Teaching Grade 10 Science Using an Inquiry Approach

Inquiry Lab – Chemical Reactions

INTRODUCTION/RATIONALE

The following activity focusses on an inquiry-based approach to learning. This was done for two main reasons. First, the approach in teaching science is shifting from the traditional (teacher-centred) classroom to a constructivist (student-centred) focus, and secondly, the new Ontario Science curriculum is centred on an inquiry-based approach that needs to be woven into every unit.

Presently, most high school science classrooms take the 'traditional' approach to learning. That is, students are viewed as 'blank slates' onto which teachers etch new information and concepts (Llewellyn, 2005). In science, these classrooms are teacher directed and 'prescription' labs are provided for students to confirm information they have been taught. In this environment, students have minimal opportunities to develop their problem solving skills and use their creativity. However, recent educational studies have shown that inquiry-based learning develops a greater understanding of course material and enhances problem solving skills. Due to this, many science teachers are shifting their approach from 'traditional' to 'constructivist'. A teaching environment that uses a constructivist approach views students as thinkers and provides them with situations to use their creativity to solve various problems. In constructivist classrooms, teachers become a facilitator, allowing students to explore and problem solve a variety of concepts. Studies have shown that when a constructivist approach is used in the classroom, students improve in both depth of their understanding and in their thinking and problem solving skills (Llewellyn, 2005). In addition, inquiry-based learning also allows for the active exploration which uses critical, logical, and creative thinking skills (Llewellyn, 2005). Furthermore, in constructivist classrooms students have opportunities to complete 'authentic science' by generating questions to be solved, spending time brain storming possible solutions, generating hypotheses, developing procedures, gathering and recording data, and communicating their findings (Llewellyn, 2005).

The new Ontario Science curriculum is designed to have an inquiry-based approach woven throughout all units in science. An inquiry-based unit such as this meets the requirements of the strand entitled, 'Scientific Exploration Skills and Exploration of Careers'. Using an inquiry-based approach will meet the following curricular expectations:

- A1. demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating);
- A2. identify and describe a variety of careers related to the fields of science under study, and identify scientists, including Canadians, who have made contributions to those fields.

In summary, the skills developed through inquiry-based learning are important for success in secondary and post-secondary endeavours. We live in an information world where information and data are available at our finger tips

through the internet. Therefore, obtaining information is not the problem. Students now need to be able use that information correctly to solve problems with which they will be confronted.

MINISTRY EXPECTATIONS

This activity covers the following Ministry Expectations:

1. Overall Expectations:

   C.2. investigate, through inquiry, the characteristics of chemical reactions

2. Specific Expectations:

   C2.3 investigate simple chemical reactions, including synthesis, decomposition, and displacement reactions, and represent them using a variety of formats (e.g., molecular models, word equations, balanced chemical equations

   C2.5 plan and conduct an inquiry to identify the evidence of chemical change (e.g., the formation of gas or precipitate, a change in colour or odour, or a change in temperature.

   C2.6 plan and conduct an inquiry to classify some common substances as acidic, basic, or neutral (e.g., use acid-base indicators or pH test strips to classify common household substances)

   C3.3 describe the types of evidence that indicate chemical change (e.g., changes in colour, the production of a gas, the formation of a precipitate, the production or absorption of heat, the production of light)

   C3.4 write word equations and balanced chemical equations for simple chemical equations and for simple chemical reactions

   C3.5 describe, on the basis of observation, the reactants in and products of a variety of chemical reactions, including synthesis, decomposition, and displacement reactions

   C3.8 C3.8 identify simple ionic compounds (e.g., NaCl), simple compounds involving polyatomic ions (e.g., KNO3, NaOH), molecular compounds (e.g., CO2, H2O, NH3), and acids (e.g., HCl(aq), H2SO4(aq)), using the periodic table and a list of the most common polyatomic ions (e.g., OH–, SO 4 -2), and write the formulae

TEACHER BACKGROUND

Introduction

This investigation is completely based on an inquiry-based approach to learning; therefore, to ensure student success, previous unit activities/labs need to develop students' problem solving skills. Specifically, for the chemistry unit, students need to be exposed to activities that present problems for which they need to develop and implement a plan. Moreover, they need to be able to apply those findings to situations outside the context in which they were learned.

The basic premise of this activity is to use their knowledge of chemical processes to discover the chemical present in unknown samples. This will be achieved by setting up an investigation in context of a CSI investigation. Students can be presented with the idea that they are 'newly trained' CSI investigators, and their first task as a rookie CSI team member is to determine the chemicals present in unknown samples that were found at a crime scene. Upon completion they will prepare a summary report that needs to provide details of their findings and may be presented to a court of law.

The format of this project can be presented a number of ways. Listed below are a few examples:

1. For an enriched class, the 'problem' could be presented the first day of class with the task outline. The class would then have to begin research on the possible chemical tests, types of reactions and nomenclature required to solve the problem.
2. An approach for academic classes could involve having the students accepted into CSI University, where they will be trained as CSI investigators. Throughout the unit, each lab and activity needs to focus on problem-based learning skills and lab techniques. Students need to gain an understanding of each skill that will allow them to make conclusions from the evidence provided. The unit would culminate with a CSI graduation and their first CSI case. A crime scene could be presented and unknown samples provided. Emphasis needs to be on the need for thoroughness and accuracy of their conclusions and lab techniques because their evidence will be used in a court of law.

3. Applied level will need more guidance; however, the idea of training as a CSI investigator can be used. At this level, this activity needs to be more structured in that students will have specific tasks and due dates set out for them. More guidance in each step of the activity also needs to be incorporated.

Skills and Concepts to Develop/Emphasize Prior to this Investigation

1. Development of Inquiry Process

- Success in this activity is dependent on the development of students inquiry skills. Due to this, preliminary activities and labs should involve the following stages of the learning cycle. If each of your labs and/or activities take this form, then students become trained in the inquiry process, and therefore, will have greater success in this activity.
- Learning Cycle
  a) Engage

  Students need to understand the 'why' of the task. That is, labs or activities should be introduced with an application to 'real world' situations. For example, chemistry lends itself to ideas that involve criminal investigations (CSI, court evidence), cleaning products (liquid plumber, Tilex), baking, etc... Engagement helps bring the students from the known to the unknown. It needs to create a 'buzz' or 'interest' into the topic. Provide it with meaning.

  b) Exploration

  During this stage, students are to raise questions, develop hypotheses to test, compare ideas, try different procedures, share observations, collect evidence. These tasks are to be completed without direct involvement of the teacher. As a teacher you become a facilitator, providing safety, guidance and various levels of help depending on the student's ability. Exploration is a time where students discover and learn from their mistakes, re-construct their idea, and test again. The goal is develop the skills of problem-solving.

  c) Explain

  During this stage students will spend time researching, comparing, questioning results they have obtained as well as other student's findings. The emphasis during this stage is to explain 'why' specific results were obtained. The goal is to deepen students understanding to allow application outside of their own context of learning.

  d) Elaborate

  Students work together and discuss and review results. This allows students to hear and evaluate alternative explanations and encourages the students to apply or extend the concepts and skills in new situations.

  e) Evaluate

  Teacher brings closure to the lesson or unit by helping students summarize the relationship between the variables studied in the lesson. During this stage, students are encouraged to examine connections between concepts and examine further links outside the context of learning through higher order thinking questions.

2. Prior Knowledge and Skills

Introductory labs should teach students the techniques, skills and background knowledge required to complete this activity. It must be emphasized that the labs need to be structured as inquiry-based labs to ensure success in this activity. Students will not be fully engaged or have a positive experience if you don't shift your teaching methods from the traditional teacher directed approach to a constructivist approach. This does not mean that all your activities and lessons need to be completely inquiry-based, it is often a matter of changing your current labs and activities to a more inquiry-based approach. Taking this approach will allow students to develop the skills in using test results and observations in order to draw conclusions (see above). Below is a list of key concepts that should be addressed prior to completing this activity. Again, as mentioned above, how and when these are taught will depend on the level you are teaching.

A) Nomenclature

- Ability to write and identify simple ionic and molecular formulas.

B) Gas Tests

- Students need to understand the results of each gas test and why they get those results.
- Students should also perform the tests in a specific order so they can use the process of elimination to formulate a logical conclusion.
- The tests they should know and understand are: glowing splint test for oxygen, burning splint test for hydrogen, limewater test for carbon dioxide, and cobalt paper test for water vapour.

C) Identification of Chemical and Physical change

- Students should be able to distinguish the difference between a chemical and physical change.
- Students should be able to make appropriate conclusions about chemical changes using appropriate evidence. That is, chemical changes need to be confirmed by two or more observations.

D) Law of Conservation of Mass and Balancing Chemical Equations

- Students should make strong connections between the Law of Conservation of Mass and why they balance chemical equations.

E) Types of Reactions

- Students should be able to identify in a lab setting, as well as in writing, chemical equations for the following types of reactions: synthesis, decomposition, single displacement, double displacement, and acid/base reactions

Materials

- dilute Hydrochloric Acid (2-4 M)
- Calcium Carbonate
- Potassium Chlorate
- splints
- lime water