

VIRTUAL LABS IN A CHEMISTRY CLASSROOM

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Abstract

Virtual Chemistry Labs can provide unique advantages within a high school chemistry classroom such as authentic student learning and creative problem solving. Virtual Labs allow students to explore and design their own lab investigation and there are modules designed to provide students with real-world scenarios when applying chemical concepts. The two Virtual Lab applications I will explore are Virtual ChemLab designed by Brian Woodfield at Brigham Young University and ChemCollective designed by David Yaron at Carnegie Mellon University.

Introduction:

In high school chemistry classrooms, laboratory experiences are essential for students to increase their analytical skills and understanding of chemical concepts. However, traditional lab activities are often taught as “cookbook” labs meaning students in lab strictly follow written directions often with little thought about what they are learning or how the lab connects to real world applications. The necessity to follow strict directions are factors of limited time, large numbers of students, cost restrictions, and the need to ensure the safety of all students in the laboratory (Woodfield et al., 2004). Labs should not only provide students with the opportunity to increase their analytical skills but also to provide active student engagement while learning. One alternative to traditional labs are virtual labs which can provide an interactive learning environment and connections to real world scenarios.

What are Virtual Labs?

Virtual labs use computers to provide “highly interactive virtual reality simulations of lab exercises.” I found two appealing products that specifically focus on implementing virtual labs within a chemistry classroom. One is called **ChemCollective** which focuses on scenario-based learning connecting chemical concepts to the real world. The second is **Virtual ChemLab** which puts students in a virtual laboratory enabling students to make decisions as if they were in an actual lab. Both of these simulations provide the user with the feeling that they are in a chemistry lab and give the user control when choosing their chemicals, glassware, and tools in order to perform the experiment. The two products have some minor differences, but their goals are the same, to “allow students to engage in authentic chemistry activities, with the educational goals of increasing cognitive flexibility” (Yaron et al. 2003).

ChemCollective

<http://ir.chem.cmu.edu>¹

* <http://creativecommons.org/licenses/by/2.0/>

¹ <http://ir.chem.cmu.edu/>

This product is currently free and funded by the National Science Foundation. The project leader is Dr. David Yaron at Carnegie Mellon University. ChemCollective provides virtual lab problems, real world scenarios, as well as tutorials. It is relatively user friendly and the virtual “lab bench” is easy to download. The material can be taken directly from the Internet at their web-site listed above. Several resources have already been created to learn how to use ChemCollective. At this web-site, there is a video with demonstrations, a step-by-step pdf guide, as well as a 24 page manual. http://www.chem.ubc.ca/courseware/121_virtual_lab/²

The virtual “lab bench”, though user friendly, does not have the same quality graphics as Virtual ChemLab (which I will discuss below) and are visually less engaging to the user.

However, the ChemCollective virtual lab provides the opportunity for students to design and implement their own experiments or practice concepts they do not fully understand. The true highlight of this product is the real-world scenarios which provide students with memorable as well as insightful applications of chemistry. For example, there is an activity called “Mixed Reception” which uses the concepts covered early on in a high school chemistry class. In this virtual activity students collect samples in order to solve a murder mystery. It also includes much more engaging graphics including 40 minutes of video (the murder, suspect interviews, etc). <http://ir.chem.cmu.edu/mr/index.php>³

Another example of scenario learning is “Mission Critical Chemistry” where students must supply fuel for a mission to Mars. <http://ir.chem.cmu.edu/mars/>⁴

There is also a scenario where the finishing touches are being added that focuses on arsenic contamination within the Bangladesh water supply. Already there are maps and a short video to complement the activity. <http://ir.chem.cmu.edu/arsenic/>⁵

Virtual ChemLab

<http://chemlab.byu.edu/>⁶

From my research, this is what I would highly recommend. The graphics are awesome and the focus of this product is to encourage creative learning. The product was developed by Brian Woodfield at Brigham Young University. He has created an open ended environment almost like a video game that lets the student approach the “problem” in multiple different ways. Woodfield’s goal is to encourage creative cognitive thinking skills allowing students to see the consequences of their decisions within the lab. The simulations focus more on the “what”, “when”, and “why” of experiments.

Virtual ChemLab must be purchased in order to use. It can be used on PC or Macintosh and runs as a standalone executable. The license is available through Prentice Hall and can be purchased as a full site-license or as a student version for an individual user. I would recommend purchasing a full site-license. This creates a server-based installation which contains a centralized database where students can view their assignments, lab books, scores and can submit their results directly to the teacher (Woodfield et al., 2004).

<http://pearsonschool.com/index.cfm?locator=PSZ15f&PMDbSiteID=2781&PMDbSolutionID=6724&PMDbSubSolution>

²http://www.chem.ubc.ca/courseware/121_virtual_lab/

³<http://ir.chem.cmu.edu/mr/index.php>

⁴<http://ir.chem.cmu.edu/mars/>

⁵<http://ir.chem.cmu.edu/arsenic/>

⁶<http://chemlab.byu.edu/>

⁷<http://pearsonschool.com/index.cfm?locator=PSZ15f&PMDbSiteID=2781&PMDbSolutionID=6724&PMDbSubSolutionId=6732&PMDbCat>

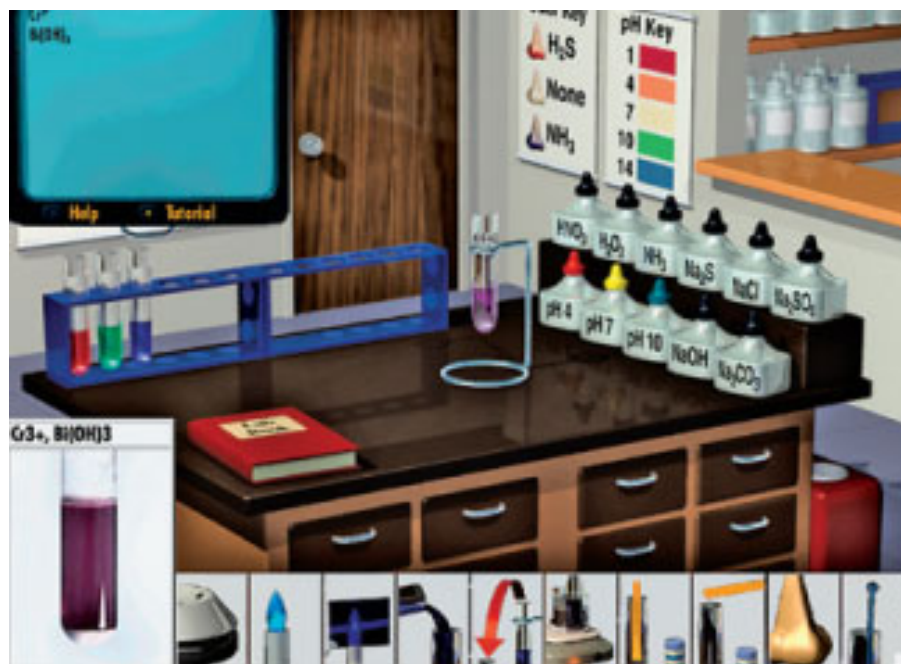


Figure 1: Graphics of Virtual ChemLab

Classroom Examples:

ChemCollective

One of the initial external users of ChemCollective were students at the University of British Columbia (4200 students over 3 semesters) (Yaron et al. 2003). Sophia Nussbaum is the instructor and has created an extremely helpful web-site (where I obtained the step-by-step guides on how to use ChemCollective). She uses ChemCollective in several different ways including as an activity to further enforce concepts traditionally regulated to pencil and paper homework. She uses ChemCollective for an introduction or as a pre-lab to familiarize students with a topic before they go into the physical lab. She has also created several labs that implement ChemCollective. For example, this worksheet is for a lab where the concentration of potassium permanganate is determined through using titration methods on ChemCollective.

<http://collective.chem.cmu.edu/chem/ubc/exp04/exp4.pdf>⁸

Though this example is for introductory chemistry classes at the college level, much of this material is covered in high school chemistry and is appropriate (with instructor support) for students at the high school level.

Classroom Examples:

Virtual ChemLab

Valerie Lechtanski has taught at Hopkinton High School in Massachusetts for twenty years and has created numerous worksheets that go along with Virtual ChemLab. Ms. Lechtanski emphasizes that Virtual ChemLab can be tailored to any level chemistry from AP to regular chemistry classes at the high school level. Virtual ChemLab can be used as an introduction to material, to supplement an in-class lab or as the lab itself. An example of one of the many labs that Ms. Lechtanski has created identifies unknown substances in a mixture and has students determine in the Virtual Lab what the unknown substances are by following a flow chart

⁸<http://collective.chem.cmu.edu/chem/ubc/exp04/exp4.pdf>

with reactions from the specific substances. <http://chemlab.byu.edu/sites/default/files/downloads/Go%20with%20the%20Flow.pdf>

Steve Haderlie is a chemistry teacher at Springville high School. He has very successfully integrated Virtual ChemLab into his chemistry curriculum. In fact, he has assisted in authoring most of the labs that go along with a recently published chemistry textbook (*10th edition of Chemistry: The Central Science, Brown, LeMay, Bursten published by Pearson/Prentice-Hall*). <http://shs.nebo.edu/Faculty.bk/Haderlie/apchem/apchem.html>¹⁰

To see the affect Virtual ChemLab has on students you need to visit Mr. Haderlie's classroom which was featured in a PBS TV series on Education and Technology Integration. Mr. Haderlie discusses how student's ability to explain what happened in a lab becomes much stronger after using Virtual ChemLab. Virtual ChemLab uses scaffolding to help students grow in their ability to think creatively and to navigate the program. This increases student's confidence to use the program as well as their confidence in their own abilities to solve problems!

<http://teachingnow.org/watchTV.php?id=37>¹¹

To see the action in the high school chemistry room you can skip to 6:02 minutes and watch the video through about 8:30 minutes. Then skip again to 14:12 minutes within the show. This is really awesome!!!

Brigham Young University obviously has students using the Virtual ChemLab program since that is where the program initiated. In the link below, a student (most likely future teacher) talks about Virtual ChemLab and the benefits of using it with students learning chemistry. This video is clearly homemade but one of the nice aspects about the video is that the different graphic views in Virtual ChemLab are shown. This future teacher talks about how she uses Virtual ChemLab to do a titration lab and the benefit this type of learning experience can provide, especially for students who may have disabilities and are unable to work in a traditional lab.

http://www.teachertube.com/view_video.php?viewkey=34202f71b55a27da899e¹²

The benefits of using a Virtual Lab program within a high school chemistry classroom include providing students with an opportunity to explore their own laboratory experiment, relate chemistry to real-life scenarios, and increase student's abilities to make decisions. I am drawn to using something like this in a chemistry classroom mainly due to the emphasis on authentic student learning and creative problem solving. I also like how students are able to become familiar with the concepts prior to entering a physical lab by using Virtual Labs. However, this by no means should be used as a substitute for students participation in a physical lab. I feel that the Virtual Lab has it's role alongside the traditional physical lab environment in almost all circumstances. There is a difference between moving a computer mouse and learning how to carefully titrate in a lab. However, in certain unique situations (like La Europa Academy for emotionally disturbed adolescent girls) where they use Virtual ChemLab, I can see how solely using Virtual ChemLab is effective because the girls at this academy are able to participate in chemistry labs without placing themselves or others at risk of being hurt. One other caution for instructors using Virtual Labs is that the instructor must be familiar with the program to be an effective teacher and this will take time (though, there are some summer seminars on how to use Virtual ChemLab to aid in this task of learning how to use the program). Students also will need to learn how to use the Virtual Lab programs. Both the ChemCollective and Virtual ChemLab report that students can quickly pick-up navigation of Virtual labs in anywhere from 5-15 minutes. However, a knowing instructor is probably essential for this as well.

Tips for teachers:

1. Be familiar with the technology before implementing it within the classroom. This will aid in helping students as they begin to use Virtual Lab programs.
2. Use Virtual Labs in conjunction with traditional labs. Virtual Labs can be used as a pre-lab to traditional labs, as follow-ups for further exploration, or as a substitute to traditional labs every now and then.
3. Use the available on-line resources that both ChemCollective and Virtual ChemLab provide. This includes already established labs with worksheets that relate to SOL topics and contain teacher tips.

⁹<http://chemlab.byu.edu/sites/default/files/downloads/Go%20with%20the%20Flow.pdf>

¹⁰<http://shs.nebo.edu/Faculty.bk/Haderlie/apchem/apchem.html>

¹¹<http://teachingnow.org/watchTV.php?id=37>

¹²http://www.teachertube.com/view_video.php?viewkey=34202f71b55a27da899e

4. Tailor specific activities within Virtual Labs to either group or individual student work. To encourage group problem solving skills, use the real-world modules that ChemCollective provides. For individual work, allow students enough time to explore the virtual labs and emphasize the importance of creativity especially when student are coming up with ideas for independent labs.

References:

Woodfield, B.F., Catlin, H.R., Waddoups, G.L, Moore, M.S., Swan, R., Allen, R. and Bodily, G. (2004). The Virtual ChemLab Project: A Realistic and Sophisticated Simulation of INorganic Qualitative Analysis. *Journal of Chemical Education*, 18, 1672-1679. Yaron, D., Evans, K.L, and Karabinos, M. (2003) Scenes and Labs Supporting Online Chemistry. Paper presented at the 83rd Annual AERA National Conference.