Networked Virtual Laboratories for General Chemistry Education

Louisiana eLearning Innovation Grant 2015/2016

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Collaborative

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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*

Objectives

- 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

Background Intellectual Merit

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.**

Background
Intellectual Merit

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;

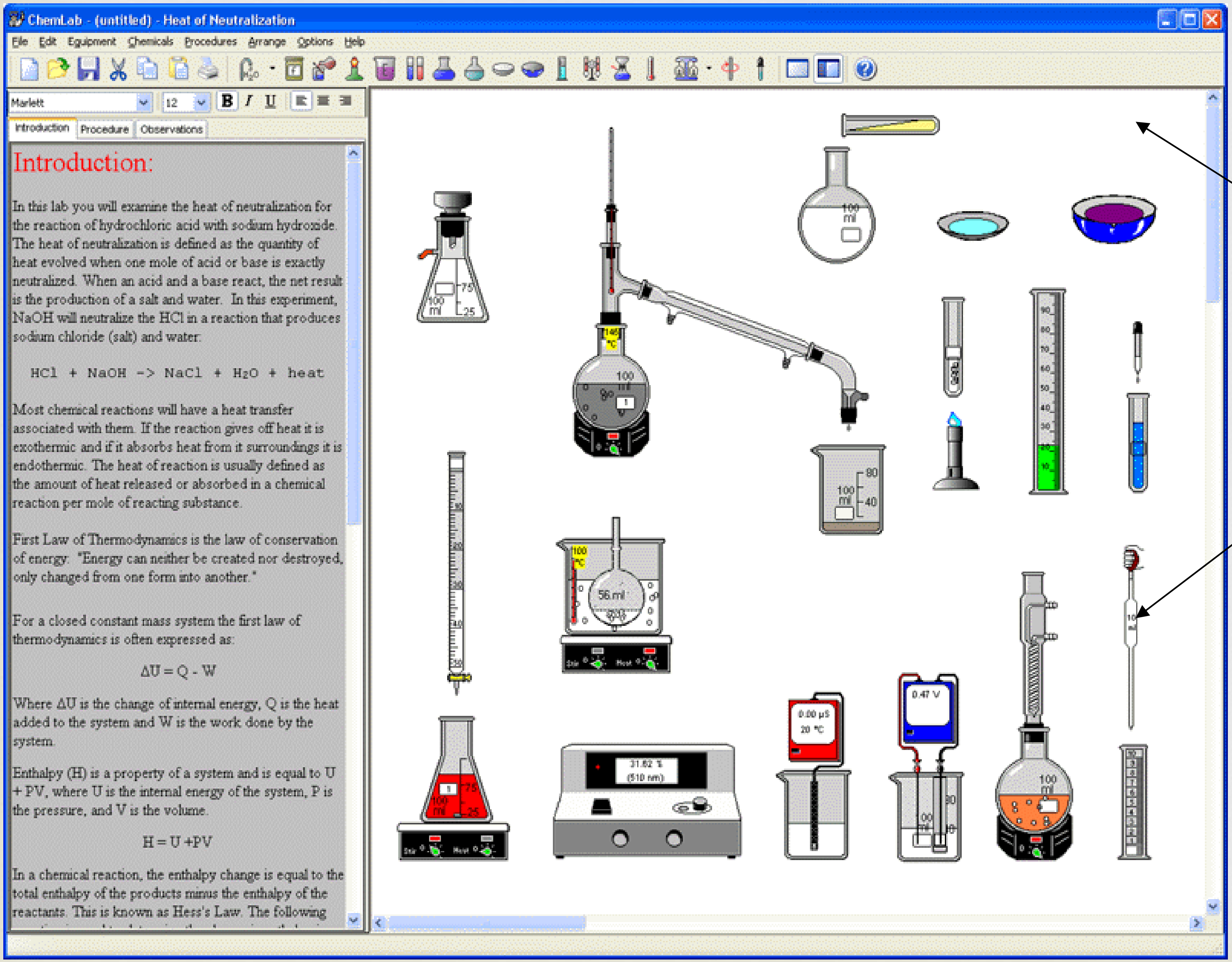
(4) make-up labs;

(5) classroom demonstrations;

(6) inquiry-based learning activities in groups;

(7) blended model alternating traditional to virtual laboratory.

ChemLab User Interface



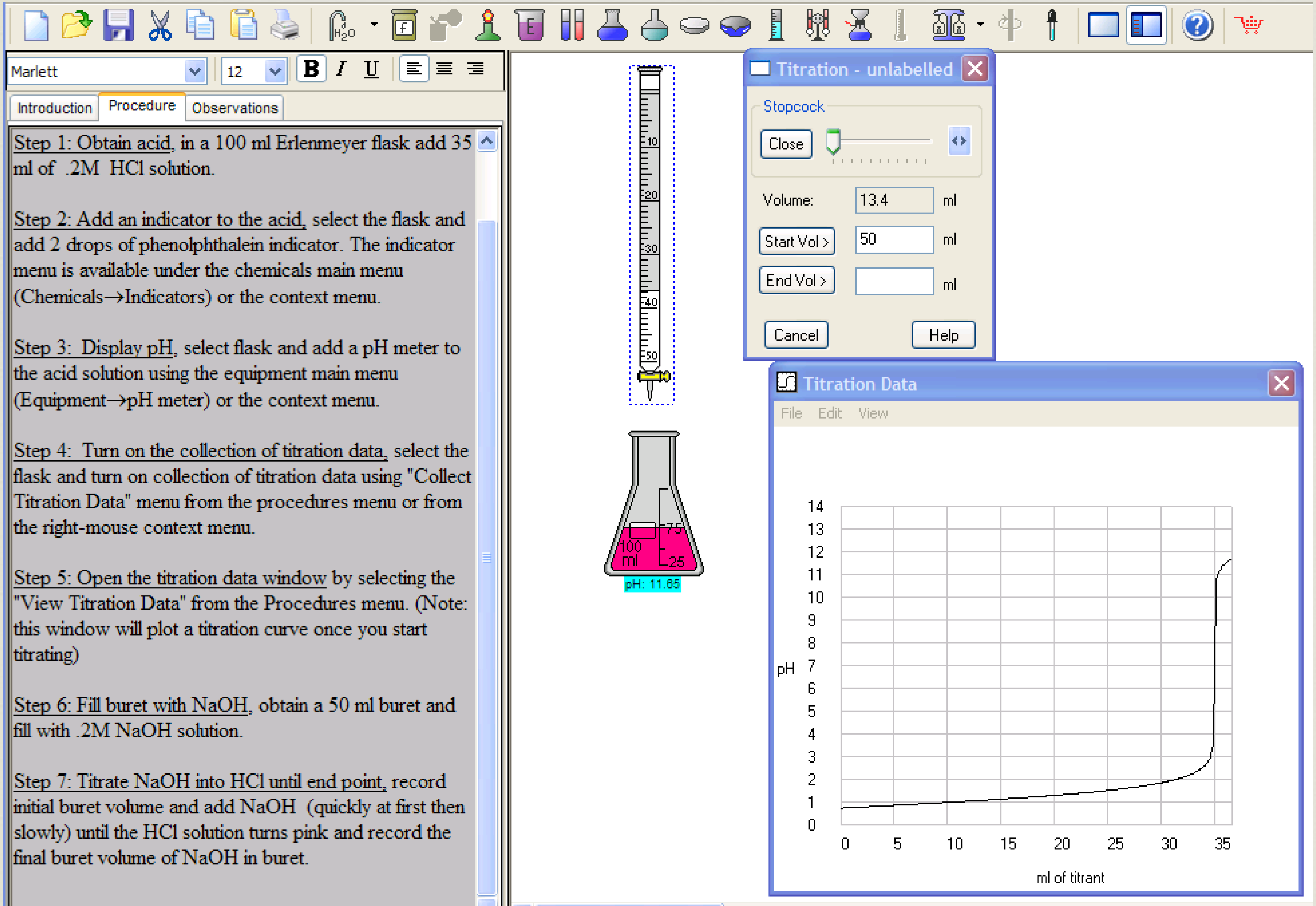
Lab Window

Lab Equipment

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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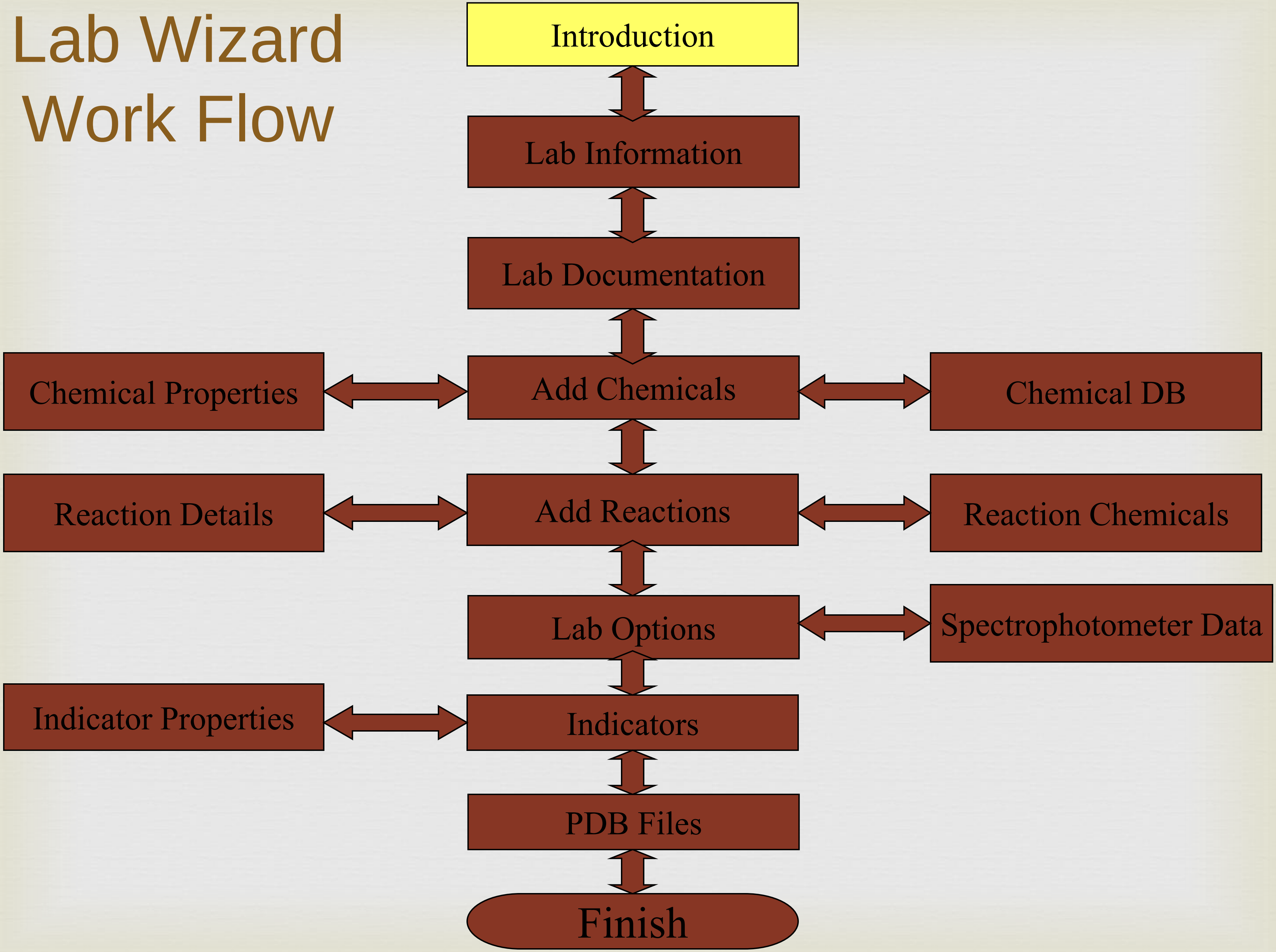
Introduction
Procedure
Observations
Step 1: Obtain acid, in a 100 ml Erlenmeyer flask add 35 ml of .2M HCl solution.
Step 2: Add an indicator to the acid, select the flask and add 2 drops of phenolphthalein indicator. The indicator menu is available under the chemicals main menu (Chemicals→Indicators) 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.
10
20
30
40
50
100 ml
75
25
pH: 11.65
Titration - unlabelled
Stopcock
Close
Volume: 13.4 ml
Start Vol > 50 ml
End Vol > ml
Cancel
Help
Titration Data
File Edit View
14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
pH
0 5 10 15 20 25 30 35
ml of titrant

Lab Wizard Work Flow



General Chemistry 112 Laboratory Experiments with Wet and Matched Virtual Lab

Current Laboratory Offerings	Matched Virtual ChemLab Experiments
Labs 1A-1B-1C: Laboratory Safety; Laboratory Equipment; Glass working	• Balance Lab • Volume Lab
Labs 2A/2B: Measurement and Density; Preparing Graphs	
Lab 3A: Empirical Formula and Percent Composition of a Substance	
Lab 4A: Simple Chemical Reactions	Bond Lab
Lab 5A Separation of a Mixture	Fractional Solubility
Lab 6A: Electrolyte in Solution – Completing the Circuit	
Lab 7A: Precipitation Reaction and Filtration	
Lab 8A: Reaction Enthalpies and Hess's Law	Heat of Neutralization
Lab 9 A: Specific Heat of a Metal	Specific Heat Lab
***Addition 1 – Suggested Lab**	Caffeine Extraction Lab
Addition 2 – Suggested Lab	Fractional Distillation Lab
Addition 3 – Suggested Lab	Limiting Reactants

Laboratories addition 1-3 are suggested laboratory experiments to be added to the current curricular offering in general chemistry 112.

Chemistry 113 Laboratory Experiments with Wet and Matched Virtual Lab

Current Laboratory Offerings	Matched Virtual ChemLab Experiments
Lab 1B: Safety Film Viewing	
Lab 2B The Structure of Covalent Molecules and Polyatomic Ions	Bond Lab
Lab 3B Boyle's Law and Charles Law & Combined Gas Law and Dalton's Law	• Charles' Law • Gas Compression • Dumas Method (Ideal Gas Law
Lab 3B: Solubility, Saturation, and Crystal Formation	Fractional Crystallization
Lab 4B: Colligative Properties: Freezing Point Depression	
Lab 5B: Production and Properties of Acid Rain	
Lab 6B: The Rate of a Chemical Reaction	Reaction Kinetics in Redox Reaction
Lab 7B: Reaction Reversibility and Le Chatelier's Principle	
Lab 8B: Standardization of a Solution and Analysis of Vinegar	
Lab 9B: Acid, Bases, pH, Hydrolysis and Buffers	Acetate Buffer
****Addition 1 – Suggested Lab**	Standardization of a NaOH Solution Lab
Addition 2 – Suggested Lab	Cation and Anion Reaction
Addition 3 – Suggested Lab	Electrochemical Cells
Addition 4 – Suggested Lab	Half Life Lab

**Laboratories addition 1-3 are suggested laboratory experiments to be added to the current curricular offering in general chemistry 112.

Professional Learning Community (PLC)
MERLOT Voices