A GRADE 9 APPLIED CHEMISTRY UNIT

ON EXPLORING MATTER

By

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ABSTRACT

In a modern society, many important products such as fuels, fertilizers and plastics are produced by chemical industries through the application of science and technology. The study of chemistry serves as a cornerstone for many disciplines such as medicine, biology, and pharmacy. However, in spite of this relevance to technology and the environment, many students see chemistry as abstract and unrelated to real life and, in fact, report that chemistry was one of the most difficult subjects they had to study in high school. This perception could explain the results of the Third International Mathematics and Science Study, released in November 1996, which indicate that Ontario students lag behind the national average and that Canadian secondary school science and mathematics students as a whole perform behind students from such countries as Japan and Belgium.

As a result of these science test results and other social and political factors, the Ontario government decided to implement a process of secondary reform, announced in 1997, that would integrate five years into four and modify the science curriculum one year at a time starting in September, 1999. Along with other legislative changes, secondary school teachers have found that they do not have adequate preparation time or professional development training and direction, nor the resources to prepare the new curriculum changes. However, in spite of these

concerns about rapid change, the Ontario Ministry of Education and Training released the Ontario Science Curriculum guidelines for Grades 9 and 10 in the late spring of 1999 with implementation to start with Grade 9 students in September, 1999.

The purpose of this project was to design a chemistry unit and curriculum format, using the new Ontario Science Curriculum guidelines for Grade 9 and 10 (1999), to help both teachers and students relate chemistry to real life, thereby improving the standard of teaching and learning science in high school. To do this, the author developed a Grade 9 "applied" chemistry unit on " Exploring Matter."

Based on the Kemp, Morrison and Ross (1994/1998) model, which uses an instructional development process involving nine components (e.g., identifying learner characteristics, establishing learning objectives and making decisions about instructional strategies and resources), the unit format uses a practical chart organizer. The approach, which other teachers may use as an example to develop other units, can make learning more effective by integrating the learning expectations stipulated in the new Ontario science curriculum guidelines, while relating content and activities to real life. By having the potential of improving teaching and learning, the instructional design approach used in this project also has the long-term potential of improving the national and international science test results for Ontario students.

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Introduction

In a modern society, many important products such as fuels, fertilizers and plastics are produced by chemical industries through the application of science and technology and the study of chemistry serves as the cornerstone for many disciplines such as medicine, biology and pharmacy. In fact, chemistry is required for acceptance into many programmes offered by universities and community college (e.g., engineering and science).

Yet, many secondary school students see chemistry as abstract and unrelated to real life. They say that chemistry is one of the most difficult subjects they need to study in high school; a view that is reflected in the results of the Third International Mathematics and Science Study. Released in November 1996, the study puts Ontario students behind the national average in both mathematics and science subject areas, and Canada as a whole loses out to countries such as Japan and Belgium. Internationally, Canada ranked sixteenth in mathematics and thirteenth in science (Figure 1), while nationally Ontario ranked fifth in both mathematics and science, behind the provinces of British Columbia, Alberta, Newfoundland and New Brunswick (Figure 2) (Maclean's, 1997, p.50).

MATH RANKING		SCIENCE RANKING	
1. Singapore	79%	1. Singapore	70%
2. Japan	73	2. Korea	66
3. Korea	72	3. Japan	65
4. Hong Kong	70	4. Czech Republic	64
5. Belgium	66	5. Netherlands	62
16. CANADA	59	13. CANADA	59
28. United States	53	17. United States	58
International average	55	International average	56

Figure 1: <u>Results of the Third International Mathematics and Science Study-by Country</u>

MATH RANKING		SCIENCE RANKING	
British Columbia	63%	Alberta	65%
Alberta	61	British Columbia	62
Newfoundland	56	Newfoundland	59
New Brunswick	54	New Brunswick	57
Ontario	54	Ontario	56

Figure 2: <u>Results of the Third International Mathematics and Science Study-by Canadian Province</u>

The Ontario government hopes to change the above results, not only to bring Ontario secondary students up to international standards, but to put them ahead, thereby providing them with the types of scientific skills they will need in a competitive global economy. However, in order to do this, Ontario must undergo a process of secondary reform, integrating five years into four and modifying each and every core curriculum, one year at a time. In the 1999/2000 academic year, the Grade 9 curriculum will be modified, including the teaching of chemistry.

Statement of the Problem

It is the view of this researcher that the international science test results for Ontario's secondary students could be improved if secondary school teaching practices for chemistry were implemented in a way that provided students, not only with objective knowledge and skills, but with an understanding of the relevance of chemistry in real life situations. The problem at the moment is that this is not the case. Students tend to see chemistry courses as the most difficult courses they have to take rather than seeing its application to products and industries -- industries where they may end up employed.

Project Objective

Given the above statement of the problem, the purpose of this project is to present a Grade 9 applied chemistry unit on "Exploring Matter" that will provide both secondary school science teachers and their students, not only with objective knowledge and skills, but with the types of learning activities that show how relevant chemistry is to everyday life. To do this, the

Grade 9 chemistry unit will be developed using the Kemp, Morrison and Ross (1994/1998) curriculum development framework and the new Ontario Science Curriculum guidelines for Grades 9 and 10.

Curriculum Development Process

Ontario Science Curriculum Guidelines (1999)

In Ontario, the Ministry of Education and Training and the Boards of Education are currently involved in a process of program and curriculum reform. As part of the secondary reform process, new science curriculum guidelines were recently released, with the overall aim being to ensure scientific literacy for every secondary school graduate.

What scientific literacy means within the context of this project is objective knowledge and the ability to apply that knowledge in practical everyday contexts. That aim can be achieved by meeting three overall goals for every Ontario secondary school student. Specifically, the secondary science program, for Grades 9 and 10, is designed to promote:

1. an understanding of the basic concepts of science;
2. the development of the skills, strategies, and habits of mind required for scientific inquiry; and
3. the relationship between science and technology, society, and the environment.

For example, the Grade 9 applied chemistry unit "Exploring Matter" enables students to understand the basic concepts of chemistry; to develop practical skills in scientific investigations;

to enhance their communication/research skills; and to apply their knowledge to everyday situations. To achieve these goals, Grade 9 students design and conduct investigations into practical problems related to matter and its properties, as well as researching career and job opportunities. Through these learning experiences, students are able to gain a new respect for the dignity of work and the knowledge on ways to contribute to the betterment of society.

Therefore, the Ontario Ministry of Education science guidelines form the foundation for the Grade 9 applied chemistry unit that will be presented and defended in this project and are consistent with the objective to link science to everyday life.

The Kemp Model

An examination of the Ontario science curriculum guidelines shows one common phenomena that can be found in all government-directed curriculum guidelines. They give only vague directions and have a lack of specificity, which may account for many of the problems in schools today. To overcome these pitfalls, it is necessary to have a good curriculum development model. As mentioned previously, the curriculum development model or instructional design used by the author is based on the work done by Kemp, Morrison and Ross (1994/1998)-- referred to as simply the Kemp Model throughout this project -- one of the most effective structures available because it is based on learning theories, information technology, systematic analysis and management methods.

Based on the principles of curriculum planning formulated by Ralph Tyler in 1949, the Kemp model seeks to respond to four elements (Figure 3):

1. Who is the program being developed for?

2. What do you want the learners to learn and/or be able to do?

3. How is the subject content or skills best learned? and

4. How do you determine the extent to which learning has been achieved (Kemp, Morrison & Ross, 1994/1998, p. 8)?

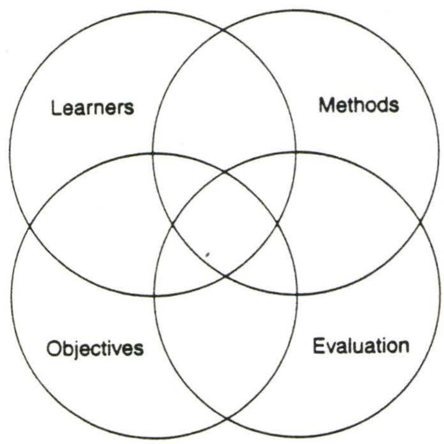

Figure 3: The Kemp Fundamental Elements of Instructional Design

In order to respond to these elements, the Kemp model consists of nine components, each of which must be examined in detail in Chapter 2 (Figure 4). However, as Kemp, Morrison and Ross suggest, although each component does not need to be analyzed in any particular sequence, the sequence chosen must be based on the four elements. The nine separate components are:

1. identifying *instructional problems*;
2. examining *learner characteristics*;
3. identifying *subject content* and analyzing task component related to stated goals and purposes;
4. stating *instructional objectives* for the learner;
5. *sequencing content*;
6. designing *instructional strategies*;
7. planning *instructional delivery* within three patterns for teaching and learning;
8. developing *evaluation* instruments to assess objectives; and
9. selecting *resources* to support instructional and learning activities (pp. 8-9).

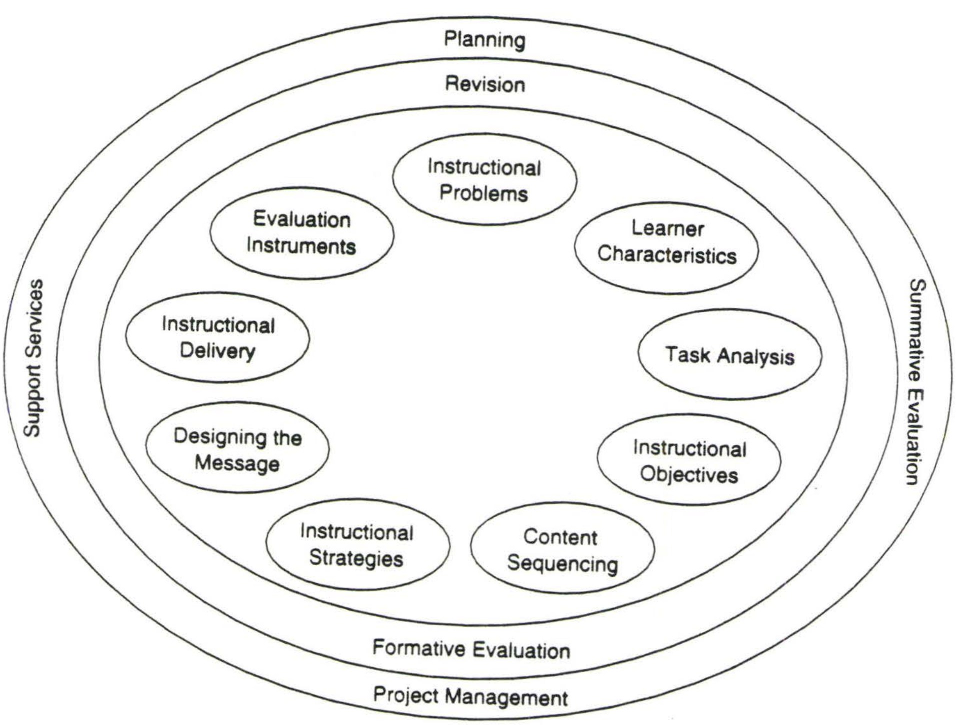

Figure 4: The Kemp Curriculum Development Model

Specifically, the Kemp Model will be the structure or framework which this author will use in this project to review the literature, and in part, to develop an effective instructional plan for the Grade 9 applied chemistry unit "Exploring Matter." (For a full explanation of the Kemp model's nine components, see Chapter 2 as well as the actual unit in Chapter 3).

Definition of Terms

The following terms are used in the project and interpreted as shown.

Curriculum:

Although the term curriculum can be used in a broad application, in the context of this project it refers to a "plan" consisting of objectives, subject content and skills, teaching strategies and the resources needed and that comprise an educational unit.

Instructional Design:

In this project, the term instructional design refers to the process of decision-making when planning, developing, evaluating and managing the development of a curriculum unit plan.

Scientific Literacy:

Scientific literacy is defined in this project to mean the possession of the scientific knowledge, skills, and habits of mind required to thrive in the science -based world of the twenty-first century. The term also includes the notion of students being able to connect scientific knowledge to everyday life experiences and events.

Scientific Investigation:

A "scientific investigation" involves the systematic application of concepts and procedures (e.g. experimentation, analysis and dissemination of data) that require skill and habits of mind which are fundamental to the development of scientific knowledge and that have proven over time to be useful in advancing scientific knowledge.

Matter:

In this project the term "matter" is anything that takes up space and has mass. Inquiring about the nature of the visible world often starts with observations of matter and leads to attempts to organize those observations. In our daily lives, when we choose our clothes, our lunch, or our shampoo, we are making choices bases on the properties of matter. Matter are suitable for different uses because of their special properties. Since different ways of using the same matter (e.g. explosives) may be beneficial or harmful to the society and environment, an understanding of matter is essential to relate science to technology, society, and the environment.

Chapter Summary

This chapter has presented the statement of the problem, the overall objective for this project, the goals of the new Ontario Science Curriculum guidelines for Grade 9 and 10, the rationale for using the nine components of the Kemp curriculum development model to develop a Grade 9 applied chemistry unit on "Exploring Matter" and the major terms that will be used throughout this project.

Chapter 2 will present the Kemp Model's nine separate instructional development components in detail for two reasons; (1) as the basis for a review of the literature; and (2) as the decision-making structure for the actual development of the Grade 9 applied chemistry unit "Exploring Matter" presented in Chapter 3. Chapter 4 will consist of a brief summary of the project -- the problem and rationale for the development of a Grade 9 applied chemistry unit -- as well as to make recommendations for further curriculum development research.

CHAPTER 2

Review of the Literature

As mentioned in Chapter 1, the foundation of instructional design and curriculum development is based on the early work of Ralph Tyler. Known as the Tyler Rationale (Tyler, 1949), he specified that all curriculum design must involve four key elements: (1) the general statements of major goals and the instructional objectives to be accomplished; (2) the suggested class activities and lists of readings; (3) the resources required; and (4) sample evaluation techniques to be used to evaluate learning outcomes (Kemp, Ross, Morrison, 1994/1998).

The Tyler specifications and elements are integrated into the Kemp model and, as presented in Chapter 3, are incorporated into the unit plan format designed in this project. Therefore, the review of selected literature sources in this chapter follows the nine components of the Kemp Model as a means of explaining and defending the unit plan format developed for "Exploring Matter" in Chapter 3.

Instructional Problems

The Kemp model suggests that all types of instructional variables need to be examined before developing a curriculum unit, such as the teacher's curriculum orientation, government curriculum requirements, the secondary reform process and the length of time allocated for the unit. These types of issues have all been examined in light of the Grade 9 applied chemistry unit on "Exploring Matter" and will be explained below.

Curriculum Reform

In the past few years in Ontario, there have been significant educational changes. One of those changes is secondary curriculum reform, a process out of which the new Grades 9 and 10 science guidelines have emerged. As a result, in the 1999/2000 academic year, high school science teachers are having to deal with new science guidelines at the same time as a reduction in preparation time, a lack of adequate in-service training and limited access to appropriate resources -- all issues relating to preparing new units of study -- such as the applied chemistry unit on "Exploring Matter" presented in Chapter 3.

Curriculum Orientation

Another potential problem area, to be examined when developing a curriculum format or unit plan, is determining teachers' curriculum orientations; namely, their beliefs about learning and instruction. Specifically, before a teacher gets started they need to deal with this issue so that instructional problems do not result; problems resulting from a lack of congruence between stated learning expectations and how instruction is carried out.

Miller and Seller (1985/1990) outline three orientations or teaching approaches; the transmission, transaction and transformational positions. In the transmission position, the function of education is to transmit facts, skills and values to students. The orientation stresses mastery of traditional school subjects through traditional teaching methodologies, particularly textbook learning. There is primarily a one-way movement to convey learning to students and historically this position is linked with traditional subjects, standardized testing and rote learning methods. Miller and Seller do not make value judgments about this position and recognize that it has much value in such traditional subjects as science, particularly the traditional scientific method. Overall, however, this is a teacher-directed orientation.

In the transaction position, the individual is seen as rationale and capable of intelligent problem-solving. Education is viewed as a dialogue between the student and the curriculum in which the student reconstructs knowledge through the dialogue process. This position involves inquiry and discovery and is traditionally congruent to the scientific method, but without the emphasis on rote learning.

The transformation position focuses on personal and social change and is seen as holistic, planning for the whole student. This orientation incorporates the best from transmission and transaction while relating learning to personal experience. As a result, the unit plan presented in this project, in Chapter 3, is developed from a transformational point of view because the rationale is to make chemistry real to Grade 9 students.

Government Guidelines Requirements

As described in the Ontario Science Curriculum for Grades 9 and 10, the overall intention of science education is that all graduates of Ontario secondary schools will achieve excellence and a high degree of scientific literacy while maintaining a sense of wonder of the world around them.

The secondary science program from Grade 9 through Grade 12, is designed to promote the following goals:

- to understand the basic concepts of science;
- to develop the skills, strategies, and habits of mind required for scientific inquiry; and
- to relate science to technology, society, and the environment (p.4).

Science is everywhere surrounding us and has a great impact on our lives. Therefore, the ultimate goal to achieve science literacy for all in Canada is an important and a worthy one to pursue by all science teachers.

Learner Characteristics

The Kemp Model talks about the necessity of gathering information about the learners to be taught. In the context of the 1999 Grade 9 applied chemistry unit presented in Chapter 3, it can be assumed that the students have already completed some science course work at the elementary school level. However, since courses at the elementary level are designed for students of all ability levels, and are not structured as they are in high school, the knowledge of science possessed by the Grade 9 applied students shows great variation.

The curriculum unit presented in this project relates to an "applied" chemistry unit for Grade 9. The rationale for this is due to the fact that there are two streams at the secondary level when teaching science; applied and academic. The applied students would have been classified as working at the "basic" and/or "general" levels prior to the reform process. The "academic" students are usually university bound and would previously have been labelled as "advanced." As a result, two types of science courses are offered: academic courses and applied courses. Academic courses emphasize theory and abstract problems whereas applied courses focus on practical applications and concrete examples.

Whatever the case, this researcher finds that the separation of science courses into applied and academic results in the Grade 9 "applied" students having a wide variations in pre-requisite knowledge and academic abilities, a lower academic image of themselves and lower expectations. This makes it difficult to teach how relevant chemistry is in everyday life and as preparation for future employment. Nevertheless, in order to obtain the Ontario Secondary School Diploma, students must earn 2 credits in science and must take and complete two science courses at the Grade 9 and 10 levels.

Therefore, learner characteristics in the Grade 9 applied chemistry unit on "Exploring Matter" are identified as differences relating to:

- a lack of pre-requisite knowledge and skills;
- reduced learning aptitude and potential;
- a lack of motivation and low self-esteem; and
- learning problems and learning disabilities.

As a result, the applied unit on "Exploring Matter" will have recommendations for teaching methods and learning activities that promote a growth in knowledge and skills, increased potential and a positive self-esteem, while connecting chemistry to real life.

Cognitive Development

To teach science effectively at the secondary level, there must be an understanding of how children develop intellectually and how children learn. The theories of several well-known psychologists have provided much direction and guidance in this respect.

For example, Piaget's Theory of Cognitive Development identified four major stages of development; the sensorimotor state (0-2 years), the pre-operational stage (2-7), the concrete operational stage (7-11) and the formal operations stage (11-15) (Notterman & Drewry, 1996).

The stages are sequential and no person skips a stage. Each child passes through each stage in the same order, but not necessarily at the same rate. The rate at which a particular child passes through these stages will depend on both maturation and environment; that is, the kinds of experiences children have as they are developing.

The implications for secondary school teachers are that, particularly for those teaching at the Grade 9 and 10 levels, some students will be at the formal operations stage while others will be moving between concrete operations and formal operations. Therefore, although the adolescent child is usually able to think logically in relation to all classes of problems, the movement to formal operations occurs at different rates for different students. This makes curriculum planning for Grade 9 applied chemistry challenging because whatever planning format is used, these potential maturational differences must be incorporated into the instructional design process (e.g., in the types of instructional activities used).

In this regard, Notterman and Drewry (1996) state how important it is for teachers to keep:

> a sharp eye on what you as the teacher are doing, on what the student does in response, and how the cognitive basis for the response may be objectively inferred. Always keep before you the fact that even if the student is in the formal operations stage (approximately junior and senior high school), it cannot be assumed that his or her language, thought, or action will be logical. Cognizance of Piagetian genetic epistemology -- especially the concepts of assimilation, accommodation and equilibrium -- helps the teacher comprehend the students' manner of intellection (p. 151).

In this "Exploring Matter" unit in Chapter 3, which as mentioned previously is based on both the expectations laid out in the Ontario Science Curriculum guidelines for Grades 9 and 10, and the elements of the Kemp Model, the students' rate of cognitive development is considered (as well as those learner characteristics mentioned previously) in the way activities are sequenced from the known to the unknown and the concrete to the abstract. To do this, the science teacher must rely on Piaget's stages of development as they are seen in the actions and thinking of their students.

Task Analysis

As with the developers of the Kemp Model, according to Gagne (1995) there is a hierarchy of learning capabilities and each learning capability depends on having understood a previously learned one. The student must begin with the simplest learning activity and progress to the more difficult problem-solving situations in a step-by-step sequence. He stresses the importance of developing a task analysis before beginning instruction because that type of process prepares both the teacher and the students for learning something new after the necessary capabilities have been acquired. This procedure, which is evident in Chapter 3's unit format, forms the foundation for higher order skills or problem-solving capabilities -- important abilities when trying to link chemistry knowledge and skills to everyday life.

Gagne suggests that teachers proceed in their curriculum planning by: (1) defining the desired product; (2) attempting to define the learning necessary to achieve that goal; (3) define the prerequisite skills to determine the skill-knowledge hierarchy; (4) formulate a behavioural objective for each skill-knowledge cell; (5) construct learning activities; and (6) construct evaluation procedures. This is done in the unit plan format found in Chapter 3.

Instructional Objectives

Kemp, Morrison and Ross (1994/1998) say that you need to know where you are going before you decide how you are going to get there. As mentioned earlier, the Miller and Seller curriculum orientations model provides the understanding as to why and how a curriculum unit is developed.

The characteristics of each orientation explain why certain learning objectives are developed and why they are prioritized as they are. For example, while the transmission orientation's emphasis is on direct instructional techniques such as lecture, repetition and recall, the transaction and tranformational positions would sequence curriculum activities in terms of problem-solving and discovery activities.

The main difference between the transactional and transformational methods would be the link and application to real life or real life problems. In chemistry, for example, an explanation usually begins with the basic elements and proceeds to more complex molecules followed by what they mean in the environment.

Understanding these differences -- understanding the destination for learning -- is important when developing instructional objectives because what a teacher believes is important is what will be the basis for the objective. In the context of this project, the Ontario Science guidelines for Grades 9 and 10 does not specify objectives, rather learning expectations. A look at the guidelines indicates that there must be a connection between knowledge and real life applications in the environment -- clearly a transformational emphasis.

Instructional Expectations

The Grade 9 applied chemistry unit on "Exploring Matter" states that the overall expectations for students by the end of the course should be that they can:

- describe the atomic structure of common elements and their organization in the periodic table;
- investigate the physical and chemical properties of common elements and compounds and relate the properties of elements to their location in the periodic table; and
- demonstrate an understanding of the importance, production, use, and environmental hazards of common elements and simple compounds.

In this unit, in order to meet these expectations, students first must learn the properties of matter and its changes. They must also learn that matter can be elements and compounds, metals and nonmetals, and that these substances are related in an important way to technology, society and the environment. The properties of matter, however, are related to their atomic structures, which can be seen in the Periodic Table -- a tool which is used by scientists to simplify the study of chemistry. Therefore, the instructional expectations are that the Grade 9 applied students taking the science course achieve the three learning outcomes stated above.

Content Sequencing

Just as the Kemp Model specifies breaking down tasks and skills, this component is consistent with the task analysis section as well as the notion of how to use instructional materials effectively. For example, in order to teach high school chemistry in Ontario, only textbooks listed in Circular 14 can be used. The reason for this was set out in the Ontario Ministry of Education, Part 1 OSIS document (1987) which stated that textbook material (content) should:

1. include all core units and have an adequate selection of optional units;
2. be suitable for the level of difficulty intended;
3. be congruent with the objectives, attitudes, skills and knowledge in the appropriate guidelines;
4. be appropriate for each students' reading level;
5. provide a variety of formats for student activities in the laboratory;
6. include applications and societal implications;
7. provide a balanced and scientific treatment of serious issues;
8. include exemplary samples to solutions to problems;

9. contain references to sciences as a human enterprise, with illustrations of notable achievements, including Canadian achievements where appropriate;
10. include a career-awareness component; and
11. be capable of motivating students to learn and enjoy science.

Therefore, a good textbook can help students learn more effectively and can be the basis for the way content is sequenced -- keeping in mind that activities are also crucial for problem-solving, investigation and application (see also the task analysis, instructional strategies and instructional delivery sections in this chapter). For example, Gillespie (1997) says that:

> There are many well-written and lavishly illustrated texts, but almost all of them treat the same conventional matter in more or less the same conventional way. No matter how excellent these text appear to the instructors who choose them, they have not succeeded in interesting the vast majority of students or in providing them with an understanding of chemistry -- or even with useful information that they remember and use later in life (p. 484).

As a result, content in chemistry should be appropriate to the student and the topic being taught. By using textbooks and/or other written materials that are carefully developed and sequenced, learning expectations can be achieved.

Instructional Strategies

Kemp, Morrison and Ross (1994/1998) describe learning as an active process and that a "well-designed instructional strategy prompts or motivates the learner actively to make these connections between what the learner already knows [pre-requisite knowledge] and the new information" (p.120). To develop appropriate strategies or learning activities, the curriculum developer must consider student abilities (see also the learner characteristics section).

Making decisions about possible instructional strategies need to consider a number of factors, including the multiple intelligences model, the characteristics of the learners and the cognitive development of the learners. As a result, all of these factors will be incorporated into the "Exploring Matter" unit presented in the next chapter.

Multiple Intelligences

According to Howard Gardner (1993), who developed the Multiple Intelligences Model (MI) each person possesses seven intelligences: verbal-linguistic, logical mathematical, visual-spatial, bodily-kinesthetic, musical-rhythmic, interpersonal and intrapersonal. As a result, teachers need to consider all the various ways students learn when they make decisions about instructional strategies.

Since science is a systemized knowledge derived from observation, study and experimentation carried on in order to determine the nature or principles of what is being studied, teaching methods and activities can help to develop these types of abilities. In fact, Armstrong (1994) says that: (1) most people can develop each intelligence to an adequate level of competency; (2) that intelligences usually work together in complex ways; and (3) there are many ways to be intelligent within each category (p.11).

Therefore, the theories of Piaget (under learner characteristics), Gagne (under task analysis) and Gardner provide insight in how teachers decide instructional strategies. Although each of the theories is different, they are not separate; in fact they complement each other. For example, each theory emphasizes hands-on learning and the use of a variety of materials in the teaching of science.

Recent study on the teaching of chemistry by Francisco, Nicol and Trautmann (1998) shows that the integration of multiple methods of teaching enhance student participation and point out that "multiple modes of learning foster the meta-cognitive skills necessary for mastering general chemistry" (p. 210).

Possible Strategies

There are multiple instructional strategies available to teachers, such as:

1. lectures and co-operative learning (e.g., discussions);
2. experiential and independent learning (projects, demonstrations, laboratory activities (including experiments), field trips and visits;
3. reminder sheet.

Lecture and Co-operative Learning

Although all of the above types of methods will be incorporated into the Grade 9 applied chemistry unit on "Exploring Matter" in Chapter 3, it should be kept in mind that the lecture method, although effective to introduce or review a topic, is not as effective for learning as discussion, which promotes an exchange of information and ideas between teacher and student and student and student, and laboratory activities where students experience and apply knowledge in a discovery and inquiry environment -- as opposed to the recipe approach which does not promote logic or creativity (Padilla, 1991).

Experiential Learning

Projects, demonstrations and laboratory activities (including experiments) approaches also provide students with opportunities to develop knowledge, skills and understanding of a selected topic and are extremely successful because students become totally involved in the learning process. In this regard Champagne and Bunce (1994) describe that:

> Peer interaction is more effective than teacher lectures in conveying scientific knowledge because peers' explanations are simpler than adults' and as a consequence are better understood by the learner. To say it in another way, the distance between two students' understanding is far less than the distance between a student's understanding and a teacher's, hence communication of ideas is facilitated (p.31).

Field trips and visits are similar learning experiences because they are exciting, involve students with other students and specialists and complement any chemistry course. These types of instructional strategies also enable students to visualize how theoretical principles can be put into useful practice in everyday life.

Reminder Sheet

The reminder sheet is an effective study strategy and teaching/learning tool. For example, at the beginning of some science courses, students are informed that they may bring a reminder sheet to their examination, with any information they want handwritten on the two sides. This technique is useful for solving problems and helping students make decisions about what is important and what is not, and as Perrin (1997) asserts, reminder sheets help students develop an overview of the subject they are studying.

Instructional Delivery

The mode of instructional delivery is very similar to the instructional strategies chosen. However, delivery involves the overall method used by the teacher, such as: teacher directed methods, independent self-paced activities, independent modular learning, experiential computer assisted instruction and so on. They are implied in the topics and activities chosen and in many cases, it is up to teachers to decide what "method" of delivery to use in order to cover certain topics, complete certain activities achieve certain learning expectations.

For example, as mentioned earlier under "Task Analysis" Gagne states the importance of breaking down the skills and knowledge into a skill/content hierarchy. In discussing methods of instructional delivery, Clark (1994) states that Gagne's theory of instructional design is important for science teachers because they need to:

- arrange the learning environment so that students will have many opportunities to master various types of learning, moving from the simplest (signal learning) to the most complex (problem-solving);
- specify the desired behavioural objective and to structure lessons in small steps and in sequence; and
- take into account what the learner already knows and what the learner needs to know (p.39).

The unit plan in Chapter 3 on "Exploring Matter" allows teachers to choose their method of delivery by listing the topics, learning expectations and the types of activities that will meet those expectations; clearly consistent with both Gagne and Clark's view of task analysis and the types of methods and activities required to teach a Grade 9 applied chemistry unit on "Exploring Matter" and that brings learning into the context of everyday situations.

Computer Technology

Computer technology is also a method of delivering learning. As early as 1987, the OSIS document asserted that:

> The computer plays a major role in science and should be seen as an essential component of the Senior Division science curriculum, as a time when post secondary educational institutions are increasingly requiring computer knowledge for entry into science and engineering programs. As the cost of computer hardware decreases and the availability of good educational software increases, science teachers in both elementary and secondary schools will be able to provide students with new and exciting approaches to science education through the use of micro-computers (p. 64).

Given the fact that twelve years have passed since that OSIS statement, computers are now the norm and students will need to be computer literate in all fields of employment involving science and technology. In fact, computer technology can now deliver instruction in the form of Computer Assisted Instruction (CAI) or Computer-Based Instruction (CBI) which involves electronic intelligence and database management programs.

For example, Geisert and Futrell (1995) and Sweeters (1994) say that CAI tutorial programs are effective electronic tools for learning new concepts or skills or new information, as well as to assess the progress of student learning during the instructional process. As well, educational databases can be used as encyclopedia or for setting up teaching/learning modules with content activities and learning evaluation tools.

As Hodson (1994) says:

> By using the computer as a tool to find answers to their own questions, students can develop real problem-solving and enquiring skills. They can learn to identify problems that are significant, worth investigating and susceptible to systematic enquiry....[As a result] computer databases have the potential, in the hands of skilled teachers, to assist students to develop a wide range of cognitive skills, enquiry procedures and attitudes that are exceedingly difficult in other ways (p.160).

Models

The idea of molecular shape and geometry or three dimensional chemistry is one of the important concepts to be learned in high school chemistry. Gillepse (1997) emphasises that: "Understanding shape is vital to understanding a wide range of topics in modern chemistry: for example, biomolecules and their functions, industrial catalysts such as zeolites and solid surfaces, and synthetic polymers" (p.863).

To utilize the Multiple Intelligences Theory in the classroom, Armstrong (1994) comments that "Unfortunately, in today's schools the idea of presenting information to students through visual as well as auditory models translates into simply writing on the board, a practice that is linguistic in nature. Spatial intelligence responds to pictures, either the images in one's mind or the images in the external world; photos, slides, movies, drawings, graphic symbols, ideographic languages, and so forth" (p.72). Armstrong also emphasises the importance of visualization and the use of colour cues to stimulate the spatial intelligence of students to help them to learn.

Models are especially important in the teaching of chemistry. The use of models will help students see, in a very concrete way, the number and the type of atoms in the molecules. They can also see that molecules are three-dimensional and they can get familiar with the shapes of simple molecules.

Moreover, the shape of a molecules can be shown by a ball–and stick model or a space-filling model. For example, students, in small groups, can be given the opportunity to build simple molecules -- all important considerations given the characteristics and requirements of the learners of the Grade 9 applied chemistry unit "Exploring Matter."

Evaluation Instruments

The purpose of assessment and evaluation in the school is to improve student learning. Information gathered through assessment and evaluation helps teachers to identify students' difficulties as well as to detect weaknesses in programs.

According to the Ontario Secondary Schools Grade 9 to 12: Program and Diploma Requirements 1999, assessment and evaluation will be based on the provincial curriculum expectations and the achievement levels outlined in the secondary curriculum policy documents. Teachers will be provided with materials, including samples of student work (exemplars), that will assist them in their assessment of student achievement. However, since these materials are not provided or available at the time of writing this project, the author will continue to follow the previously stipulated assessment and evaluation practices.

At present, therefore, the evaluation instruments secondary school science teachers use include assignments, projects, performance evaluations, lab-reports, quizzes, tests and examinations. In Ontario secondary schools, the value assigned to the level of achievement is in the form of a percentage grade -- based on whether the student is at the applied or academic level.

Instructional Resources

The primary resource for the Grade 9 applied chemistry course on "Exploring Matter" is *Science 9* by Nelson. This is a new textbook as part of the secondary reform process mentioned earlier. This textbook is used in both applied and academic courses so it contains some materials and prose that is too difficult for the applied students. The teachers guide for this textbook is not available at the time of this writing.

Other types of resources used are videos, CD-Rom, models and the usual type of science equipment and materials found in a science lab. As well, there are library materials and other textbooks, as well as access to computers, software and the internet. Therefore, as Kemp suggests, these types of resources will be mentioned throughout the unit plan found in Chapter 3.

Chapter Summary

This chapter was a selected review of the literature on instructional design elements and their importance when developing a curriculum unit format. The review was presented using the Kemp Model's nine components. Chapter 3 will be a presentation of a curriculum unit on "Exploring Matter" as specified in the Ontario Science Curriculum for Grades 9 and 10. The unit will have a consistent format using headings and a chart format and will incorporate all the elements and principles discussed in Chapters 1 and 2.

CHAPTER 3

A Grade 9 Applied Chemistry Curriculum Unit

A Unit on Exploring Matter

As mentioned in Chapters 1 and 2, the general purposes for the Grade 9 applied chemistry unit on "Exploring Matter" presented in this chapter are to enable students to understand the nature of matter, that matter is essential to relate science to technology, society and the environment, and that matter can be helpful or harmful. The rationale for these purposes, as discussed in Chapter 1, is to link chemistry knowledge and skills with an understanding of everyday usage and applications.

Specifically, Grade 9 applied science students need to:

- be taught how to work safely with chemicals in the laboratory, at home or at work;
- study the properties of matter and learn to appreciate that the everyday use of materials is a result of their physical and chemical properties;
- recognize that elements and compounds have distinct properties -- some of which are used in their daily life; and
- familiarize students with the fundamental structure of matter.

Through the study of the structure of atoms and molecules, students also need to be guided to acquire knowledge of some basic chemical principles, such as the relationship between properties of matter and its structure, to identify the element chemical symbols using the periodic table, and to recognize chemical formulae of some common chemicals used daily such as oxygen, water and table salt.

Theoretical Defence

The statement of rationale and chart format presented in this chapter are completely consistent with the Kemp Model's four principle elements: learner characteristics; teaching methods; learning objectives and evaluation techniques. For example, the "rationale" statement provided before each sub-unit implicitly and explicitly makes allowances for learner characteristics and learning objectives, as does the learning expectations section on the charts. Similarly, the teaching/learning activities, teaching methods, possible instructional resources and the learning evaluation sections on the Unit sub-topic charts relate directly to Kemp's planning elements (Figure 3).

The Kemp instructional design process (Figure 4) is also evident in the Unit format, although in a much more systematic way because instructional problems, task analysis, content sequencing, instructional strategies, instructional delivery and instructional resources, are based on the requirements of the Ontario Science Curriculum guidelines for Grades 9 and 10 (1999). However, although decisions about learning expectations and the sequence of those expectations, are from the guidelines, the teaching/learning activities and evaluation techniques are based on good teaching and the instructional design process presented by Kemp.

The Unit Format

The unit on "Exploring Matter" to follow is organized according to five separate Grade 9 applied chemistry sub-topics:

1. Introduction to Lab Safety;
2. Properties of Matter;
3. Physical and Chemical Change;
4. Elements and Compounds, Metals and Non-metals; and
5. The Atom and the Periodic Table.

The overall unit begins with time allocation information followed by each sub-topic. The sub-topics are presented using introductory headings "Rationale" and "Resources" followed by a "Planning Chart" showing the sub-topics, learning expectations, possible teaching/learning activities and methods for learning evaluation. When referring to the textbook, it is *Science 9*, published by Nelson (1999 Edition). The charts are presented in such a way so as to give teachers the freedom they need to make their own choices and decisions as to how they will implement the activities and evaluation techniques -- depending on the needs of their students.

Time Allocation and Sequence

No.	Sub-Topics	Time (minutes)
1	Introduction to Lab Safety	150
2	Properties of Matter	300
3	Physical and Chemical Change	375
4	Elements and Compounds, Metals and Non-metals	600
5	The Atom and the Periodic Table	325

Sub-Topic 1: Introduction to Lab Safety

Rationale

The fundamental nature of science is experimental, requiring the skills of observation and deduction. Clearly then, it is important that students know the skills and procedures required to work safely and effectively in the lab/classroom. In fact, the Ontario Science Curriculum guidelines for Science Grades 9 and 10 state specifically that students should, by the end of this course, demonstrate knowledge of laboratory safety and disposal procedures while conducting investigations such as: wearing safety glasses, practising orderliness and cleanliness; following WHMIS guidelines and emergency procedures; and using proper procedures for handling and storage.

However, we do not only use chemicals in the lab. We use a lot of chemicals everyday, some of which are hazardous such as chlorine bleach, window cleaner, paint and paint thinner. This sub-unit on lab safety is important for students, then, not only to learn to respect hazardous materials and how to handle these materials with proper precautions, but also how to relate their use to everyday life and the environment.

Resources

1. Textbook– pp.14-15
2. Lab Safety Video
3. Safety Monograph-Hamilton Wentworth Roman Catholic Separate School Board
4. Household products with hazardous symbols (e.g., liquid bleach, foam carpet cleaner, windshield washer fluid and CLR/calcium, lime and rust remover)

Planning Chart

Sub-Topics	Learning Expectations	Teaching/Learning Activities	Learning Evaluation
1.1 Lab Safety	-to learn knowledge of laboratory, safety and disposal procedures	-lab safety video & discussion	-teacher/ student conferences
1.2 Hazardous & WHIMIS Symbols	-to identify hazardous materials and follow WHMIS guidelines and emergency procedures	-safety monograph -students setting safety rules -student brainstorm dangerous household products or chemicals	-discussion of safety rules

Sub-Topic 2:
Properties of Matter

Rationale

When we choose our clothes, our food, or our shampoo, we are making choices bases on the properties of matter. These properties of matter are important to our daily lives. Scientists have found it useful to categorize properties as physical or chemical. Knowing the properties of a substance can help you identify and choose the correct substance. Different substances with different properties are put to various usages due to their special properties.

Resources

1. Textbook– pp. 16-21
2. Different known substances (e.g., copper wire, zinc plate, sulphur block and vegetable oil)
3. Different substances in small transparent bottles with numbers (e.g., salt, sugar, flour, candle and copper wire)
4. Materials as described on p.20 in textbook
5. Handouts– Appendix A: Physical Properties of Some Known Substances
   Appendix B: Properties of Matter

Planning Chart

Sub-Topics	Learning Expectations	Teaching/Learning Activities	Learning Evaluation
2.1 Physical Properties	-to learn the terminology of describing physical properties -to use physical properties to identify substances	-students given known substances & asked to describe them -students given unknown substances & asked to identify them	-complete lab sheet (Appendix A) -complete lab sheet (Appendix B)
2.2 Chemical Properties	-to organise, record & analyse the information gathered -to determine, using observation, the evidence for chemical changes	-students to use physical & chemical properties to identify 5 unknown substances /all white solids, but having different properties as described (given)	-lab skills to complete the experiment -complete lab report
2.3 Using the Properties of Matter	-to determine how the properties of substances influence their uses	-students brainstorm the properties of substance and their uses	-teacher/ student conference

Sub-Topic 3:
Physical and Chemical Changes

Rationale

There are numerous changes in matter that affect us everyday; for example, the baking of flour for bread, burning gasoline and boiling and freezing water. Understanding and categorizing physical and chemical changes are, therefore, an important step to making use of change.

In a physical change, the substance remains the same substance, whereas in a chemical change , a new substance is formed. In this sub-topic, students learn to describe, using their observations, the evidence for chemical changes (e.g., energy change, formation of gas or precipitate, change in colour or odour and change in temperature).

Many chemical changes are taking place everyday, such as corrosion (rusting of steel) and combustion and they have a great impact on technology, society and environment.

Resources

1. Textbook– pp.28-39
2. Video/Chemical Reactions (Bill Nye)
3. Materials as described on p.32 in textbook
4. Handout– Appendix C: Physical and Chemical Changes

Planning Chart

Sub-Topics	Learning Expectations	Teaching/Learning Activities	Learning Evaluation
3.1 Chemical Changes	-to identify the clues of a chemical change -to observe and describe the evidence for chemical change	-demonstration & discussion of some chemical changes e.g., burning a candle, mixing vinegar & baking soda -video/Chemical Reactions -students perform four reactions & asked to identify them as physical or chemical change	-complete worksheet/ distinguish physical & chemical changes & give reasons (Appendix C) -complete lab-report
3.2 Some Important Chemical Changes in Everyday Life - Corrosion & Comb-ustion	-to recognize the importance, use & environmental hazards of common chemical changes	-discuss the kinds of corrosion & prevention -discuss fossil fuels & combustion, pollution	-complete exercise in the textbook p.35 & p. 39

Sub-Topic 4: Elements and Compounds, Metals and Non-metals

Rationale

Scientists classify matter into two main groups: elements and compounds. The common elements are mainly metals and non-metals. Metals and non-metals have different properties and hence different usage in everyday life. Many metals such as nickel, gold, zinc and iron are mined, extracted and refined in Canada. They are important to the economy of the country. However, they also cause local environmental concerns and health and safety issues.

The atmosphere contains many gases such as nitrogen, oxygen, carbon dioxide and water vapour and a very small amount of argon and ozone. Some of these gases can be tested easily in the lab. Compounds can be broken down into elements and shown by the electrolysis of water.

Scientist uses chemical symbols to represent elements and they write chemical formulae for compounds. Some common formulae are : H_2O and CO_2. Chemical formulae can also be found on many labels such as fertilizers and drugs.

Resources

1. Textbook– pp. 44-75
2. Video/Elements, Compounds and Mixtures
3. Models
4. Internet and computer encyclopaedia
5. Periodic Table
6. Handouts– Appendix D:Classifying Elements

Appendix E: Chemical Symbols

Appendix F: Mining in Canada

Appendix G: Breaking Compounds into Elements

Appendix H: Testing for Gases

Appendix I: Identifying Mystery Gases

Appendix J: Building Models of Molecules

Planning Chart

Sub-Topics	Learning Expectations	Teaching/Learning Activities	Learning Evaluation
4.1 Elements & Compounds	-to classify pure substances as elements & compounds -describe an element as a pure substance made up of a type of particle or atom with its own distinct properties	-video/ Elements, Compounds & Mixtures -students examine samples of different types of elements & compounds	-teacher/student conferences
4.2 Elements	-distinguish between metals & non-metals & identify their characteristics properties -identify & write symbols of common elements	-students classify elements into metals & non-metals by examining some of their physical properties such as lustre, malleability & conductivity -students use the Periodic Table	-complete lab report (Appendix D) -complete handout (Appendix E)

4.3 Metals & Non-metals	-identify uses of elements in everyday life -explain how a knowledge of the physical & chemical properties of elements enables people to determine the potential uses of the elements and assess the associated risks	-discussion	-complete exercises in the textbook p.51
4.4 Uses of Elements	-describe the methods used to obtain elements in Canada -outline local environmental concerns & health & safety issues related to the ways in which they are mined & processed	-library research -discussion -making poster -presentation	-complete assignment (Appendix F)
4.5 Compound	-recognize compounds as pure substances that may be broken down into elements by chemical means	-demonstration/ electrolysis of water	-complete handout (Appendix G)
4.6 Tests for Elements & Comp-ounds	-to identify oxygen, hydrogen, carbon dioxide & water	-demonstration on tests for gases -students prepare gases & identify mystery gases	-complete handout (Appendix H) -complete lab report (Appendix I)
4.7 Elements & Compounds	-describe compounds & elements in terms of molecules & atoms -identify & write symbols/formulae for common compounds	-students to construct molecular models of simple molecules -students to write formulae of H_2O, O_2, CO_2	-complete handout (Appendix J)

Sub-Topic 5:

The Atoms and the Periodic Table

Rationale

The fundamental of matter is the atom. Through the study of the structure of atoms, ions and molecules, students are guided to acquire knowledge of some basic chemical principles. Emphasis is placed on the recognition of patterns of chemical behaviour and the relationship between properties of matter and its structure. The Periodic Table is shown as an organized arrangement of elements that explain physical and chemical properties. It is a useful tool to study elements as it can be used to relate the properties of elements to their location in the Periodic Table.

To visualize the process of finding the structure of the atom, students are given a sealed box containing an object and asked to describe it without opening the box (the black box puzzle). This experiment is similar to the process that scientists followed when they produced their models of matter. The video "The Atom" shows how scientists worked to find out the structure of the atom. The atomic structure (Bohr-Rutherford model) of common elements and their organisation in the Periodic Table is then described. A relation between the properties of elements and their location in the Periodic Table is then explained in term of the electron arrangement.

Resources

1. Text–pp. 80-93 and pp.105-113
2. Video/The Atom and the Chemical Families
3. Sealed boxes containing an object such as tennis ball or pencils
4. The Periodic Table
5. Handout– Appendix K: The Structure of the Atom

   Appendix L: Electron Arrangement

   Appendix M: The Periodic Table

   Appendix N: The Periodic Table and Electronic Arrangement

Planning Chart

Sub-Topics	Learning Expectations	Teaching/Learning Activities	Learning Evaluation
5.1 Model for the Atom	-to use a model to see how scientists produce the model of an atom	-black box puzzle -video/The Atom	-teacher/ student conferences
5.2 Structure of the Atom	-to identify each of the three fundamental particles and its charges, location and relative mass	-discussion	-complete handout (Appendix K)
5.3 Atomic Model	-Bohr-Rutherford model	-draw Bohr diagrams	-complete handout (Appendix L)

5.4 Periodic Table	-to identify general features of the Periodic Table (e.g. arrangement of the elements based on atomic structure, groups, or families of elements, periods or horizontal rows) -to demonstrate an understanding of the relationship between the properties of elements and their position in the Periodic Table (e.g., metals appear on the left of the Periodic Table & non-metals appear on the right)	-video/Chemical Families -small group discussion	-complete handouts (Appendices M&N) -complete activity and exercise in the textbook pp.108 -113

Chapter Summary

The purpose for this chapter was to present the Unit on "Exploring Matter", a Grade 9 applied chemistry unit. The rationale, the resources and the planning chart that were used are consistent with both the Kemp Model's four elements (Figure 3) and design process (Figure 4), as well as the Ontario Science Curriculum guidelines for Grades 9 and 10 (1999). Chapter 4 will summarize this curriculum development project, present recommendations for further research and close with some final comments.

CHAPTER 4

Summary and Recommendations

Discussion

As mentioned at the beginning of this project, in a modern society, many important products such as fuels, fertilizers and plastics are produced by chemical industries through the application of science and technology and the study of chemistry serves as a cornerstone for many disciplines such as medicine, biology, and pharmacy. However, many students see chemistry as abstract and unrelated to real life, saying that chemistry is one of the most difficult subjects they have to study in high school, an attitude that could account for the results of the Third International Mathematics and Science Study, released in November 1996. The results of the international science study showed that Ontario students lag behind the national average in both mathematics and science subjects, and that Canadian secondary science students as a whole are behind students in such countries as Japan and Belgium. This author felt that these results could account for the lack of student interest in the chemistry subject area.

The Ontario government wants to improve the international test results upward as well as the attitude students have about science by undergoing a process of curriculum reform at the secondary level, including modifying the science curriculum. However, to make these changes happen, teachers need adequate preparation time, in-service training and the appropriate resources to prepare for the new curriculum. Hence, the purposes for this project were to deal with the fact that: (1) due to legislative changes and the secondary reform process, Ontario secondary science teachers do not have enough preparation time, in-service training and instructional resources to deal with the new science curriculum; and (2) most secondary school students do not relate chemistry to their everyday life and future employment opportunities.

In this project the author provided a unit format for a Grade 9 applied chemistry course on "Exploring Matter," which not only makes learning more relevant to students (transformational) but has the long-term potential of improving the international science test results for Ontario secondary school students. The unit organization found in Chapter 3 provides a practical chart format that shows teachers what to include when developing a unit using the learning expectations stipulated in the new Ontario science guidelines.

The unit format presented in Chapter 3 is also systematic, easy to follow and theoretically defensible. Based on the Kemp Model, an instructional development process involving nine components, it is explained in detail in Chapter 2. However, although the Kemp components were not used in either a linear or circular sequence, the underlying assumptions within each component were incorporated into the unit format (including the chart organizer) and can be modified for all types of chemistry courses, whether "applied" or "academic."

Recommendations for Further Study

As a result of the work completed for this project, and the unit format presented in Chapter 3, a number of recommendations are appropriate given the fact that only the Grade 9 component of the Ontario Science Curriculum guidelines for Grade 9 and 10 is being implemented in the 1999/2000 academic year. For example, it is recommended that:

1. using the format in Chapter 3, units be designed for the remaining Grade 9 "applied" and "academic" Grade 9 science courses;
2. using the format in Chapter 3, units be completed for the Grade 10 chemistry units;
3. research be done to evaluate the unit format presented in Chapter 3 to evaluate its effectiveness by measuring student learning outcomes;
4. research be done to evaluate the unit format presented in Chapter 3 to evaluate its effectiveness by measuring teacher beliefs and/or student opinions using self-report;
5. teachers of other science courses such as physics and biology use the unit format presented in Chapter 3 to design courses of study; and
6. teachers assigned to non-science subject areas use the unit format presented in Chapter 3 to design courses of study.

Final Word

The introduction of the Ontario Science Curriculum guidelines for Grades 9 and 10 (1999) began a change process that will affect all science courses taught in Ontario's high schools. As a result, teachers of science face a lot of challenges now and for many years to come. To begin with, they have less preparation time, insufficient direction about the new courses they are expected to teach, do not have the resources they need and there is insufficient in-service training to prepare to teach the new courses.

In this author's opinion, the secondary reform process was implemented too hastily without sufficient consultations. As a result, neither the students nor the teachers are prepared for the changes. As Fullan and Steigelbauer (1991) pointed out: "If reforms are to be successful, individuals and groups must find meaning concerning what should change as well as how to go about it." To date, this type of consultation does not appear to have happened. However, in spite of the challenges, the author assumes that secondary school teachers will do their best and that they will find the unit format presented in this project a helpful and practical tool.

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Appendix A: Physical Properties of Some Known Substances

Do not taste any of the substances.

Observation:

Name of Substance	State	Colour	Hardness	Other Properties
copper				
zinc				
lead				
sodium chloride (table salt)				
sulphur				
vegetable oil				
air				

Discussion:

1. You were asked not to taste any of the substances. Why?

2. Which of the physical properties were the easiest to determine?

3. Which of the physical properties were more difficult to determine?

4. Why is it important to be able to tell substance from one another? Give an example.

Appendix B: Properties of Matter

Introduction:

When you observe matter- whether you see it, touch it, hear it smell it, or taste it- you are observing its characteristics, called its physical properties.

Purpose: To identify substances by examining their physical properties.

Materials and Apparatus: The substances given are contained in small bottles numbered 1-12.

Procedure: Observe the various substances given and describe their state, colour, hardness and other properties (if any) and try to identify the samples given. Do not taste any of the substances.

Observations:

Sample No.	State	Colour	Hardness	Other Properties	Identity
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

Discussion:

Conclusion:

Appendix C: Physical and Chemical Changes

Complete the following:

No.	Observation	Physical Change ? Chemical Change ?	Reasons
1	Milk sours		
2	Clothes fade		
3	Bread is baked		
4	A tea bag is put into water		
5	A new substance is formed		
6	Coffee beans are ground		
7	A tree is cut		
8	An egg is cooked		
9	Paints are mixed		
10	Paints dry		
11	Clothes drying		
12	Tarnishing of silver		
13	Burning of a candle		
14	Evaporating of water		
15	Copper turns greenish		
16	Formation of frost		
17	Boiling of water		
18	Toasting of bread		
19	Rusting of a nail		
20	Digestion of food		

List four clues for recognizing a chemical change.

Appendix D: Classifying Elements

Refer to Textbook pp.48-49.

Observations:

	Element	Colour	Lustre	Malleability	Density	Magnetism	Electrical Conductivity
1	iron						
2	copper						
3	lead						
4	nickel						
5	tin						
6	aluminium						
7	magnesium						
8	carbon						
9	sulphur						
10	iodine						

Discussion:
Based on your observations, can you classify elements according to different properties? Explain.

Appendix E: Chemical Symbols

Chemical symbols are abbreviations of the names of the elements. With the help of the Periodic Table on the inside back of the textbook, find out the names and symbols of the following elements.

Atomic number	Chemical Symbol	Name of Element	Atomic Number	Chemical Symbol	Name of Element
1	H	hydrogen	22	Ti	
2			26		
3			28		
4			29		
5			28		
6			29		
7			35	Br	
8			47		
9			53		iodine
10			78	Pt	
11			79		gold
12			80	Hg	
13		aluminium	82		lead
14			92	U	
15					
16					
17					
18					
19					
20	Ca	calcium			

Appendix F: Mining in Canada

Assignment:

Natural resources such as minerals are very important to the economy of Canada. These provide many job opportunities and related trading opportunities for Canadians.

Read pages 70 to 73 in your textbook for some background information and then do some additional research in the library, using reference books, computer encyclopaedia or internet to find out more about mining in Canada.

1. Define the following terms related to mining: a) minerals, b) ore, c) metallurgy, d) alloy and e) slag.

2. Pick one metal that is mined in Canada, place your name in the classroom to let your teacher know your choice (no more than two students per metal) and then answer the following questions about the metal:

   a) Where in Canada is the metal found?

   b) What is the mineral that is mined to recover the metal?

   c) How is the metal separated from the other material in the ore?

   d) What are some uses of the metal?

   e) Metals are often mixed with each other to make alloys to change its properties. What are some alloys made from your metal?

   f) Where else in the world is the metal found?

3. Present your findings in a poster that you can share with others in the class.

Appendix G: Breaking Compounds into Elements

Refer to Textbook pp.52-53.

Demonstration: Draw a diagram of the apparatus used to show the electrolysis of water.

Discussion:

1. What happens in the apparatus when power is turned on?

2. What is the effect of turning off the power?

3. Compare the relative amounts of gas in the tubes.

4. Describe the physical properties of the gases. Suggest what the gases are.

Conclusion:

1.Define electrolysis.

2. Write a word equation to show the electrolysis of water.

Appendix H: Testing for Gases

What is a chemical test ?

No.	Gas	How to Test for the Gas	Observation
1	Oxygen		
2	Hydrogen		
3	Carbon dioxide		
4	Water vapour		

Appendix I: Identifying Mystery Gases

Refer to Textbook pp.56-57.

Observations:

Part	Reaction	Result 1	Chemical Test Used	Result 2	Identity of Gas
1	Hydrogen peroxide and manganese dioxide		(a) burning splint		
			(b) glowing splint		
2	Hydrochloric acid and magnesium		(a) burning splint		
			(b) glowing splint		
3	Hydrochloric acid and sodium bicarbonate		(a) burning splint		
			(b) glowing splint		
			(c) limewater		

Discussion: Answer questions 13 (a) to (f) in the textbook p.57.

Conclusion:

Appendix J:Building Models of Molecules

Refer to the Textbook pp.62-63.
Observations and Results:

Atom	Symbol	Colour	Number of Connections per Atom
hydrogen		white	
oxygen		red	
nitrogen		orange	
carbon		black	

Name	Diagram	Formula
hydrogen		
oxygen		
nitrogen		
ammonia		
methane		
water		
ethene		
carbon dioxide		

Appendix K: The Structure of the Atom

The atom consists of three subatomic particles.
These particles are called protons, neutrons and electrons.
A proton carries a positive charge.
A neutron has the same mass as a proton but has no charge.
Electrons are very light and carry a negative charge.
The mass of one proton is equal to the mass of approximately 2000 electrons.

Summary

Particle	Symbol	Relative Mass	Charge
proton			
neutron			
electron			

Protons are especially significant, because the number of protons in atom determines what the atom is.
Example: An atom with 1 proton is a hydrogen atom.
An atom with 6 proton is________.
An atom with 12 proton is __________.

Bohr-Rutherford Model of an Atom:
1. There is a small centre or nucleus. The protons and neutrons are in the nucleus.
2. Around the nucleus is a cloud of moving electrons.
3. The electrons travel around the nucleus much like planets around the Sun.

Note:
1.In an atom, the number of protons is equal to the number of electrons. Hence an atom is neutral.

Element	No. of Protons	Total Positive Charge	No. of Electrons	Total Negative Charge	Net Charge of Atom
hydrogen					
oxygen					
magnesium					
copper					
uranium					

2. The nucleus of an atom is positively charged. Why?

3. An atom is neutral. Explain.

4. As protons and neutrons are much heavier than electrons, most of the mass of the an atom is in the______________.

Atomic Number and Mass Number:
Atomic number is the number of protons in an atom.
Example:
A hydrogen atom has one proton. Its atomic number is 1.
A carbon atom has six protons. Its atomic number is ______.

Mass number is the total number of protons and neutrons in the nucleus of an atom. Or

Mass number = number of protons + number of neutrons

Example:
With the help of the Periodic Table, complete the chart

Periodic Table Symbol	Atomic Number	Mass Number	Number of Protons	Number of Electrons	Number of Neutrons
$^{65}_{30}Zn$					
$^{4}_{2}He$					
$^{23}_{11}Na$					

Appendix L: Electron Arrangement

Refer to Textbook p.92.

Bohr Diagram:

1. The symbol of the element is shown in the centre to represent the _________________.
2. Concentric circles are drawn to represent the ____________.
3. Electrons are shown in the orbits.
4. Maximum number of electrons in the first three orbits are 2,8,8 respectively.

Example:

Bohr-Rutherford Diagram:
Similar to Bohr diagram, in addition, the number of protons and neutrons are shown.
Example:

Appendix M: The Periodic Table

With the help of the Periodic Table on the inside back cover of the textbook, answer the following questions:

1. How is the Periodic Table arranged?

2. How many Groups (vertical columns) or Families of elements are there?

3. How many Periods (horizontal rows) are there?

4. What is the total number of elements listed in the Periodic table? What is the name of the first element?

5. Are there more metals or non-metals?

6. Where can you find the metals or non-metals in the Periodic Table?

a) Metals appear on the _________________ side of the periodic table.

b) Non-metals appear on the _____________ side of the periodic table.

7. a) Name five metals

   b) Name five non-metals

8. Name two metalloids.

9. Give the name of a metal at liquid state.____________________.

10. Give the name of a non-metal at solid state. __________________.

11. Give the name of a non-metal at liquid state.___________________.

Appendix N: The Periodic Table and Electron Arrangement

Draw the Bohr diagram for the elements with atomic numbers from 1 to 20.

GROUP / PERIOD	I	II	III	IV	V	VI	VII	VIII
1	1							2
2	3	4	5	6	7	8	9	10
3	11	12	13	14	15	16	17	18
4	19	20						

Observation:

1. Elements in Group I have ___________ electron in the outermost orbit.

2. Elements in Group II have __________ electrons in the outermost orbit.

3. Elements in Group VII have ________ electrons in the outermost orbit.

4. In general, elements of the same Group or family have in the outermost shell ____________.