APPENDIX 1: THE ADAPTED ATTITUDE TOWARDS CHEMISTRY (ATC) QUESTIONNAIRE

Section A: Demographic Information (Please place a tick next to the correct choice)

Gender	Female	
	Male	
Age	20-21	
	22-23	
	24-25	
Sponsorship	Funza Lushaka	
	NSFAS	
	Self	
	Others (Please Specify)	

Section B: Adapted Attitude towards Chemistry (ATC) questionnaire items.

SD= Strongly Disagree (1), D= Disagree (2), Na/Nd= Neither agree Nor disagree (3), A= Agree (4), SA= Strongly Agree (5).

ATC Items	Responses				
1. I like chemistry course more than the others.	SD	D	Na/Nd	A	SA
2. Chemical symbols are like Chinese to me.					
3. I would like to have chemistry lessons more often.					
4. The progress of chemistry is responsible for many environmental problems.					
5. Chemistry knowledge is useful to interpret many aspects of our everyday life.					

6. Chemistry module is not related to the other modules.					
7. I solve chemistry exercises very easily.					
8. Chemistry module helps the development of my conceptual skills.					
9. During chemistry lessons, I am bored.					
10. Chemistry knowledge will be useless after my graduation.					
11. Chemistry knowledge is essential for understanding other courses.					
12. The progress of chemistry improves the quality of our lives.					
13. Chemistry is our hope for solving many environmental problems.					
14. My future career is independent from chemistry knowledge.					
15. The progress of chemistry contributes to the development of a country.					
16. Chemistry is a very sophisticated subject for our compulsory education.					
17. I make many efforts to understand chemistry.					

18. I find the use of chemical symbols easy like walk-over.					
19. The profession of a chemistry teacher is one of the less attractive.					
20. Every citizen must have chemistry knowledge.					
21. I hate chemistry modules.					
22. Chemistry knowledge is necessary for my future career.					
23. I would like to have fewer chemistry lessons.					
24. I understand the chemistry concepts very easily.					
25. I find the chemistry module very interesting.					
26. When I try to solve chemistry exercises, my mind goes blank.					
27. Students are indifferent to chemistry applications.					
28. The progress of chemistry worsens the conditions of living.					
29. I am incapable of interpreting the world around me using chemistry knowledge.					

30. I would like to become a chemistry teacher when I finish school.					

Appendix 2: Semi-structured interview (Student 1 = S1)

Instructions

Please respond honestly to the following questions and be as explicit as possible. This session should take at least 30 minutes of your time. If at any time you will uncomfortable with the question please take some time to pause, ask the researcher to explain the question further. You are welcome to elaborate the points you make using experience-based responses.

R= Researcher, S= Student

Speaker	Response
R	How did you find the PhET simulation laboratories and the activities? Provide a brief explanation.
S	I really enjoyed investigating my chemistry concepts with the simulations. It felt like I was playing a game with multiple levels of difficulty.
R	Please be more explicit on what you refer to as multiple levels of difficulty.
S	The activities, especially with balancing equations, were well-scaffolded from easy equations at first then to very difficult ones that needed more thinking,
R	After the intervention classes, did you need help with the activities associated with the PhET simulation laboratories? Explain your reasoning.
S	Personally, I found that I could self-direct my learning of the chemistry concepts and that was the best thing for me. I did not really need any assistance as there are little cues embedded in the simulations that guide you with the task.
R	What were some of the gains you observed with using PhET simulations?
S	You know with chemistry experiments there is always a danger factor. The simulations eliminated this fear. The best part was that I could do my work from the comfort of my hostel without going to the campus anytime of the day or night.
R	In terms of content visualisation and assimilation where there any changes?
S	Oh yes! I found that the main benefits for me was improved visualisation of the interaction between molecules. Also with the tasks on transmittance and absorbance, it really made even more sense when I engaged in the simulations, changing the concentrations of the various solutions that where given.
R	What were some of the disadvantages of using the PhET simulation laboratories?
S	The simulations are really a great tool to enhance understanding of certain concepts. However I find that science process skills cannot be learned when relying only on the simulations. I feel the learners I will teach as a chemistry

	need the authenticity that is associated with traditional hands- on laboratory settings.
R	Did the PhET simulations improve your conceptual understandings of the learned chemistry concepts in any way?
S	105% they did.
R	Please elaborate on this. How specifically where the simulations helpful in improving your conceptual understandings?
S	One of my problems have always been understanding the relationship between concentration of a solution, absorbance and the transmittance of light through such a solution. With the PhET simulations I could really see the different effects of increasing or reducing the concentration of solution on absorbance and transmittance of light.
R	In your practice as an aspiring chemistry teacher will you consider incorporating PhET simulations when teaching certain abstract concepts?
S	The simulations are an excellent tool for complementing chemistry learning. So I will actually blend the PhET sims in my teaching. What I am not quite sure is whether I will have the relevant simulations to cover all the anticipated abstract concepts I will be teaching.
R	Do you have any advice on how simulations can be improved to meet learning needs for South African classrooms?
S	Yeah, like I mentioned I am not sure the simulations provided by the university of Colorado will be able to cater for the specific learning needs of the South African learner based on the CAPS curriculum. I believe that we could tailor make our own simulations for the CAPS curriculum.

APPENDIX 3: Semi-structured interview (Student 7 = S7)

Instructions

Please respond honestly to the following questions and be as explicit as possible. This session should take at least 30 minutes of your time. If at any time you will uncomfortable with the question please take some time to pause, ask the researcher to explain the question further. You are welcome to elaborate the points you make using experience-based responses.

R= Researcher, S= Student

Speaker	Response
R	How did you find the PhET simulation laboratories and the activities? Provide a brief explanation.
S	They are highly interactive and have a game-feel to them which I actually enjoyed. While learning I felt like I was playing a game where I had to win.
R	After the intervention classes, did you need help with the activities associated with the PhET simulation laboratories? Explain your reasoning.
S	I could read and understand the instructions which boosted my ability to single-handedly solve chemistry problems. I did not really need to ask many questions along the way. What I was mainly applying was some critical thinking.
R	What were some of the gains you observed with using PhET simulations?
S	The ability to repeat the simulations, try different things and even get some data while trying these different simulations was really amazing. You try different things in the virtual laboratories without fear of spoiling anything
R	What do you mean when you refer to getting some data?
S	In the Faraday's law experiment I simply altered the concentration of a solution from low to high and recorded the associated absorbance and transmittance on a data table and analysed. This helped me to confirm a hypothesis I earlier stated.
R	What were some of the disadvantages of using the PhET simulation laboratories?
S	The PhET simulation 2D bonding structures could create misconceptions in the way they are represented.
R	How do you mean? Please elaborate.
S	The rigidity of the represented bonds in compounds and molecules within the stimulations hindered one‘s ability to visualise inter and intra-molecular bond interactions in a chemical reaction between two reactant. I feel generally representation of chemical interactions is problematic.
R	Did the PhET simulations improve your conceptual understandings of the learned chemistry concepts in any way?

S	That for me was one of the main benefits of the virtual earning. The visualisation improved hence my ability to remember the aspects we first did during the lecture. I really which I could have simulations for all the other difficult organic chemistry aspects.

Introduction

R	Have you looked at the PhET website and have not found simulations on some of the topics that challenge you?
S	Yeah, but I am not quite sure I really checked extensively. I will make a mental note to do this again.
R	In your practice as an aspiring chemistry teacher will you consider incorporating PhET simulations when teaching certain abstract concepts?
S	I will definitely be including these simulations in all the topics that have a simulation freely available for my use like the PhET simulations. My only worry is that learners will not have a feel of the real thing while working in a virtual laboratory.
R	Do you have any advice on how simulations can be improved to meet learning needs for South African classrooms?
S	I feel that for the South African context an opportunity should be given to teachers and learners to formulate their own simulations to cater for diverse learning needs. I also desire that the associated activities for the different simulations be compliant with the CAPS assessment standards.

APPENDIX 4: PhET Computer Simulation Activity: Acid-Base Solutions

1. Take a few minutes to **play** with the sim (http://phet.colorado.edu/en/simulation/acid-base-solutions). Check out both the Introduction and Custom Solution tabs. **Explore** what factors affect pH. **List** the factors you found that affect pH.

Investigating Concentration Changes

2. a. **Create** a strong acid solution in the "Custom Solution" tab.
   b. **Draw** bar graphs for Initial and Equilibrium concentrations.
   Hints: No calculator needed – try the 'Equilibrium Concentration' view.
   Don't forget to label your graphs!

Initial Concentrations	Equilibrium Concentrations

   c. What equilibrium concentrations are affected by changing the initial concentration?

3. a. **Create** a weak acid solution in the "Custom Solution" tab.
   b. **Draw** bar graphs for Initial and Equilibrium concentrations.
   Hints: No calculator needed – try the 'Equilibrium Concentration' view.
   Don't forget to label your graphs!

Initial Concentrations	Equilibrium Concentrations

   c. What equilibrium concentrations are affected by changing the initial concentration?

4. Are your results for the strong and weak acid in questions 2 and 3 consistent with the definition of strong and weak acids?

Investigating the Effects of Acid Strength and Concentration

5. a. What does the ‘strength’ slider (in the sim) effect?

   b. What does the term ‘strength’ mean? (In your own words)

6. How does strength affect the pH of acids?

7. How does initial concentration affect the pH of acids?

8. a. Is it possible for a solution of weak acid and a solution of strong acid to have the same pH? Design and carry out an experiment using the simulation to answer this question. What are your results?

   b. What was your strategy for testing whether a solution of strong acid and a solution of weak acid can have the same pH?

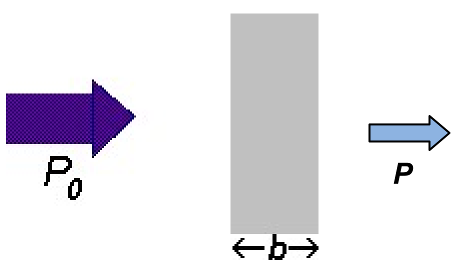
APPENDIX 5: Beer's Law - Introduction Activities

Many compounds absorb ultraviolet (UV) or visible (Vis.) light. When dissolved in water, the absorption of some of the frequencies (colors) of light causes them to transmit others, and the solutions are thus colored. For example aqueous Cu^{2+} solutions often *appear* blue, because the Cu^{2+} ion *absorbs* visible light in the 600 – 650nm range.

Table 1: Absorbed Wavelength, Absorbed Color, and Perceived Color

Absorbed Wavelength (nm)	Absorbed Color	Perceived (Transmitted) Color
400	violet	green - yellow
450	indigo	yellow
480	blue	orange
490	blue-green	red
530	green	purple
570	yellow-green	dark blue
600	orange	blue
650	red	green

The diagram below shows a beam of monochromatic radiation of radiant power P_0, directed at a sample solution. Absorption takes place and the beam of radiation leaving the sample has radiant power *P*.



The amount of radiation absorbed may be measured in a number of ways:

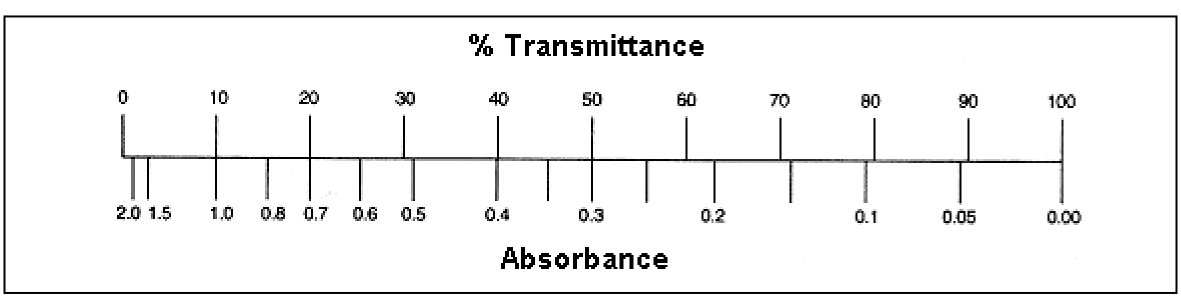
Transmittance, $T = P / P_0$
% Transmittance, $\%T = 100\ T$

Absorbance,

$A = \log_{10} P_0 / P$
$A = \log_{10} 1 / T$
$A = \log_{10} 100 / \%T$
$A = 2 - \log_{10} \%T$

The last equation, $\boldsymbol{A = 2 - \log_{10} \%T}$, is worth remembering because it allows you to easily calculate absorbance from percentage transmittance data.

The relationship between absorbance and transmittance is illustrated in the following diagram:



So, if all the light passes through a solution *without* any absorption, then absorbance is zero, and percent transmittance is 100%, and the solution appears colorless. If all the light is absorbed, then percent transmittance is zero, and absorption is infinite.

Beer's Law

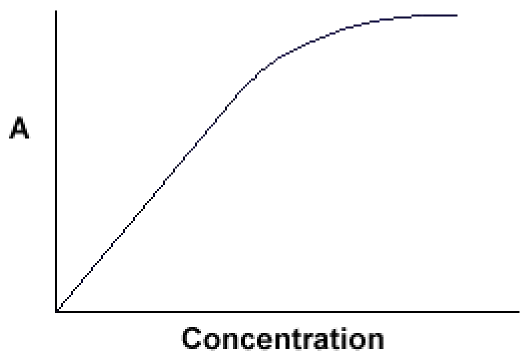
Now let us look at Beer's law - the equation representing the law is straightforward:

$$A = \varepsilon bc$$ *(on the AP test reference sheet you will see this written as* $A = abc$*)*

Where A is absorbance (no units, since $A = log_{10} P_0 / P$)
ε is the molar absorbtivity with units of M^{-1} cm^{-1}
b is the path length of the sample - that is, the path length of the cuvette in which the sample is contained. We will express this measurement in centimeters.
c is the concentration of the compound in solution, expressed in M

The reason why we prefer to express the law with this equation is because absorbance is directly proportional to the other parameters, as long as the law is obeyed. We are not going to deal with deviations from the law.

A = εbc tells us that absorbance depends on the total quantity of the absorbing compound in the light path through the cuvette. If we plot absorbance against concentration, we get a straight line passing through the origin (0,0).



Note that the Law is not well obeyed at high concentrations. This deviation from the Law is not dealt with here.

The linear relationship between concentration and absorbance is both simple and straightforward, which is why we prefer to express the Beer-Lambert law using absorbance as a measure of the absorption rather than %T.

Adapted from: http://teaching.shu.ac.uk/hwb/chemistry/tutorials/molspec/beers1.htm

Beer's Law - Lab

PURPOSE
The purpose of this laboratory activity is to determine the concentration of an unknown copper (II) sulfate solution.

THEORY
You will be using a colorimeter. In this device, light from a light emitting diode (LED) will pass through a solution placed in a cuvette inside the colorimeter. The light that passes through the solution will strike a photocell. **A higher concentration of the colored solution absorbs more light and transmits less light than a solution of lower concentration.** The computer-interfaced colorimeter monitors the light received by the photocell as either an absorbance or a percent transmittance value.

The amount of light that penetrates the solution and strikes the photocell is used to compute the absorbance of each solution. When a graph of absorbance vs. concentration is plotted for a series of standard solutions, a direct relationship should result. The direct relationship between absorbance and concentration for a solution is known as Beer's law.

In this experiment, you will generate a standard plot of absorbance versus concentration using colored solutions of known concentration. When a graph of absorbance vs. concentration is plotted for the standard solutions, a linear (straight line) relationship should result.

Beer's Law - Lab Data Sheet

Trial	Volume (mL) 0.4M $CuSO_4$	Volume (mL) H_2O	Molarity	% Transmittance	Absorbance ($A = 2-\log_{10} \%T$)
1	2	8			
2	4	6			
3	6	4			
4	8	2			
5	~10	0			
unknown					

Calculations:

a) The dilution calculation, including units, for Trial 1

b) The absorbance calculation for Trial 1

c) Solving for the molarity of the unknown sample, including units, using the formula for the best fit line from the graph.

Beer's Law Colorimetry Lab Data

1. Using the dilution equation $M_1V_1 = M_2V_2$, calculate the $[Cu^{2+}]$ for each of the trials.

2. Using the measures % transmittance for each sample, calculate the absorbance for each trial. *(Note: do NOT move the decimal in the percent transmittance, leave it as a number between 1 – 100.)*

3. Open Graphical Analysis from the start menu.

4. Enter your data from your lab sheet, plotting molarity on the x axis and absorbance on the y axis. Label the axes appropriately.

5. Choose "Linear Fit" from the "Analyze" menu to plot the best fit line for your data.

6. Using the equation given for the best fit line and the measured absorbance for the unknown sample, calculate the molarity of your unknown.

What you should turn in…

1) The lab data sheet with the data table complete.

2) The work shown for

   a) The dilution calculation, <u>including units</u>, for Trial 1

   b) The absorbance calculation for Trial 1

   c) Solving for the molarity of the unknown sample, <u>including units</u>, using the formula for the best fit line from the graph.

3) A printout of the graph of absorbance vs. molarity.

NEATNESS ALWAYS COUNTS