

The Virtual Laboratory: Using Technology to Enhance the Learning Experience of Students in Biology, Chemistry, and Physics

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Overview

- Why a Virtual Laboratory?
- Advantages and Disadvantages of incorporating technology into the lab classroom
- Selecting and Implementing a Virtual Laboratory curriculum
- The Virtual Laboratory in practice
- Conclusions

The Charles Drew University

- Incorporated in 1966 in South Los Angeles as a post-graduate medical education center
- Has grown to include the College of Medicine and the College of Science and Health
- Mission: “...to conduct education and research in the context of community service in order to train physicians and allied health professionals to provide care with excellence and compassion, especially to underserved populations.”

College of Science and Health Student Enrollment Demographics

	2000-01	2001-02	2002-03	2003-04	2004-05
	%	%	%	%	%
Black	57	57	53	52	49
White	3	3	7	8	10
East Indian/Pak	1	1	2	3	2
Hispanic	22	22	23	23	22
AmerInd/AlskNat	0	0	1	0	0
Asian	8	8	7	7	10
Puerto Rican	0	0	0	0	0
Chinese	1	1	2	0	0
Filipino/Pac Isl	4	4	4	4	4
Other/Unknown	5	5	3	4	3
Total	100	100	100	100	100

Biomedical Sciences Program

- BS degree program for students interested in pursuing a career in biomedical research or health care services
 - Small class size
 - Research focused
 - Emphasis on community service and the University's mission of serving the underserved

In deciding whether to implement virtual lab technology at CDrewU, we asked:

Can technology based learning tools meet the learning objectives of our courses?

Why do we use Labs?

- What common learning objectives do laboratory exercises hold for STEM students?
 - Learn standard practices and procedures
 - Familiarity with equipment
 - Practice with concepts taught in lecture
 - Apply the Scientific Method
 - Develop online critical thinking skills

Do virtual labs meet these objectives?

- Learn standard practices and procedures

Pro:

- Step by step instruction
- Students must be precise in measurements and calculations
- Inattention to detail can lead to mistakes

Con:

- Students are not “hands-on”

Do virtual labs meet these objectives?

- **Familiarity with equipment**

Pro:

- Some curricula incorporate operating instructions for lab equipment similar to what students would see in a lab manual
- Students can practice using equipment in virtual realm before wasting resources with operational mistakes

Con:

- No substitute for hands-on practice with complicated apparatus

Do virtual labs meet these objectives?

- Practice with concepts taught in lecture

Pro:

- Virtual lab curricula can be designed to meet the needs of the class
- Students can repeat virtual experiments for practice or developing conceptual understanding

Con:

- Doing/ repeating lab exercises outside instructional supervision can be frustrating for students who lack conceptual understanding

Do virtual labs meet these objectives?

- Apply the Scientific Method

Pro:

- Not all virtual exercises are models or demonstrations
- Students can develop a hypothesis and design an experiment to carry it out
- Virtual labs give students more ability to be creative without being restricted by resources or safety concerns

Con:

- Not all virtual curricula allow students to develop the experiment using the scientific method.

Do virtual labs meet these objectives?

- **Develop online critical thinking skills**

Pro:

- Virtual exercises allow the student to make mistakes
- Carrying out experiments in “processor time” gives instant feedback
- Opportunities for self-analysis and reflection in the laboratory

Con:

- Not all virtual curricula allow students to “feedback” their critical thinking to improve or reflect on the exercise.

What limits the Lab experience?

- Time
- Money
- Equipment availability
- Instructor time/ resources/ knowledge
- Safety concerns
- Student ability
- **Virtual laboratory exercises can remedy nearly all of these concerns!**

Best Practices combine learning modalities

- Virtual labs – no substitute for hands on
- Integrated curricula provide the greatest variety of learning experiences
- Integrated curricula address a greater variety of learning objectives (Ma and Nickerson, 2006)
- Prepares students for the use of virtual/real integrated systems in their future careers

But what does the Literature Say?

- Not much, really
- Most studies to date focus on utilizing Virtual Labs in online classes, HS classes, or Engineering classes (McCombs, et. al., 2006; Kerr, et. al., 2004)
- The most applicable literature indicates that curricula which address the greatest variety of learning objectives and learning styles are best (Ma and Nickerson, 2006; Madrazo and Motz, 2004)

To Go Virtual or Not?

- Our Premise: Enriching the learning experience of our students gives them more opportunities to succeed
- CDrewU BMS has incorporated Virtual Labs into 3 basic science courses
 - Chemistry: Model ChemLab (<http://modelscience.com>)
 - Physics: Interactive Physics (<http://interactivephysics.com>)
 - Biology: Biology Labs On-Line (<http://biologylabsonline.com>)

Selecting a Virtual Curriculum

- We developed a set of standard criteria:
 - Emphasis on content otherwise unavailable
 - Requires manipulation rather than simulation
 - Develops critical thinking skills rather than just observation skills
 - Flexibility of curriculum/ ability to develop CDrewU-specific labs
 - Availability of program/ materials for students
 - Adaptability to currently approved curricula

Implementing Virtual Curricula

- Our goal is to utilize virtual labs in 40-50% of lab experiences
- For most concepts: 1 hands on lab, 1 virtual lab
- Virtual exercises currently make up about 30-40% of lab curriculum (after 1 year)

Qualitative Outcomes

After 1 year's implementation, Overall:

- Improved student satisfaction with lab courses
- Increased type and number of educational experiences for students
- Less wasted “trouble-shooting” time

Demonstration

[Biology Labs Online](#)

Conclusions

- Non-traditional, technology-based exercises enrich the laboratory learning experience and increase student interest and satisfaction
- Virtual Laboratory experiences reinforce critical thinking skills and understanding of the scientific method

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