Networked Virtual Laboratories for General Chemistry Education

Louisiana eLearning Innovation Grant 2015/2016

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This Louisiana eLearning Innovation Grant proposal is a multidisciplinary project involving two departments of the College of Sciences and Agriculture (CSA) at Southern University and A&M College in Baton Rouge (SUBR), the department of chemistry and the doctoral program in Science/Mathematics Education (SMED).
**Goals**

*The short term plan*: establish a networked virtual laboratory for General Chemistry and to conduct action research that guides the implementation and the evaluation of a course redesign using virtual laboratory.

*The long term plan* implement a curricular redesign for Science, Technology, Engineering, Mathematics (STEM) through the use of innovative educational technologies including Virtual laboratory and Open Education Resources.

*NSF HBCU-UP 2016*
Establish a Networked Virtual Laboratory for general chemistry at SUBR using the networked professional version of the Model Chemlab software from Modelscience Inc.

Develop and deploy virtual laboratory experiments covering the curriculum offerings in General Chem.

Develop interactive and inquiry-based eLaboratory manuals for general chemistry using the Lodestarlearning authoring tool.
Objectives

Building capacity to engage Louisiana faculty, graduate research students and STEM teachers in a state-wide Professional Learning Community (PLC) focusing on educational research and implementation of virtual laboratory.

Build research capacity in the areas of adoption and implementation of STEM virtual science laboratories to accompany online science courses.

Doctoral Students Chemistry/Biology
Predominately non-science courses and degree programs are offered by universities online. This situation may be attributed to the facts that

- Educators are still skeptical about offering science courses online.
- Lack of mechanisms for transferability of courses to other institutions and professional schools.
- The lack of knowledge and agreement regarding benchmarks for course quality, and
- The lack of knowledge regarding available tools to deliver laboratory courses online.
Traditionally, STEM instruction at the undergraduate level has consisted of a lecture component and a hands-on laboratory. Until recent years, physical, hands-on laboratory experiences were the only experiences available.

There are circumstances when offering hands-on experiential work to students is not practical.

- distance education limitations,
- costly equipment or supplies,
- inadequate lab space
- or time constraints
Laboratory Options

- Hybrid - Campus-based labs
- **Simulations – Virtual Labs**
- Remote-Access Labs
- Kitchen Labs
- Lab Kits
  - Instructor Assembled
  - Student Assembled
  - Commercially Assembled
Case for VLabs?

- Development of critical thinking skills by emphasizing scientific method approaches to lab activities.
- Access to experiments over a wider range of STEM topics and phenomena.
- Reduction of bottleneck courses by increasing section offerings.
- Inclusion of laboratory experiments that cannot be conducted in wet labs due to laboratory safety concerns.
- Reduction of institutional costs for materials, laboratory support and waste disposal.
- Increased affordability for students in cases where lab fees are imposed.
- Improved convenience to students with 24/7 access to virtual labs.
Effectiveness Research?

A recent meta-analysis of 56 empirical studies presenting a first attempt to synthesize post-2005 empirical studies showed clear advantages in favor of NTL.

- Learning outcomes varied and content knowledge was the primary outcome measured.
- Studies used a variety of research instruments by which to assess learning outcomes.
- Blended approach to laboratory learning seems more effective.
- Technological Development in NTL learning environments seems related to learning outcomes.
Integration Modalities?

There has been renewed interests in blended learning experiences that incorporate various combinations of virtual laboratory and traditional classroom instruction.

1. supplement to actual laboratory assignments;
2. pre-lab or post-lab activities;
3. homework or quizzes;
4. make-up labs;
5. classroom demonstrations;
6. inquiry-based learning activities in groups;
7. blended model alternating traditional to virtual laboratory.
ChemLab User Interface

Lab Window

Lab Equipment

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ChemLab

User Interface

Lab Window

Lab Equipment
Model ChemLab Design

- Easy to use interface modeled on common lab procedures.
- Real time simulation engine.
- Student lab notebook workspace.
- Extensible with Plug-ins and LabWizard tool to develop experiments.
- Demonstration mode.
- Integrated with RasMol molecular viewer.
- Bundled with pre-designed experiments.

http://www.modelscience.com/ChemLabDocs.html
Step 1: Obtain acid, in a 100 ml Erlenmeyer flask, add 35 ml of 2M HCl solution.

Step 2: Add an indicator to the acid, select the flask and add 2 drops of phenolphthalein indicator. The indicator menu is available under the chemicals main menu (Chemicals→Indicators) or the context menu.

Step 3: Display pH, select flask and add a pH meter to the acid solution using the equipment main menu (Equipment→pH meter) or the context menu.

Step 4: Turn on the collection of titration data, select the flask and turn on collection of titration data using "Collect Titration Data" menu from the procedures menu or from the right-mouse context menu.

Step 5: Open the titration data window by selecting the "View Titration Data" from the Procedures menu. (Note: this window will plot a titration curve once you start titrating)

Step 6: Fill buret with NaOH, obtain a 50 ml buret and fill with 2M NaOH solution.

Step 7: Titrate NaOH into HCl until end point, record initial buret volume and add NaOH (quickly at first then slowly) until the HCl solution turns pink and record the final buret volume of NaOH in buret.
Lab Wizard Work Flow

1. Introduction
2. Lab Information
3. Lab Documentation
4. Add Chemicals
5. Chemical DB
6. Reaction Chemicals
7. Add Reactions
8. Reaction Details
9. Lab Options
10. Indicators
11. Indicator Properties
12. PDB Files
13. Finish
# General Chemistry 112 Laboratory Experiments with Wet and Matched Virtual Lab

<table>
<thead>
<tr>
<th>Current Laboratory Offerings</th>
<th>Matched Virtual ChemLab Experiments</th>
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<tr>
<td>Labs 1A-1B-1C: Laboratory Safety; Laboratory Equipment; Glass working</td>
<td>• Balance Lab</td>
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<td>• Volume Lab</td>
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<td>Labs 2A/2B: Measurement and Density; Preparing Graphs</td>
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<td>Lab 3A: Empirical Formula and Percent Composition of a Substance</td>
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<td>Lab 5A Separation of a Mixture</td>
<td>Fractional Solubility</td>
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<td>Lab 6A: Electrolyte in Solution – Completing the Circuit</td>
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<td>Lab 7A: Precipitation Reaction and Filtration</td>
<td>Heat of Neutralization</td>
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<td>Lab 8A: Reaction Enthalpies and Hess’s Law</td>
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<tr>
<td>Lab 9 A: Specific Heat of a Metal</td>
<td>Specific Heat Lab</td>
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<tr>
<td>*Addition 1 – Suggested Lab</td>
<td>Caffeine Extraction Lab</td>
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<tr>
<td>Addition 2 – Suggested Lab</td>
<td>Fractional Distillation Lab</td>
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<tr>
<td>Addition 3 – Suggested Lab</td>
<td>Limiting Reactants</td>
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Laboratories addition 1-3 are suggested laboratory experiments to be added to the current curricular offering in general chemistry 112.
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<tr>
<td>Lab 1B: Safety Film Viewing</td>
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<td>Lab 2B The Structure of Covalent Molecules and Polyatomic Ions</td>
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<tr>
<td>Lab 3B Boyle’s Law and Charles Law &amp; Combined Gas Law and Dalton’s Law</td>
<td>Charles’ Law</td>
<td>Gas Compression</td>
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<td>Lab 3B: Solubility, Saturation, and Crystal Formation</td>
<td>Fractional Crystallization</td>
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<td>Lab 4B: Colligative Properties: Freezing Point Depression</td>
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<td>Lab 5B: Production and Properties of Acid Rain</td>
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<tr>
<td>Lab 6B: The Rate of a Chemical Reaction</td>
<td>Reaction Kinetics in Redox Reaction</td>
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<td>Lab 7B: Reaction Reversibility and Le Chatelier’s Principle</td>
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<td>Lab 8B: Standardization of a Solution and Analysis of Vinegar</td>
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<td>Lab 9B: Acid, Bases, pH, Hydrolysis and Buffers</td>
<td>Acetate Buffer</td>
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<td>Addition 4 – Suggested Lab</td>
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Professional Learning Community (PLC)  
MERLOT Voices

Online Learning & Virtual Science Laboratory
Created by Moustapha Diack  
View Communities

This OL&VSL community discussion focuses on current practices for integrating virtual and simulated Science/Math laboratory to support online STEM Education. This community intends to engage Louisiana faculty, graduate research students and STEM teachers to develop a state-wide Professional Learning Community (PLC) focusing on educational research and implementation of these learning environments. This OL&VSL PLC will include resources.