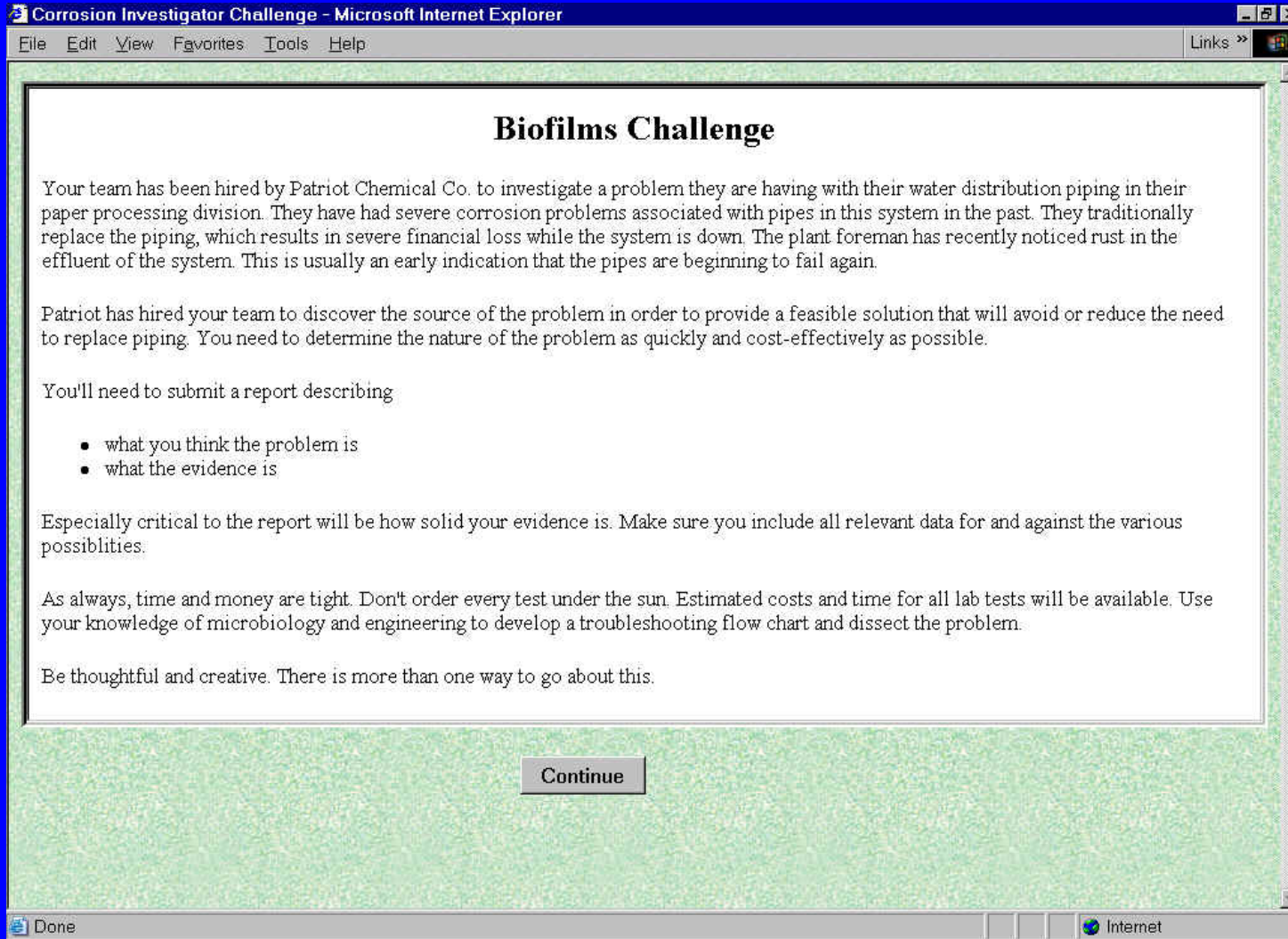
- Investigate (research domain, run experiments, analyze results)
- Decide (make claims, select evidence, construct report)



An Example: Corrosion Investigator created by Indie



Challenge Screen



Corrosion Investigator Challenge - Microsoft Internet Explorer

File Edit View Favorites Tools Help Links »

Biofilms Challenge

Your team has been hired by Patriot Chemical Co. to investigate a problem they are having with their water distribution piping in their paper processing division. They have had severe corrosion problems associated with pipes in this system in the past. They traditionally replace the piping, which results in severe financial loss while the system is down. The plant foreman has recently noticed rust in the effluent of the system. This is usually an early indication that the pipes are beginning to fail again.

Patriot has hired your team to discover the source of the problem in order to provide a feasible solution that will avoid or reduce the need to replace piping. You need to determine the nature of the problem as quickly and cost-effectively as possible.

You'll need to submit a report describing

- what you think the problem is
- what the evidence is

Especially critical to the report will be how solid your evidence is. Make sure you include all relevant data for and against the various possibilities.

As always, time and money are tight. Don't order every test under the sun. Estimated costs and time for all lab tests will be available. Use your knowledge of microbiology and engineering to develop a troubleshooting flow chart and dissect the problem.

Be thoughtful and creative. There is more than one way to go about this.

Continue

Done Internet

Reference Screen

Corrosion Investigator - Microsoft Internet Explorer

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Corrosion Investigator

Experiment Report Reference Logout

Project Cost: \$0 Day 1 Advance Date

Reference

- Plant Foreman**

This individual is responsible for the day-to-day operation of the paper processing machinery. This person will be a valuable resource for questions pertaining to the day-to-day operation of the plant. Any questions directed to this individual will be answered promptly, unless it is outside the foreman's expertise, in which case the question will be redirected to the appropriate individual.

[Send email](#)
- Plant Manager**

The plant manager is responsible for the operation of the entire plant.. Detailed questions regarding the paper processing procedure should be directed to the plant manager. For example, the plant foreman could tell you general questions about paper processing, where a question like: What are the pipes in the system composed of? would require the plant manager. Response times are generally slower for the plant manager.

[Send email](#)
- Scientific Consultant**

The scientific consultant can be useful for advice for interpreting data sets as well as explaining different laboratory-derived data sets in more detail. The scientific consultant can also be used to comment on the plausibility of hypotheses or to check on the feasibility of a proposed experimental plan. There are costs for this service that are determined individually based upon the specific questions being asked.

[Send email](#)

Using the system

Challenge

Contact

Experiment Screen

Corrosion Investigator - Microsoft Internet Explorer

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Corrosion Investigator

Experiment Report Reference Logout

Project Cost: \$95050 Day 36 Advance Date

Notebook

[DGGEcheck point 3]all bacteria: 382 bands
[DGGEcheck point 4]all bacteria: 272 bands
[DGGEcheck point 5]all bacteria: 274 bands
[DGGEcheck point 6]all bacteria: 193 bands
[DGGEcheck point 7]all bacteria: 168 bands
[DGGEcheck point 8]all bacteria: 289 bands
[DGGEcheck point 9]all bacteria: 238 bands
[Hydrology]check point 12 flow rate: 3.586 m/s
[Water Chemistrycheck point 12]temperature: 24.872 C
[Water Chemistrycheck point 12]NO2: ND

Test

analyze bacteria Look for test

About this test

Culturing Test

These analyses allow the determination of the number of bacteria present in a given environmental sample that are capable of growing under specified growth conditions. Bacteria are grown on semi-solid petri plates and form small circular colonies on the surface of the plate. The type of growth medium, incubation temperature, and nature of your sample will determine the number of colony forming units or number of bacteria present in your sample capable of growing under the specified conditions. Besides the number of bacteria present, you may request at an additional price to have the number of different colony types measured and a gram stain analysis conducted. Both of these assays are indicators of microbial diversity. The gram stain is measuring the type of cell wall a microbe has.

Results

DGGE RESULTS:

Location of Sample: check point 8
all bacteria: 289 bands

previous next Run Test

Parameter Screen

Corrosion Investigator - Microsoft Internet Explorer

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Corrosion Investigator

Experiment Report Reference Logout

Project Cost: \$5000 Day 22 Advance Date

DGGE

Location of Sample

<input type="checkbox"/> check point 1	<input checked="" type="checkbox"/> check point 2	<input type="checkbox"/> check point 3
<input type="checkbox"/> check point 4	<input type="checkbox"/> check point 5	<input type="checkbox"/> check point 6
<input type="checkbox"/> check point 7	<input type="checkbox"/> check point 8	<input checked="" type="checkbox"/> check point 9
<input type="checkbox"/> check point 10	<input type="checkbox"/> check point 11	<input type="checkbox"/> check point 12

Primer Set

<input type="checkbox"/> all bacteria	<input checked="" type="checkbox"/> denitrifiers	<input type="checkbox"/> methanogens
<input type="checkbox"/> methanotrophs	<input type="checkbox"/> nitrifiers	<input checked="" type="checkbox"/> Fe oxidizers
<input type="checkbox"/> sulfur oxidizers	<input checked="" type="checkbox"/> sulfate reducers	

Total Cost: Delay:

Reason for ordering the test:

Report Screen

Corrosion Investigator - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Favorites Print Encoding

Address http://idano.cs.nwu.edu:8080/indie/biofilm/html/background_frame.html Go Links »

Corrosion Investigator

Experiment Report Reference Logout

Project Cost: \$20000 Day 22 Advance Date

Notebook

[check point 12]
denitrifiers: 2 bands
[check point 12]
sulfur oxidizers: 11 bands
[check point 2]
denitrifiers: 1 89 bands
[check point 2]

Use Evidence

Report:

Location: recirculating pipes
Diagnosis: biologically-induced corrosion

[check point 12]
sulfur oxidizers: 11 bands
(Reason: high sulfur appearance)
[check point 2]
denitrifiers: 1 89 bands

Retract Evidence

Email Address: Submit Report

Done Internet

Go Public

- **Poster at AERA (New Orleans, April 2002)**
- **Poster at ED-MEDIA (Denver, June 2002)**
- **Paper submitted to ICLS (Seattle, October, 2002)**

Future Work

- **Analyze data from pilot testing**
- **Enhance functionality to meet user needs**
- **Build an authoring tool to support incremental authoring**
- **Apply the Indie architecture to another module**