Computer Simulated Laboratory: Student Perceptions and Outcomes

Janelle M. Chiasera
The Ohio State University
1583 Perry Street
Columbus, Ohio 43210
Phone: 614-292-7303 Ext. 1#
Fax: 614-292-0210
E-mail: jchiasera@amp.osu.edu

Background

Academic administrators have kept a close eye on Clinical Laboratory Science (CLS) programs due to low enrollment and high cost per student. As a result, approximately 50% of our programs have closed over the past ten years resulting in a national shortage of our practitioners. Most of the programs that remain viable are not filled to capacity and are at an increased risk for closure. Therefore, educational programs are forced to find new ways to deliver education at a reduced cost and increase enrollment without sacrificing the quality of education.

Our Clinical Laboratory Science program is the most costly program in our school with the major contributor to the cost being our laboratory sessions. The labs we deliver are typically heavily laden with time, labor and cost intensive laboratory procedures primarily focused on the laboratory procedure and the psychomotor skills needed to complete that task. This was fine in the past because the clinical laboratory needed professionals that could perform an array of manual laboratory procedures effectively and efficiently. However today, our professionals very rarely sit at a laboratory bench and perform manual testing. Today, our professionals are required to interact with high-tech automated instrumentation specifically designed to replace the manual testing procedures we used to perform. This changed the role of the CLS professional to one that can now work in a laboratory centered around highly automated instrumentation. Our laboratories need entry-level professionals that are cognizant of instrumentation principles, errors and trouble-shooting, and data reporting and accuracy. Their role relies more on their ability to critically think, problem solve and trouble-shoot rather than relying on the ability to perform test procedures effectively and efficiently. Although we have seen this change in the workforce there hasn't been the same change in our educational curricula. We are still teaching laboratories that are focused on labor and time intensive laboratory procedures. The use of technology in our labs will allow us to present our students with an environment focusing more on developing critical thinking and problem-solving skills as the student interacts with the simulation on various content levels.

Because blood pH and arterial blood gas analysis is computerized and effectively automated in the clinical laboratory and because it is the most difficult and costly laboratory to prepare for our students, we believe that a computer-simulated laboratory can replace our traditional wet laboratory. The computer simulation will allow the student to interact with a blood gas analyzer at the computer level without being fearful of adversely affecting costly instrumentation and/or supplies. It will also allow the student time to focus on problem-solving and critical thinking skills that were poorly developed in our wet labs because the student was so focused on performing the lab procedure correctly. It will allow faculty to present the student with a number of interesting situations that would better foster an environment of inquiry-based learning for the student. Last, it would significantly decrease the chemical and biohazardous waste, time and labor associated with our wet laboratories.

Focus/Research Questions:

The focus of this study is on the design and development of a computer-driven blood gas laboratory for use in three university clinical laboratory science programs in the mid-west. The computer-driven laboratory is meant to replace time consuming, cost ineffective wet laboratories that clinical laboratory science educators currently use.

The specific research question addressed by this study is as follows: Under what conditions do distance learning opportunities lead to increased learning as defined by traditional and non-traditional measures, with results of specific application to Ohio's higher education institutions?

<u>Projects specific questions</u>:

1) Does a computer-simulated laboratory result in the same learning outcomes as a traditional wet laboratory as measured by post-test scores?
2) Is there a difference in post-test scores between three institutions that use a computer-simulated laboratory?
3) Does a computer-simulated laboratory achieve the seven good practices of undergraduate education developed by Chickering and Gamson in 1987?
4) What are the perceptions of students that use the computer-simulated laboratory exercise?
5) What are the perceptions of students that complete a traditional wet laboratory in blood pH and arterial blood gases?

The computer-driven blood gas laboratory design:

With our rationale clearly in sight, we developed the computer laboratory with the intention of replacing the wet laboratories educators currently use. The laboratory was designed with all directions and options on-line, that is, the student has all the information needed to complete the lab on the computer module, with the intent to have the module be a self contained unit. The student merely needs to log onto the website to begin the computer module. The website is divided into 6 chapters that the students will work through at their own pace. The first two pages of the website contain introductory information as well as objectives and prerequisite knowledge needed to complete the module. See Figures A and B. Chapters 1-5 contain review information for the student to refresh their memory about blood gas analysis, electrochemistry, control verification and sample collection and preparation. See Figures C and D. An additional feature we added to the review chapters is a section called “test you knowledge” which includes a series of questions the student can answer to assess the knowledge of the current chapter they are working on. The answers to the questions are given to the student as they click the mouse on the answer button on the webpage. See Figures E and F for an example of the link to the “test your knowledge” section and the chapter “test you knowledge” questions. Upon completion of the chapters and the “test you knowledge” sections the students can decide if they want to continue on to the next chapter or reread or repeat the activity/ies of the current chapter. At chapter 6 the student is given the opportunity to look at the inside workings of a blood gas instrument as well as look at a textual and animated description of how blood gas electrodes operate. See Figures G and H. In addition, chapter 6 also includes 4 cases that the students will work through with study questions involved with each case. Each case has a start button and syringe so the student can initiate the blood gas analysis just as they would in an automated laboratory environment. See Figure I. Each case also has a series of questions that ask the student to interpret data, problem solve, and critically think. The student is given the opportunity to answer the questions and then check their work by viewing the answers after they complete the text box. See Figure J. The computer module was tested for accuracy and content by a panel of 5 experts in the field of clinical chemistry. In addition, it was tested for completeness and ease of use by a panel of 8 former clinical laboratory science students.

Methodology:

Subjects: 42 students from three university-based Clinical Laboratory Science programs were randomly assigned to two groups (A and B). Group A students (approximately 20) received the blood gas computer module while group B students (approximately 22) received the scheduled traditional wet laboratory established by that institution. Both groups sat through the same lecture component given by the institutions instructor. Upon completion the group was randomly divided and half were assigned to complete the computer laboratory while the other half completed the original assigned traditional wet laboratory. The principle investigator was present at each site while the computer lab was being completed for technical support only.

Data collection: Upon completion of the computer-simulated laboratory or wet laboratory both groups were administered (by individual site) an identical post-test and qualitative questionnaire. The post-test was prepared from a set of objectives developed by the investigator. The post-test consists of 20 multiple-choice questions covering the analytical theory and principles of electrochemistry. These questions were developed by the investigators and were reviewed for accuracy and content by the university program instructors that piloted the module. The post-test was piloted on 8 students for ease of use. See Figure K for an example of the format of the posttest questions. A qualitative questionnaire was developed by the investigators in order to reveal the perceptions of the student and the meanings they assigned to the task (wet laboratory or computer simulation). We used the Flashlight Program to create a questionnaire to assess how well the computer simulation can implement the seven good practices of undergraduate education developed by Chickering and Gamson in 1987.

Results:

Posttest scores and questionnaire results were entered into SPSS for data analysis. To determine the effect of a computer lab on posttest scores between the two groups we performed a comparison of the means. We found no significant difference when we compared the treatment group (n=20, mean 18.56) and the traditional wet laboratory (n=22; mean 19.0; p = 0.624). We found no significant difference between the three groups (group 1, n=14, mean 18.8; group 2, n=15, mean 19.3; group 3, n=13, mean 19.2) on post test scores by an analysis of variance (p=0.949). In addition, we co-varied for GPA in case any changes seen would be due to GPA differences in the groups and found there was no impact of GPA on posttest scores (p=0.365). We ran descriptive statistics on the questionnaires to reveal the perceptions of the students toward the wet laboratory and the computer laboratory. The results for the questionnaires are as follows: both groups agreed that the laboratory instruments were easy to use (mode=1 (computer lab); mode=2 (wet lab)); both groups disagreed that they missed important information because the instrument didn't work (mode=4 (computer lab); mode=3 (wet lab)); both groups agreed that the lab was appropriate for the assigned task (mode=2 (computer lab); mode=2 (wet lab)); both groups disagreed that they were at a disadvantage because they lacked technical skills (mode=3 (computer lab); mode=3 (wet lab)); both groups agreed with the statement that they were able to learn at their own pace (mode=2 (computer lab); mode=2 (wet lab)); both groups agreed with the statement that they were able to learn the terms and concepts involved with blood gas analysis (mode=2 (computer lab); mode=2 (wet lab)); both groups disagreed with the statement that they missed important information because they spent too much time trying to figure out the equipment (mode=3 (computer lab); mode=3 (wet lab)); both groups agreed with the statement that they acquired skills and knowledge that would be useful in their profession (mode=2 (computer lab); mode=2 (wet lab)); both groups agreed that their experience with the lab helped them better understand blood gas analysis (mode=2 (computer lab); mode=1 (wet lab)); both groups disagreed with the statement that they would not recommend this lab to other students (mode=3 (computer lab); mode=3 (wet lab)); both groups agreed that the skills and knowledge learned in the lab would help them in their profession (mode=2 (computer lab); mode=2 (wet lab)); both groups agreed that the labs helped them work through a process to solve problems (mode=2 (computer lab); mode=2 (wet lab)); both groups felt comfortable performing the laboratory tasks (mode=1 (computer lab); mode=2 (wet lab)); both groups enjoyed using the laboratory equipment (mode=1 (computer lab); mode=2 (wet lab)); both groups agreed that they could apply what they learned in the lab to "real world" problems (mode=2 (computer lab); mode=2 (wet lab)); both groups agreed that they understood what they were expected to learn (mode=1 (computer lab); mode=2 (wet lab)); the computer group strongly agreed that the computer lab offered a variety of ways to assess their learning (mode=1), the wet lab group disagreed that the wet lab offered a variety of ways to assess their learning (mode=3); finally, both groups agreed that they were overall satisfied with the laboratory they participated in (mode=2 (computer lab); mode=2 (wet lab)). Refer to table 1 (computer laboratory) and 2 (wet laboratory) for the tables of results.

Discussion:

From this study we have concluded that, with the population of students studied, there was no difference in learning outcomes between those students that took a traditional wet laboratory and those students that completed the computer laboratory. Therefore, the computer laboratory could be used as an alternative to the current labor, cost and time intensive wet laboratories. We found no significant difference between institution in posttest scores implying that the computer module worked as well as a traditional wet laboratory at all the institutions we studied. Finally, students seemed to have overall good perceptions of the computer laboratory as well as the traditional wet laboratory. The only difference between the two groups was that the computer users felt they had more opportunities to assess their learning throughout the lab than the wet laboratory users.

Conclusion:

Technology has significantly impacted our lives on several different levels and has resulted in change almost on a daily basis. The students we are educating have grown up with technology and are used to an environment that is fast-paced, convenient and available to them at their fingertips. As educators, we need to take our education environment to a level that will foster that technological environment and suit the needs of our students all at a reduced cost without sacrificing the quality of our education. We believe that the use of technology in our laboratories will give us the opportunity to meet the needs of our students and lower the cost and time associated with our traditional laboratories without sacrificing the quality of that education. This computer laboratory will allow us the ability to provide open access to our labs not only to our students, but to students at a distance as well as students in other health related disciplines that rely heavily on electrochemistry i.e. circulation technology students, respiratory therapy students, medical students, and anesthesiology students.

Final comment:

In an effort to make the study more valuable in terms of power, data will continue to be collected for the next 2 months in an effort to increase the sample number. All data collected will be added to the existing data, the statistics rerun, and the conclusions reported as an addendum.

Figure A: Introductory page of website

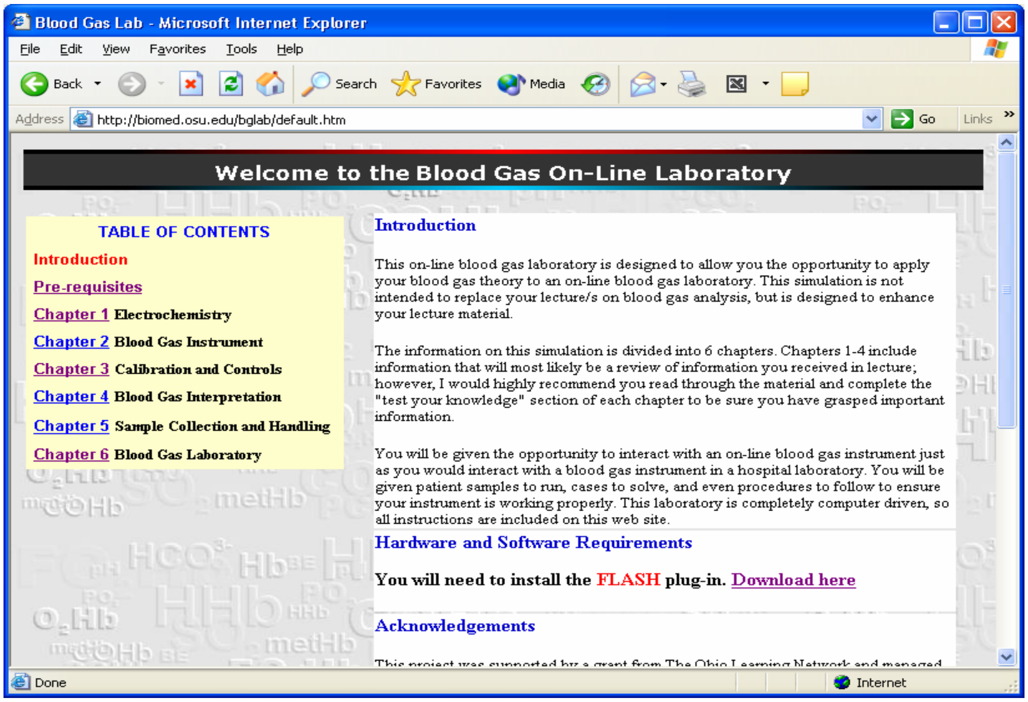


Figure B: Pre-requisite page of website

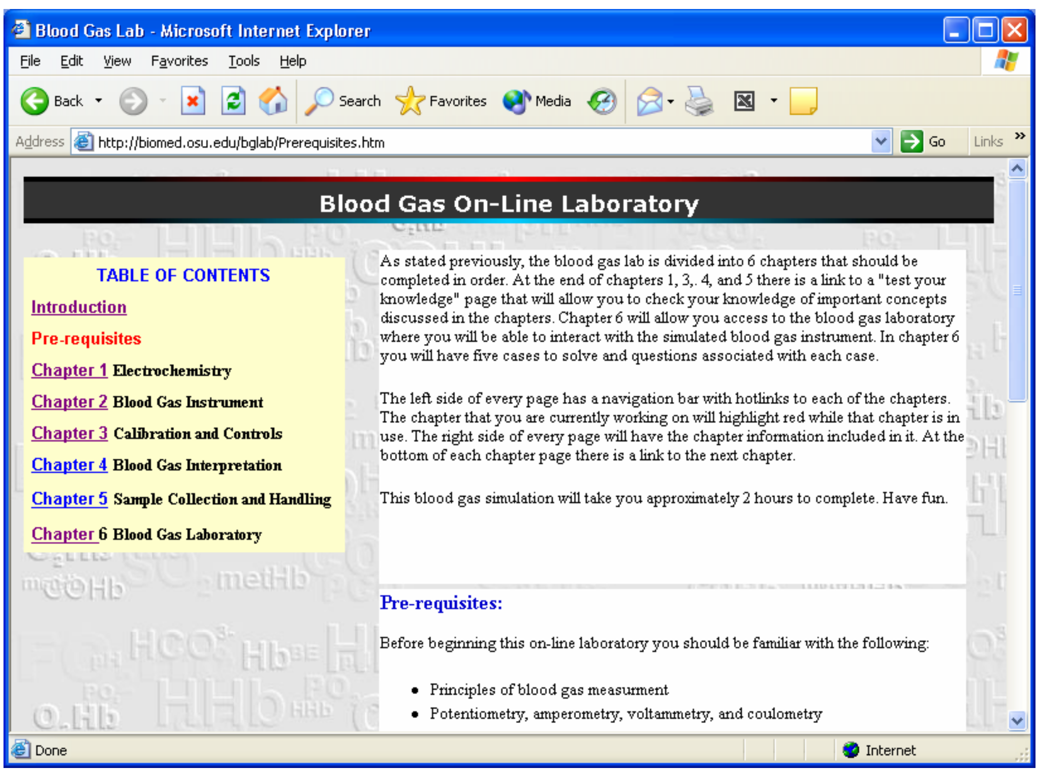


Figure C: **Chapter 2 example**

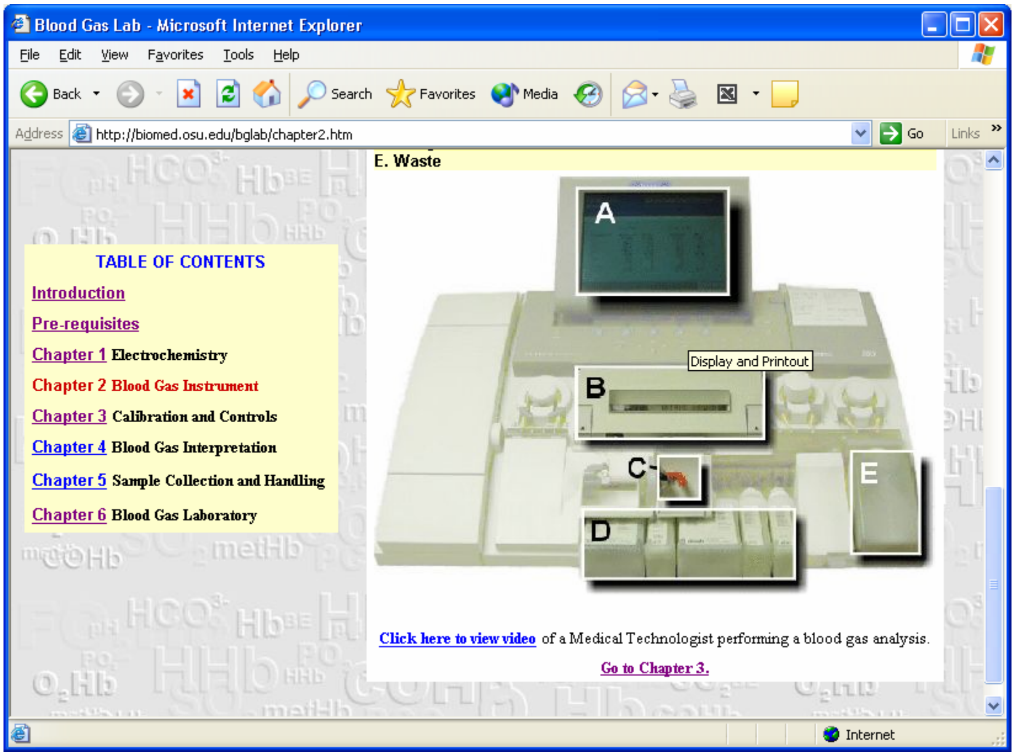


Figure D: **Chapter 3 example**

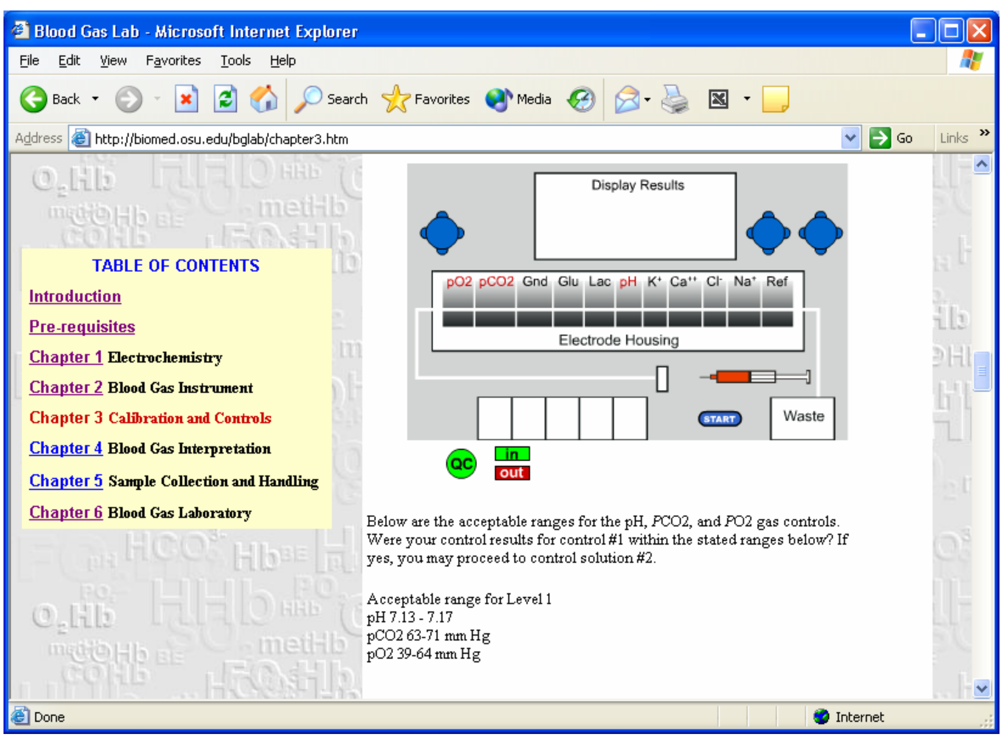


Figure E: **Chapter three "test your knowledge" link**

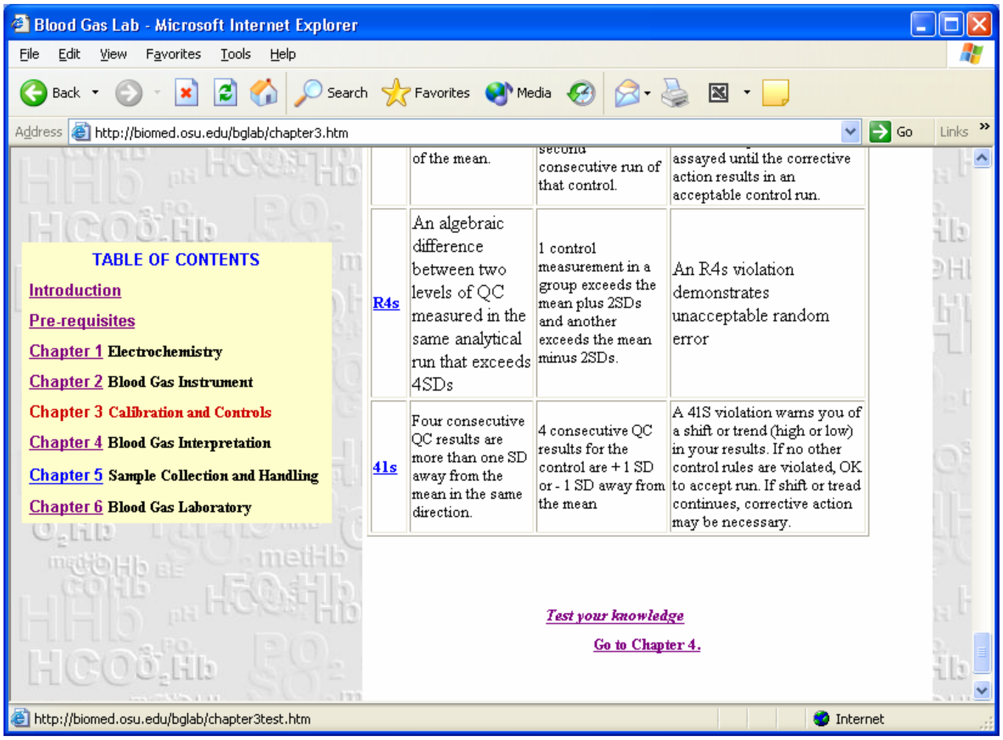


Figure F: **Chapter three "test your knowledge" questions**

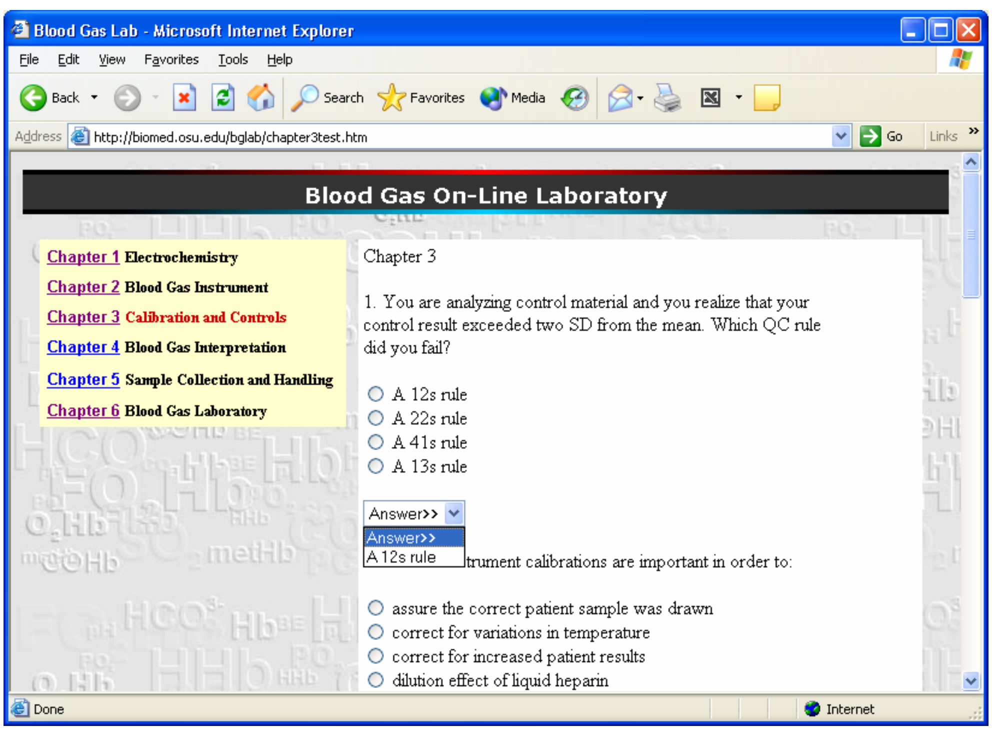


Figure G: **Animated PCO2 electrode with text description**

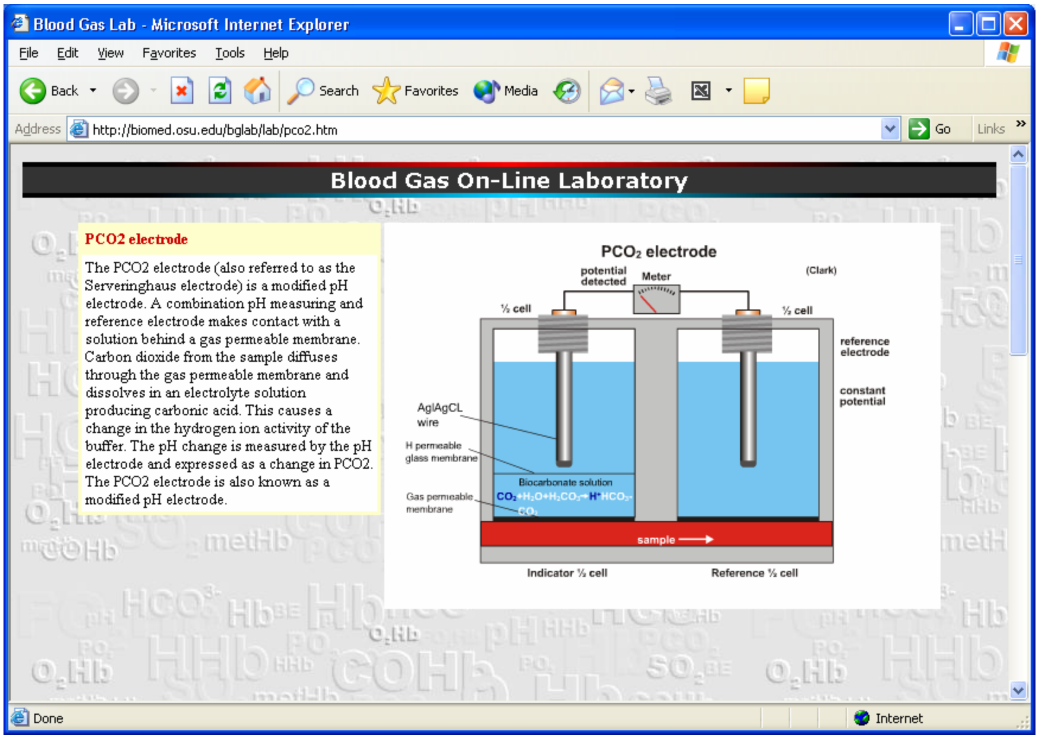


Figure H: **Inside of blood gas instrument**

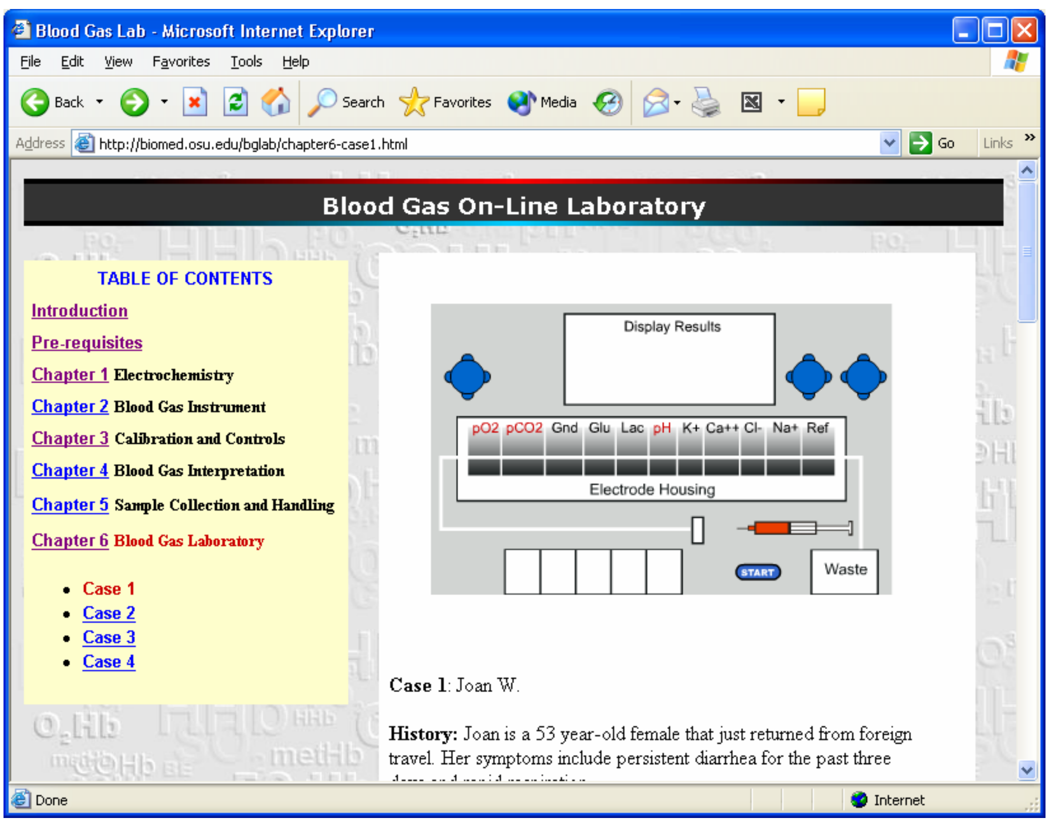


Figure I: **Functional instrument with syringe and start button**

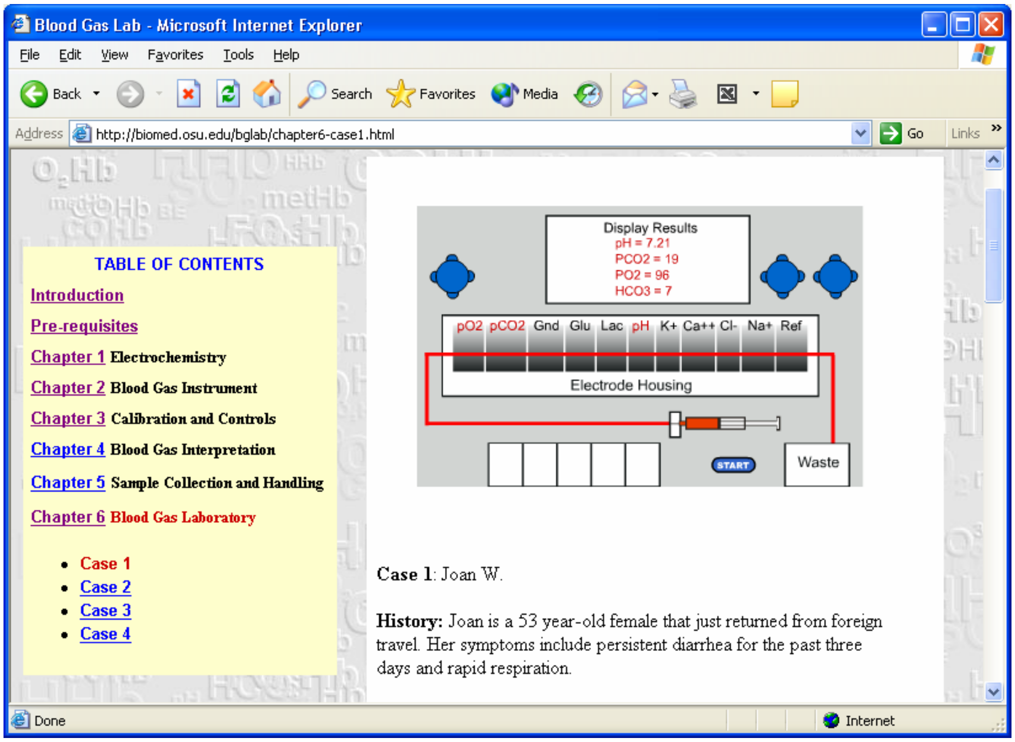


Figure J **Case questions with answers exposed**

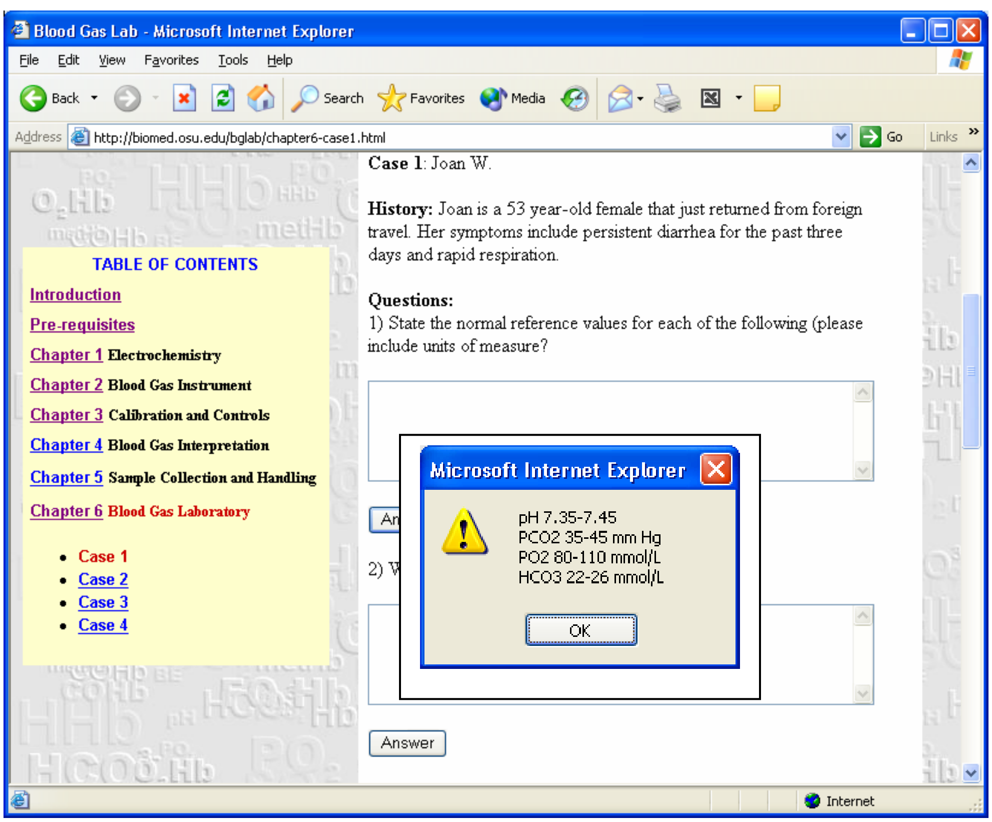


Figure K: **Posttest example questions**

1. An arterial blood syringe in a plastic container is stored in ice water for 60 minutes prior to blood gas analysis. Which of the following changes is likely to occur?

   A PO_2 decreases
   B PO_2 increases
   C PCO_2 increases
   D HCO_3 increases

2. You receive an arterial blood gas syringe and notice that the cap is missing. Which of the following changes are likely to occur?

   A Increased CO_2; increased O_2
   B Increased CO_2; decreased O_2
   C Decreased CO_2; decreased O_2
   D Decreased CO2; increased O_2

3. Which of the following blood gas parameters is a calculated parameter?

   A pH
   B PCO_2
   C HCO_3
   D PO_2

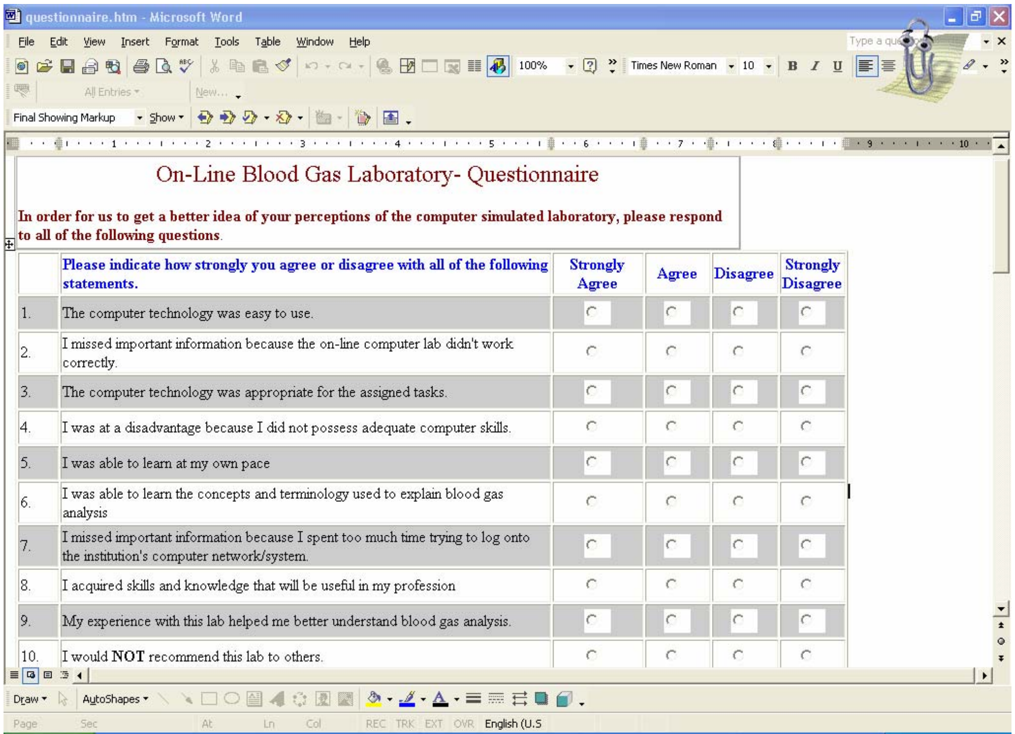
4. Coulometry is used to measure:

   A chloride
   B pH
   C bicarbonate
   D PO_2

5. A potentiometric electrode that measures an analyte that passes through a selectively permeable membrane and rapidly enters into equilibrium with an electrolyte solution is a:

   A pH electrode
   B PCO_2 electrode
   C PO_2 electrode
   D HCO_3 electrode

Figure L: Questionnaire



On-Line Blood Gas Laboratory- Questionnaire

In order for us to get a better idea of your perceptions of the computer simulated laboratory, please respond to all of the following questions.

	Please indicate how strongly you agree or disagree with all of the following statements.	Strongly Agree	Agree	Disagree	Strongly Disagree
1.	The computer technology was easy to use.				
2.	I missed important information because the on-line computer lab didn't work correctly.				
3.	The computer technology was appropriate for the assigned tasks.				
4.	I was at a disadvantage because I did not possess adequate computer skills.				
5.	I was able to learn at my own pace				
6.	I was able to learn the concepts and terminology used to explain blood gas analysis				
7.	I missed important information because I spent too much time trying to log onto the institution's computer network/system.				
8.	I acquired skills and knowledge that will be useful in my profession				
9.	My experience with this lab helped me better understand blood gas analysis.				
10.	I would **NOT** recommend this lab to others.				

Table 1: Questionnaire results for computer module group (1=strongly agree; 2=agree; 3=disagree; 4=strongly disagree)

Question	N	Minimum	Maximum	Mode
1	20	1	2	1
2	20	3	4	4
3	20	1	3	2
4	20	3	4	3
5	20	1	2	2
6	20	1	2	2
7	20	3	4	3
8	20	1	2	2
9	20	1	2	2
10	20	3	4	3
11	20	1	3	2
12	20	2	3	2
13	20	1	1	1
14	20	1	2	1
15	20	1	3	2
16	20	1	1	1
17	20	1	1	1
18	20	1	3	2

Table 2: Questionnaire results for wet laboratory

(1=strongly agree; 2=agree; 3=disagree; 4=strongly disagree)

Question	N	Minimum	Maximum	Mode
1	22	1	2	2
2	22	3	4	3
3	22	1	2	2
4	22	2	4	3
5	22	2	3	2
6	22	1	2	2
7	22	3	4	3
8	22	1	2	2
9	22	1	2	1
10	22	3	4	3
11	22	2	2	2
12	22	1	3	2
13	22	2	3	2
14	22	1	2	2
15	22	2	2	2
16	22	2	3	2
17	22	2	3	3
18	22	1	2	2