The Feasibility of Distance Learning with the Traditional Laboratory-Based Chemistry Class

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Distance Learning (DL) is defined as “learning that takes place when the instructor and student are separated by space and time. The gap between the two can be bridged through the use of technology – such as videoconferencing, and online technology” (Kent State University). DL is not a new thing, in non-laboratory based classes it has been around for as long as there has been a way to send instructional content out to willing participants who want to learn. However, in terms of classes that have “wet labs” associated with them there has been a reluctance to accept them and utilize them in this country. (Boschmann, 2003) This reluctance is not born by the student but by our academic and political system. There is a hesitancy to conduct these classes via DL because of inherent risk of conducting dangerous labs at home, not to mention the risk associated with the shipment of the supplies needed to conduct them. With this risk is the additional cost that would be incurred by the student to participate in them (Kennepohl, 1996). However, even with these significant hurdles other countries, including New Zealand, India, the United Kingdom and Sri Lanka (Kennepohl, 1996, Ross, 1994) have had these laboratory based DL classes since the early 1990’s. Using the DL systems of other countries as their guide, enterprising academic institutes in this country have started to develop a viable lab-based DL system here in the United States. This paper summarizes several peer reviewed journal articles that illustrate this.

As the speed and reach of the World Wide Web becomes increasingly faster and farther reaching the feasibility and popularity of a higher education degree in a science field that is obtained purely through distance learning has become a legitimate alternative to a traditional science based education received through a conventional brick and mortar university. Even traditional universities have implemented some form of DL science courses into their curriculum. All one has to do is search the internet for learning opportunities and a host of both internet based colleges such as the University of Phoenix and Kaplan University Online, as well as more traditional schools such as the University of Virginia, Harvard University and MIT have online options for the student who is interested in studying in the science field. There are several reasons for this growth in popularity. First and foremost internet based courses allow students to have greater flexibility in their schedules (Epstein, 1999), no longer are students required to sit through an hour lecture or a 4 hour lab class. Internet based classes also allow students that would not have access to
a higher education to gain that access, no longer do you have to live near a school to attend it. All that is required is for the student to have a high speed internet connection and a willingness to succeed (Epstein, 1999). However, there are some disadvantages to the DL Science Degree, most notably; there is often a high upfront cost to the student to purchase the lab supplies for home use (Kennepohl, 1996). Also of note is that the students do not get to experience the true sights, smells and other physical sensations of being in the lab. (Tatli, 2010) Lastly, students do not gain the experience of working with some of the instrumentation that most labs use, (Boschmann, 2003) this is of particular concern because we have to assume that the student is obtaining the degree to work in a science based field where they will more than likely work in a lab. For a list of the compiled pros and cons of DL for lab based classes see below.

In particular Wet lab-based science classes have been the most reluctant to convert to a DL format. There are several very valid reasons for this. Firstly, how can labs be developed for home use that are safe for the student and have ingredients to the lab that are legal to ship via traditional methods, yet still illustrate the original purpose of what the lab was intended for in the traditional academic setting. (Kelly, 1993) Also of concern, how can home based labs maintain validity in the eyes of professional scientists that may ultimately hire the student? How can students in the lab based DL class gain the experience of working with equipment that is too big or expensive to ship out for home use? These are all valid points that are being addressed by DL universities to bring the best possible solution to the student. (Talia, 2012)

**Advantages of distance learning for the student**

- Students take a more active role in their education and are more engaged in their learning (Hounshell and Hill, 1989)
- Students felt less pressure because they could learn at their own pace
- Students do not feel intimidated by being in “the lab” (Stieff and Wilensky, 2003)
- Increased flexibility of learning styles
- Increased flexibility of doing the lab, thus students can progress in the lab at their own pace. Also allows students to repeat before the exam to review. (Yang and Heh 2007)
- Students have the option of repeating labs over and over until they master the concepts
- Labs are typically done with chemicals experienced every day, thus taking the fear and mystic out of chemistry and allowing students a greater awareness of the chemical reactions that take place every day. (Patterson, 2000)
- No wasted time waiting for a reaction or experiment to come to completion. (Tatli, 2010)
- Students are better able to concentrate on experimental concepts and not equipment functionality or tools use which is most often a secondary effect of the traditional wet labs
- Allows each student to be engaged and work independently, in contrast most general chemistry lab settings have groups of students working on an experiment, which causes the students to gain a very compartmentalized view of the lab experiment. In other words most students within groups will work independently on a portion of the lab and will come together at the end to share results. This leads to a student population that understands a small portion of the lab but not the whole picture of the lab.
- Newer VL are bringing Avatars into the lab so that each student can have their own avatar (Tatli, 2010)
- Use of expensive balances can be alleviated by sending pre-weighed chemicals

**Disadvantages of distance learning**

- Initial up-front cost is much higher than traditional on site courses
- Safety and legal concerns over shipping chemicals hampers their efforts.
- Relies on students to be aware about safety more so than in a traditional classroom setting.
- Must have clearly written, un-ambiguous labs
- Students do not get “the lab feel” (Tatli, 2010)
- Labs are limited to non-dangerous, inexpensive versions of the ones done in a traditional in-class setting, with that said; these labs can still accomplish the task of teaching the fundamental of whatever subject is being taught.
- “Lacks credibility” in the eyes of pros that are used to only traditional brick and mortar schools. Also, students do not gain the knowledge of working in a real lab with real equipment.
- Lack physical sensations such as touching, smelling and seeing actual experiment (Tatli, 2010)
- Effect of pedagogical content for teaching virtual labs is not yet understood for most traditional labs

The institute conducting the DL version of the lab-based class also incurs advantages and disadvantages. One advantage is that the DL version of the lab based class is essentially self sustaining once it has been created and all of the problems have been worked out. With this the cost once it has been created is minimal to the institute (Tatli, 2010). Another advantage is that there is a minimal amount of waste when DL labs are used and no waste when virtual labs are conducted. One disadvantage to the institute is that there is a large amount of cost to set up the DL versions of lab based classes. With this large cost there is
also additional commitment required by the individuals that are creating the course. (Kennepohl, 1996)

The popularity of these DL versions of all academic classes can be seen anytime you go online and will continue to grow as prices come down for the setup of these classes. One factor influencing their popularity is that more and more people in the profession of science are starting to consider them as valid alternatives to a traditional brick and mortar education. With this validity the stigma of graduates from these institutions is declining and more of them are finding their way into the work force as equals, this in turn with have a positive effect on the enrolment of these institutions. Lab based sciences classes have only recently, in the last decade, found their way into the DL institute. The reasons outlined in this paper illustrate why they were slow to gain traction however it is the belief of the author that these initial hurdles have been overcome and that DL lab based science classes have gained traction and will continue to do so until the number of DL based science degrees rival that of traditional universities.

References

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Kent State University; Excellence in Action, http://www.kent.edu/dl/technology/dldef.cfm


ANNOTATED READINGS

- Authors report on a decade long study to implement Web-based content courses for in-service high school teachers. The courses used pedagogical content knowledge as a guiding principle for the development of their courses. They describe pedagogical content knowledge as a way of knowing the material and knowing ways to transfer that content in a teaching situation. The authors outline their design rational for the courses and how they implemented those courses over the internet. In the study the authors used a multi-state course design that involved participants from over 25 states including Hawaii. They close the paper with the project outcomes and issues related to the project participation, which included recruiting participants, academic honesty and factors that affected course completion.

- The authors describe the development of a distance learning general chemistry course for science majors. The paper is used to describe the different versions of the class and the labs that were used to perfect the distance learning model. One of the requirements for the lab is that it had to be conducted using materials that could be purchased in a hardware or grocery store and is based on what they called “kitchen chemistry” experiments, i.e. the experiments were no more dangerous than cooking. The majority of the paper is used to describe the student demographics, the class evaluation methods and the student outcomes for years one, two and three of the class offering. Year one of the class, what the authors call version one, was not a true distance learning class because the students were required to meet in lab every Saturday and were give weekly exams, i.e. was not as flexible as a typical DL class. Students enrolled in year one liked the class but disliked the weekly exams and Saturday labs. In years two and three, coined Version two by the authors, the class was a true distance learning course where everything was done at the student’s home.
The results of the study showed that while there was a high rate of attrition the students on average performed much better on chemistry standardized tests and laboratory practical’s than conventional brick and mortar chemistry students. The authors speculated that the higher rate of attrition was more due to the higher proportion of non-traditional older students enrolled in the course that had more family requirements on their time than due to an increased difficulty level of the DL course that would cause students to drop the course due to a lack of understanding with the material.

- The authors describe the use of a virtual 3-D laboratory to help students become familiar with the lab setting in order to overcome their fear of being in a real lab. A CD-ROM was given to students upon enrolling in a distance learning general chemistry course so that they could get a virtual feel for the lab. The DL course was conducted with an on campus version of the lab. This paper describes the results of two studies that looked at the effects of student use of the virtual 3-D lab on whether these students felt more prepared for their on campus laboratory sessions than students that did not use the virtual lab. Because of the voluntary use of the virtual labs the number of students that used the virtual lab was low. The results of the two studies found that in general the use of the 3-D virtual lab did nothing to overcome the fear and anxiety felt by incoming students for the real lab work. The authors speculated that student fear is not due to an unfamiliarity of the lab but with a lack of confidence in the material being taught and a lack of ability to do the mathematical calculations needed to do the lab correctly.

Hoole, D., Sithambaresan, M., (2003) Analytical Chemistry Labs with Kits and CD-Based Instructions as Teaching Aids for distance Learning. Journal of Chemical Education. 80(11), 1308-1310
- This paper describes how Analytical chemistry can be taught at home using web-based content or content delivered by CD coupled with an at home lab kit. The authors, whom teach in Sri Lanka, outline the need for a good distance education program in countries such as Sri Lanka who have been devastated by war. The paper outlines the labs that were conducted and the kit that was used for an in home alternative to a traditional setting. While the students could conduct the labs at their homes it was not a true distance learning environment because they had to go to the central headquarters complex for a basic safety orientation. However once this safety orientation was complete the students started the at home portion of the labs. Some of the labs completed were titrimetry, chromatography, separation techniques spectroscopy electrochemistry and others. Labs conducted in the home were similar but not identical to those conducted in the lab. The home labs had to illustrate the concepts of the labs without the dangerous aspects of the labs. So safety was a paramount for the home labs. The authors close with the advantages and disadvantages of the home base labs compared to their traditional counterparts.
Fozdar, B., Kumar, L. (2006) Teaching Chemistry at Indira Gandhi National Open University (IGNOU). Turkish Online Journal of Distance Education. 7(2) 80-89
- The Authors compare and contrast the difference for a bachelor’s degree in chemistry from the open, and online Indira Gandhi National Open University. They describe the criteria for delivering a laboratory based science degree through distance learning and condense it down to cost of equipment, chemicals and safety issues that hinder this mode of study. Criteria that make this mode of study popular among students are flexibility, innovation, use of newer technology, cost effectiveness and quality education materials. The authors also outline the main objective for providing distance learning, and they are to provide an opportunity for those people who might have missed the chance to get a degree in higher education. The main bulk of the paper is used to describe how IGNOU conducts its online distance learning and how they make it a viable option for traditional brick and mortar schools.

- The authors set up a controlled study to compare distance learning to traditional in class learning and whether DL could be applied to the organic chemistry classroom. They took great care in selecting a random population of students to determine which setting would result in the most informed students and the best overall performance. The authors outline the groups of students participating in the study and to show the similarity so that the results from the comparison can be directly compared and so that there is not inherent difference in student populations that would bias one group over the other. They then outline the variables in each study, i.e. instructors, off site and on site classrooms, lessons and labs taught and number of students in each group. The authors also describe how data was collected, overall performance was measured but also student perceptions and attitudes were also assessed, these were done using online and conventional questionnaires. The authors finished with the results of the study. In general, there was no significant difference for either the onsite and DL classes. However, the DL students felt like there was a significant amount of time wasted due to “technical difficulties”. With that said most students supported the DL version because they would not have been able to take the course without this option.

Phipps, L. R. (2013) Creating and teaching a Web-Based. University-Level Introductory Chemistry Course that Incorporates Laboratory exercises and Active Learning Pedagogies. Journal of Chemical Education (no page numbers assigned)
- The author describes how they took an introductory, chemistry course for non-majors and converted it to a web-based course. She compares and contrasts the difference between the on-campus version of the course and the web-based version of the course to include the difference in teaching strategies, lab methods and learning outcomes used in
the online course as opposed to the traditional course. The different student populations for each class were also described. The paper also describes the difficulties of converting the traditional course to a lab based class.

Wang, L (2009) Learning Chemistry Online. Chemical and Engineering News, 87(36) 97-99 - The author comments on the state of the distance learning in the chemistry fields in the United States and how Chemistry curriculum in this country has fallen behind in the DL arena. The author links the lack of online chemistry classes in this country because of a thought by most educators that chemistry has to be a “hand on learning experience” She also describes how some universities are trying to implement DL courses into their current curriculum by using more innovative techniques to express the material.