University of Alberta

Using Action Research to Improve Science Safety in Alberta's Schools

by

Arthur Wayne Bauer ©

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Dedication

To my father, Alex Bauer, for his strength and support in encouraging me to always pursue higher education and learning.

To my wife Sandra, my daughter Sarah, and my son Jonathan, for all your love and understanding.

Using Action Research to Improve Science Safety

in Alberta's Schools

Arthur W. Bauer

Dr. David Geelan, Advisor

Abstract

This study used a collaborative action research process focused on the goal of improving science safety in Alberta's schools. Sixteen members of the Provincial Science Safety Committee participated and completed both a qualitative Likert scale survey and an open ended questionnaire.

Areas of science safety in need of improvement are arranged into four categories:

1. Improvements that encompass the broad area of science safety.
2. Specific improvements related to professional development and training.
3. Improvements dealing with staffing.
4. Specific practices in need of improvement.

A professional development model including topics, resources and ways of demonstrating due diligence is presented for school board trustees, superintendents, school district administrators, science teachers, teacher aides, and laboratory technicians. The research conducted will aid school districts in designing science safety programs, policies and procedures guided by current legislative requirements.

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Chapter 1

Introduction

This research project adopts a collaborative action research process/ methodology focused on the goal of improving science safety in the province of Alberta. Using my past fourteen years of experience as a District WHMIS Coordinator, I was contracted to develop a draft resource for Alberta Education in the spring of 2002. The Department assembled a Provincial Science Safety Committee consisting of a multi-stakeholder group of experts to review and revise the draft. The goal was to deliver a support document that would be able to guide science education and resource development through the next curriculum cycle.

During the draft development phase, resources were gathered from other provinces and school districts. The approach was to adopt key sections and incorporate these into a provincial resource that would be reviewed by a committee and meet the needs of Alberta. It is important to note that all of the participants in this research study have been connected to the resource development and have been chosen because of their expertise in this area. As a result, readers of this thesis should consult the most recent copy of the provincial science safety resource *Safety in the Science Classroom* so that it may serve to provide a framework for the breadth and depth of work completed thus far.

Upon reviewing the references for our Provincial Science Safety Resource, it became obvious that there were no peer referenced journal sources used in the draft phase. This gap was the main reason for pursuing research in science safety as the potential for informing and enhancing science safety issues needed to be explored. A second area requiring further study was the necessity for a legislative review which is included in the literature review as a separate section. The appendix also contains additional information on Alberta's:

- provincial science curricula,
- Teaching Quality Standards and science safety,
- Teacher Growth, Supervision and Evaluation Policy.

The literature review is a fundamental component of the research in this particular project. In moving from personal experience to public resource development, the articles cited in the review have engaged Alberta Education staff and members of the provincial committee with the relevant "research". Subsequent revisions have resulted in an already improved resource that will form the context for further discussions.

Science Safety: A Personal Perspective

The issues and concerns raised in the literature confirm many of the problems that I have encountered through my teaching career. Every school in which I have taught has had serious problems with liability, negligence, and safety. In 1990, the Province of Alberta initiated a toxic round up in which I represented my district as a WHMIS coordinator. Regrettably, a provincial professional development plan was never created and many toxic chemicals were reordered by teachers when they returned the next year. Safety in-servicing is largely neglected in Alberta schools and the demands on teacher time often do not allow for adequate instruction. Funding is a serious issue and many schools do not have the necessary professional development budgets to address these matters. Administrators often have no background in safety and many schools do not have emergency preparedness plans that address chemical hazards and procedures in case of spills or chemical fires. School districts are without safety policies, however the direction that could be provided by these policies would be helpful in raising the conscientiousness of staff and students.

There is a definite need to explore science safety in Alberta and Canada. Most of the literature is from the United States with very little research being conducted in Canadian universities. As a result, I suggest that work in this field is both timely and necessary.

The draft questionnaire developed for this research project is designed to examine three specific areas:

1) Areas for improvement in science safety (Gap analysis/identification)

2) Exemplary practices (What are we doing well in science safety)

3) Professional development (What are the needs, structures, and resources of our stakeholders in science safety).

These areas, as they relate to the study, are further developed in the chapter on methodology.

Chapter 2

Literature Review

Science Safety in Alberta's Schools

In the fall of 2001 staff from the Science Curriculum and Teacher Resource Departments of Alberta Learning began to work on the development of Alberta's first formal Science Safety Resource. Ten years had passed since the provincial toxic round up and concerns about safety and instruction in science classrooms were being raised. The decision to create a provincial resource was based upon a number of fundamental issues:

- Teacher resource materials for science safety were incomplete and outdated.
- Science safety resources in the form of curriculum support materials were not developed for Alberta schools.
- Information on the safe storage, handling, and use of science equipment and chemicals would enhance professional development and science instruction.

Science safety is a shared professional responsibility. An awareness of legislative requirements, staff competency, district policy, and monitoring and compliance, all contribute to the due diligence that a district and its employees must demonstrate. Science safety enhances laboratory work in schools and provides teachers with the confidence to instruct in a safe manner. Developing a culture of safety and respect for our environment permeates the literature and guides inquiry into the study of research on science safety.

In conducting the literature review on science safety each of the following data base searches was used using a variety of key words:

- ERIC
- Academic Search Premier (through EBSCO)
- OVID: Bibliographic records
- UMI Proquest Digital Dissertations.

References selected were subject to peer review and came primarily from two major journals; *The Journal of Chemical Education*, and *The Science Teacher*.

Dr. Margaret-Ann Armour from the University of Alberta's Department of Chemistry was consulted, as she is recognized in Canada for her contributions to safety in science education programs. She confirmed that the above two journals were widely acknowledged as sources for information on this topic and suggested one other, *The Journal of Chemical Health and Safety of the American Chemical Society*.

The focus of the literature review is an examination of references dating back to 1980. This date was purposefully selected as it encompasses new Occupational Health and Safety Guidelines which were adopted in Canada in 1982, as well as the Occupational Safety and Health Administration Standards which were implemented in the United States in 1991.

Generating a culture of safety involves shared responsibility towards developing an awareness of safety procedures and science instruction activities in our schools (Hanssmann 1980; Gerlovich 1992; Sichak 1983; Mandt 1993). Concerns for safety in schools were outlined by Hanssmann in the 1980 article, Safety is Everyone's Responsibility in the Schools. Many of the issues raised continue to re-emerge throughout the literature and are problems in school districts throughout the United States and Canada. In an effort to address unsafe conditions in Delaware schools, Hanssmann identifies a number of serious problems. Teachers had little or no training in the identification of safety hazards and often relied on the instruction they received as part of their undergraduate or college courses. Documented hazards were symptomatic of an educational system where under-funding and a lack of knowledge contributed to school labs that were clearly redundant and hazardous. Administrators and teachers were requesting help with inspections but it was clear that there was an atmosphere of ignorance and neglect. Among the many problems identified were:

- outdated and hazardous chemicals in need of removal,
- old and unlabeled chemicals,
- carcinogenic substances, and
- inoperable safety equipment.

A lack of personal protective equipment, improper storage conditions, venting, lighting, and poor electrical wiring were also noted. Architects were often unaware of the design of science facilities, and the special needs of science classrooms and preparations areas. Student education was also identified as a concern. Often, poor teacher instruction and faulty demonstration techniques meant that students were ill informed or in some cases, never given an adequate background for science activities, nor required to use safety equipment.

The call to promote safety in school science laboratories is broad and multidimensional (Hill 2003). Chemical storage, handling, and disposal are necessary components of school safety and science instruction (Gerlovich 1989; Armour 1988; Allen 1983; Sichak 1983; Summerlin and Summerlin 1999; Young 1997). The lack of specific legislation for schools meant that, in 1983, government regulations for industrial labs and businesses had to apply to schools. An attempt to create an awareness of how Occupational Safety and Health Act Standards and Environmental Protection Act Standards impacted schools focused on the importance of designing for safety (Sichak 1983). Hazardous chemicals such as heavy metals (lead, cadmium, mercury); and carcinogenic (cancer causing) and mutanogenic (causing birth defects) substances were present in schools and needed to be disposed of. Government had a clear role in promoting safety and working with management to build effective safety and health programs. Requirements for storage, handling, and disposal were identified as essential in this process.

Storage requirements include an inventory of all substances and the categorization of these chemicals based upon their reactivity and classification. An inventory can be cross-referenced to existing curriculum objectives and pedagogical practices. As curriculum changes and textbook resources identify laboratory activities essential for science instruction, an inventory will enable teachers to address disposal and management concerns (Carpenter, Hizer and Baker 1999). Hazardous chemicals are also generated as part of many chemistry experiments and science instructors must take steps to dispose of these waste substances (Allen 1983; Armour 1988; Young 1997). Arrangements for storage of these wastes until disposal is another problem;

especially if a school district is without a regular disposal program. An inventory is fundamental in tracking chemicals and generated wastes from 'cradle to grave'.

Waste minimization is also an effective way of reducing storage space requirements and disposal costs. It also sets a good example for students and is necessary for responsible scientific research and environmental stewardship. Schools can minimize waste by doing micro-lab activities whereby concentrations of chemicals are reduced. By minimizing the quantities of reagents, and involving the students in an understanding of how wastes will be disposed of, a concept of personal responsibility can be established. Experiments that use environmentally friendly chemicals or substances that can be easily reused, recycled or neutralized, help to promote responsible science education.

Specific techniques are identified in the literature to help science educators minimize wastes and identify substances for disposal (Armour 1988; Dunkleberger and Yohe 1992; Young 1997). Such methods include:

- acid or base neutralization;
- volume reduction of dilute solutions;
- solvent recycling; and
- specific disposal reactions for: strong oxidizing agents, soluble cyanides, and solutions of heavy metals, (lead, cadmium, dichromate, nickel and silver).

Once waste minimization methods have been used, clearly labeled containers identifying the contents as being "For Disposal Only" must be used.

All storage areas must also be regularly managed. Specific safety cabinets for acids, bases, flammable liquids, flammable solids, and oxidizers should be designated. These storage and prep areas should be free from obstructions, cleaned regularly, and inspected frequently (Dunkleberger and Yohe 1992; Mandt 1993; Kaufman 2002). By developing laboratory safety and inspection procedures, teachers and administrators will be able to maintain safe working and learning environments thereby demonstrating a collaborative approach. Architects and planners also need to be aware of special science facility design requirements and ensure that additional space is provided for science instruction (West, Moltz and Biehle 1999).

Many Alberta school districts are without policies and procedures to deal with chemical safety. Funding is a serious concern and administrators need to take steps to promote professional development and prevent serious accidents (Penker and Elston 2003; Kaufman 2002; Lemons 1993). School boards, as employers, are required through legislation to implement worker [teacher] education programs for school safety and these programs should include information on the handling, storage, and disposal of hazardous chemicals.

A three step process used in Iowa may present a series of steps that the province of Alberta could implement with the Alberta School Boards' Association (Gerlovich and Miller 1989). The first step involved the formation of an advisory committee which included the following members: Department of Natural Resources, Department of Transportation, fire marshals, university chemists, classroom Chemistry teachers, school administrators, chemical transport and disposal companies, school insurance carriers, and school board association representatives. Throughout the process, attention was focused on the specific needs of schools, and a collaborative initiative was implemented to remove hazardous chemicals and waste substances from schools. The second step resulted in the development of a twelve to fifteen month action plan that started with in-servicing participants, the conducting of safety assessments [audits], and the development of chemical inventories. Relevant laws, codes, regulations, and standards were consulted by the committee members when the action plan was being developed and training was provided for all teachers in the areas of hazard assessment, chemical identification, and waste disposal procedures. The action plan consolidated specific school information so that a cost effective procedure could be developed for the final step which included pick up, transportation, and disposal at a suitable site. The scope of this operation included 436 school districts with over 28,000 containers of chemicals removed from schools. The wastes included radioactive materials, gas cylinders, unknown substances, air sensitive chemicals, and peroxide forming [explosive] substances. This effort was a major collaborative initiative in which a multi-perspective approach was used to address specific safety problems and concerns. As a model, this approach may be advantageous to all school boards in meeting science education safety requirements.

Teacher training in laboratory safety and inspection procedures is a required part of demonstrating due diligence. Teacher liability and the obligations of school boards as employers and administrators as supervisors cannot be ignored. The courts have altered the role of the science teacher, and liability extends beyond the teacher to include all levels of administration and the school boards (Dunkleberger and Yohe 1992; Hoff 2003; McDuffie, Longo and Neff 1999; Purvis, Leonard and Boulter 1986). As a result, many recommendations exist for reducing potential liabilities.

In-servicing is a necessary component that teachers, as employees, must attend and have access to; and school boards, as employers, must provide. Teachers are empowered to do lab activities when they know that they are conducting them safely, and students benefit from an enhanced science education by being involved in safe laboratory experiences. It is important to provide professional development to teachers in this area or they may begin to unnecessarily view liability as a reason for not doing experiments. Recommendations include:

- developing procedures and consistency in enforcing rules,
- using safety contracts for student behavior,
- the mastery of skills through skill performance assessments done prior to lab activities,
- the cognitive testing of safety rules,
- pre-lab safety discussions,
- purchase and maintenance of personal protective equipment, and
- the development of a procedure for periodic laboratory inspections.

Unfortunately, issues of due diligence, legal liability, and negligence have often resulted in suits for damages and medical expenses (Gass 1990; Richardson, Gentry, Lane and Vanberkum 1994; Hoff 2003; McDuffie, Longo and Neff 1999; Purvis, Leonard and Boulter 1986). Anyone may be involved in a potential lawsuit: students, teachers, administrators, visitors, support staff, suppliers, and text authors or publishers.

The basis for a lawsuit depends upon a number of factors

- the degree of harm,

- the conduct of individuals,
- the duty of individuals and the levels of education they have received, and the circumstances of the incident and whether "reasonable" instruction has occurred.

A guiding principle in all of these situations is a requirement for "reasonable foreseeability", whereas reasonable risks are identified for instruction and safety in science education programs. A special requirement for teachers is supervision which may warrant different requirements depending upon the sophistication of the experiment being conducted. The nature of instructions, the choice of material for an experiment, and the ability to deal with emergency situations may all have a bearing on any individual case. Standards of care vary and the degree of care is higher when younger children, children with special needs, or experiments with higher risks are involved (Cheney and Roy 1999). Although each situation is unique, several areas of concern have been identified

(a) specifically for the teacher:

- the failure to provide adequate supervision,
- the failure to properly and adequately instruct, and
- the failure to exercise and provide judgment;

(b) specifically for schools:

- laboratory security,
- appropriate facilities,
- proper instruction including school board policy, and laboratory rules and regulations,
- protective gear,
- appropriate age related and content related materials for the learners involved.

Prudent steps are necessary in demonstrating due diligence and avoiding accidents that may result in the possibility of injury to students (Richardson, Gentry, Lane and Vanberkum 1994; Young 1997). Some specific recommendations are that: school review [safety] committees should be formed; science departments should regularly be inspected and reports should be filed in the school office and district office; staff development should be up to date and include safety, first aid and cardiopulmonary resuscitation; and a district awareness of the potential hazards must be addressed by policies that promote safety and reduce liability.

Due diligence can also be demonstrated by adopting safety practices and procedures. Laboratory safety rules can be posted and discussed with students before they are permitted to conduct experiments (Corley 1994). Environmental health and safety audits help to define existing and potential liabilities and provide an accountability structure that ensures regulatory compliance (Rainer, Kretchman and Cox 2000; Kaufman 2002; Gerlovich, Whitsett, Lee and Parsa 2001; Gerlovich and Gerard 1989). Teachers and administrators can conduct lab safety surveys (West 1991) similar to safety audits and develop a list of recommendations for in-servicing and professional development. Student safety contracts help to explain reasons for safety to both students and parents (Davidson 1999). These contracts help to build an atmosphere of personal responsibility and a rapport with students that focuses on safety.

Safety education for science educators is an essential part of pre-service instruction (Carpenter, Hizer and Baker 1999; O'Haver 1997; Moore 1990; Plohocki 1998; Dombrowski 1983). Approaches include workshops or in-service programs made available to students and may include complete courses in laboratory safety and stockroom management. New teachers often inherit laboratories and chemical storage areas that overwhelm them as they begin their teaching careers. They may also experience problems when they move to a new school. Pre-service instruction within the Chemistry Department of the Science Faculty or the Education Faculty is debated in the literature; however, the need to address safety matters is clear (Zaidman 1992; Moore 1990; Mandt 1993; Everett and DeLoach 1988; Lemons 1993). Major topics or areas of study are suggested and include laboratory management, stockroom management, and safety training. These major topics are broken down in the following ways:

(1) Laboratory Management

- the design and modification of the chemical laboratory, including ventilation requirements, safety equipment, space requirements;

- the design, modification, and evaluation of laboratory experiments, including both traditional verification and exploratory inquiry types;
- grouping of students for more effective use of laboratory time and materials;
- techniques to deal more effectively with special groups of students, such as mobility handicapped, in the laboratory;
- the role of the computer in the laboratory, including hardware modifications to collect and analyze data and software availability and evaluation; and
- simple instrument maintenance.

(2) Stockroom Management

- design and modification of stockroom facilities,
- safe storage of chemicals, chemical waste disposal,
- inventory systems, and
- purchasing equipment and supplies.

(3) Safety

- legal requirements,
- interpretation and use of MSDS sheets,
- safety rules and contracts,
- safety equipment, and
- safety inspections.

(Moore, J. T. 1990, p. 166)

In the absence of a full course, a twenty hour program for undergraduates may be used. This suggested program combines elements of safety training with the following topic areas:

• legal requirements	1 hr.
• chemical hygiene and use of MSDS	6 hrs.
• safe storage of chemicals	3 hrs.
• chemical waste treatment and disposal	3 hrs.
• inventory systems and recordkeeping	2 hrs.

- review and monitoring of lab exercises 2 hrs.
- special techniques for handicapped 1 hr.
- safety inspections 1 hr.
- safety equipment and fire protection 1 hr.

(Mandt, D. K. 1993, p.59)

Ongoing safety instruction is necessary for all science educators. Curriculum, standards for safety, legal legislation and teaching assignments change over time. It is reasonable to suggest that all teachers receive ongoing in-service workshops and that mandated safety training be provided by school districts. In-service opportunities update teachers and continually focus on matters of safety.

Cultivating safety involves all those connected to science education. A review of the literature indicates that there are many contributors to science safety in our schools. This research process explores the intricacies and levels of awareness necessary to implement a new provincial science safety resource. The resource will be a cornerstone document for educators as they provide instruction and model safe practices that demonstrate due diligence and environmental stewardship.

Chapter 3

A Review of Related Legislation

Identifying Related Federal and Provincial Legislation

By identifying related sections of federal and provincial legislation (that may be referenced by all connected to science education), this review of legislation is designed to provide insights on safe practices related to laboratory and classroom science instruction. The position presented throughout is that both instruction and practice can be enhanced by increasing an awareness of legislation as it pertains to safety in educational settings.

Due diligence, as an approach to science safety, recognizes that reasonable and prudent practices are essential to ensure sound pedagogical instructional strategies that identify potential hazards and reduce the likelihood of accidents. Identifying legislation applicable to science safety furthers the practice of due diligence and a broader awareness of safety issues so that laboratory work may be enhanced by providing educators with the confidence that they are acting in a safe manner. However, it is not intended to be a legal document and the author does not assume responsibility for the validity or completeness of the information provided or for the consequences of its use. This review process is designed to provide dependable information as a starting point to help teachers, district administrators and school boards to make sound decisions regarding science safety.

The following consists of two main parts:

Part A: Science Safety and Links to Federal and Provincial Legislation

Part B: A Quick Reference Guide to Legislation (located in Appendix B.)

Part A: Science Safety and Links to Federal and Provincial Legislation

As this section examines the impacts of legislation on science safety and instruction, it must be acknowledged that many additional provincial documents and policies will provide insights on professional practice. Examples of this include: The

Program of Studies (with its requirements for Science Education), The Professional Code of Conduct, The Teaching Quality Standards, and their related Knowledge, Skills and Attributes, Teacher/Administrator Growth, Supervision and Evaluation Policies and legal precedents involving the rights, responsibilities, and legal liabilities incumbent on all educational levels. Issues concerning insurance, what constitutes negligence and the principle of *in loco parentis* as it relates to standards of care, are not presented in this submission.

Due Diligence

Due diligence focuses on actions that would be deemed as being both prudent and reasonable. Policies, procedures and conducts to insure safety and avoid accidents are all components of due diligence. Teachers, administrators and school districts are subject to higher standards of care, as they possess knowledge related to subject matter, program delivery and the safe use of chemicals and apparatus in science education programs. By providing a safe working environment for students and staff, school districts demonstrate due diligence. Specifically, concepts of foreseeability, preventability and control are combined with requirements for staff competency, staff training, monitoring and compliance, and an awareness of legislation when concerns regarding risk avoidance and the fulfillment of legal responsibilities are raised. As each article of legislation is identified with the intent to provide insights towards ways in which due diligence may be demonstrated.

The following federal and provincial legislation will be examined:

School Act
Teaching Profession Act
Labour Relations Code
Environmental Protection and Enhancement Act
Water Act
Hazardous Products Act
Occupational Health and Safety Regulation and Code
Dangerous Goods Transportation, and Handling Act and Regulations
The Alberta Building Code
The Alberta Fire Code.

School Act

Upon examining the School Act, the interrelationship of responsibilities that exist within a school system become apparent. From student to trustee, all involved have a role to play in demonstrating due diligence and ensuring that science instruction is conducted in a safety conscious manner. In the following sections of the Act, the legal requirements of students, teachers, principals, superintendents, and school boards are outlined. However, it is clear that all educators must collaboratively work together to meet the goals of education as outlined in our provincial curricula.

Students – Section 12

The code of conduct outlined in this section sets out conditions for students that are consistent for a safe learning environment. A diligent student pursuing his or her studies cooperating fully with everyone authorized by the board and complying with the rules of the school should be able to make a positive contribution to the science program. When instruction from teachers and teachers' aides includes safety procedures of any kind, it is reasonable to expect students to follow these directions and act in a manner that promotes safety. Laboratory work has students using chemicals, apparatus, and personal protective equipment. Instructions received by students should always include any required safety precautions or special requirements for chemical disposal before commencing the activity. Students conduct consistent with appropriate instruction demonstrates due diligence in the classroom.

Teachers – Section 18

Teachers are responsible for providing competent instruction and supervision. Science demonstration and laboratory work require special training and a knowledge of safe practices when equipment and reactive substances are being used. Minimizing risks and preventing accidents are fundamental in the lesson planning process. Safe activities consistent with the approved Science Course Program of Studies both encourage and foster learning for students. Teachers would also be responsible for maintaining a safe learning environment in science classrooms where both labs and demos are done. Special safety, first aid and fire equipment requirements would be considered an essential part of competent instruction. Teachers should begin each science course with a tour of the safety equipment in the science lab and a review of safety procedures or policies necessary for science instruction. Deficiencies or safety concerns of any kind should be put in writing and directed to the school principal.

Principals – Section 20

Providing instructional leadership in the school requires principals to interact with legislation, district policies and all approved courses of study. Evaluative responsibilities ensure that students meet the standards of education set by the Minister, and district personnel are equipped with the necessary skills to provide competent instruction. One of the main purposes of the Provincial Science Safety Resource is to provide administrators with the guidance they require to demonstrate due diligence when planning and monitoring science education programs. Charged with the direct management of the school, everything from the allocation of staff and resources, the development of an emergency response plan, to the requirement of supervision, evaluation and discipline must (as the Act states) be the responsibility of the principal. Subsequent legislative requirements follow and the role of the principal is fundamental in that he or she must be:

-aware of safety requirements
-able to evaluate staff competency
-involved in monitoring and compliance.

Inspections – Section 43

As the Minister of Education may authorize the inspection and evaluation of "teacher, schools, the operations of school districts and divisions, educational programs, instructional materials or buildings used as a school," all policies and procedures concerning safety and science instruction may be part of such an inspection. Although this is not current practice, the Act does provide for such inspections.

Responsibility to Students – Section 45

Part Three of the School Act outlines the requirements placed upon school boards. In this section, the board shall ensure that all students are provided with an educational program consistent with the requirements of the Act and its regulations (Subsection 1). Subsection Eight further requires that each student is provided with a "safe and caring environment that fosters and maintains respectful and responsible behaviours." It is reasonable to suggest that this section would include the safety of staff and students in all matters. As a result, all pertinent legislative requirements also fall under the direction and responsibility of the board.

Emergency Closure of School Building – Section 57

This section allows a board to temporarily close a school should the health or safety of the students be endangered. It also requires the board to remedy the situation and reopen the school as soon as possible.

Powers of Boards – Section 60

The establishment of policy for educational services and programs combined with requirements for insurance and the maintenance of school property are responsibilities of the board. Copies of such rules or policies must be made available to employees who are affected by them and due diligence would be demonstrated by such actions. Policy development offers the board an opportunity to clarify and allocate personnel to discharge its responsibilities.

Under subsection 2, a board may establish committees and specify the powers and duties of such committees. Boards may choose to empower such a committee with the responsibility of determining any implications for action or policy arising from the implementation of the Provincial Science Safety Resource.

Delegation of Power – Section 61

By resolution, a board may authorize employees or committees "to do any act or thing or exercise any power that a board may or is required to do" (except for those referred to in Subsection 2). Both sections 60 and 61 emphasize the important role that policy plays in making explicit procedures and processes for district employees. As the Science Safety Resource involves all connected with science education, the drafting and implementation of policy may allow the board to set up necessary structures and delegate responsibilities to employees with special training in science education and the safety, handling and disposal of hazardous materials.

Superintendent of School – Section 113

As the Chief Executive Officer of the Board and Chief Educational Officer of the District or Division, the Superintendent supervises the operation of schools and the provision of educational programs. By providing leadership in all matters relating to education and fiscal management, the health and safety for all students and staff is a responsibility of the superintendent. As the province brings forward the Science Safety Resource and a new Senior High Science Curriculum, superintendents have a unique opportunity to examine the operation of schools, safety in science classrooms and the overall implementation of the science program.

The School Act and Program of Studies

School boards "shall provide an evaluation program consistent with the requirements of the Act," and that program "shall also be provided with a safe and caring environment that fosters and maintains respectful and responsible behaviours" (Section 43 (7), (8)). The Program of Studies sets out the requirements that further guide superintendents (Section 113 (5)), principals (Section 20 (b)), teachers (Section 18 (b), (c)), and students (Section 12 (c)); in the educational programs they must deliver and receive. As a result, the entire K to 12 Science Curriculum serves as the foundation for identifying the goals of science education in Alberta. In matters related to science safety, the Program of Studies is fundamental to the conceptual development of students, and the designing and implementing of a laboratory program. Therefore, it is important to note that all education levels should consult the Program of Studies for Science as well as the New Provincial Science Safety Document (Fall 2004) and other resources produced by the Department of Learning as they pertain to educational programs.

Teaching Profession Act

The Teaching Profession Act impacts educational programming and the role of teachers in many ways. For the purpose of this submission, the objects of the powers of the Alberta Teachers' Association and its role in discipline will be examined.

Powers – Section 4

The objects of the Alberta Teachers' Association as stated in the Act are fundamental to the cause of education and the teaching profession in Alberta. The Association is established as having powers that make it a firm stakeholder in educational matters. Science education, the health and safety of students and staff, the operations of schools and delivery of programs by teachers are all areas of interest and responsibility. Subsection (b), Parts *i* to *vi* outline the object of the Association to improve the teaching profession.

As teachers are the front line deliverers of educational programs and they are responsible for the supervision and safety of the students under their care, it is reasonable to suggest that the Alberta Teachers' Association has a positive and professional development role to play in the implementation of a Provincial Science Safety Resource.

Unprofessional Conduct – Section 23

As the Teaching Profession Act also establishes the Alberta Teachers' Association with the responsibility of discipline, the conduct of members is subject to the opinion of a hearing committee. In matters of student supervision, safety and the demonstration of due diligence when issues of negligence or liability are a concern, a charge of unprofessional conduct may be warranted. Section 23 outlines the grounds for such a charge.

Labour Relations Code

The preamble of the Labour Relations Code establishes employee-employer relationships that encourage fair and equitable resolutions to matters concerning the terms and conditions of employment. Collective bargaining and collective agreements as mechanisms of setting the terms and conditions of employment are legitimate processes of negotiation and agreement. The Labour Relations Code is briefly mentioned in this submission because, should action be brought forward to the Labour Relation Board, it has the ability to make inquiries, and conduct both investigations and inspections. As situations of this nature are complex, further investigation in matters involving the Labour Relations Code will be required.

Inquiries, Investigations and Inspections – Section 13

The board or an officer may examine all books and other records relating to employment or terms or conditions of employment. They may enter, inspect and examine the premises (schools), question employees and expect reasonable assistance when pursuing matters related to the Act. As records concerning safety inspections, fire drills, and staff training programs may fall into this category, it is important to include this particular part of legislation.

Environmental Protection and Enhancement Act

The purpose of the Act is to support and promote the protection, enhancement and wise use of the environment. Legislative requirements are "essential to the integrity of ecosystems and human health and to the well being of society." Polluters are expected to pay for the costs of their actions and schools or school districts are not afforded any special status under the Act. For all intents and purposes schools are considered to be no different than commercial waste generators.

Certificate of Qualification Required – Section 79

Before hazardous waste can be disposed of, school districts must enter into an agreement with a qualified waste broker who may legally accept the material and ensure its proper disposal. The Act requires that these companies be licensed. As the Science

Safety Resource indicates, Alberta Environment may be contacted so that potential waste brokers may be identified. School districts may then look at their particular needs and select a broker.

Prohibited Release Where No Approval or Regulation –Section 109

Division 1 of the Act sets out the requirements for the releases of substances generally. Section 109 would apply to schools, as they are not given prior approval or regulation as to the release of substances "in an amount, concentration or level or at a rate of release that causes or may cause a significant adverse effect." This section clearly states that "no person shall knowingly release or permit the release into the environment of a substance in an amount, concentration or level or at a rate of release that causes or may cause a significant adverse effect."

Duty to Report Release – Section 110

Should a prohibited release occur, the person[s] who releases or causes or permits the release of a substance into the environment must report it to the owner of the substance or to "any person to whom the person reporting reports in an employment relationship." Reporting is to be "as soon as that person knows or ought to know of the release." In schools and school districts, key individuals for notification would be school principals and district superintendents.

Manner of Reporting –Section 111

When reporting a release, the report must include the specific information outlined in Subsection 1, Parts A to E. This includes:

> A person who is required to report to the Director pursuant to section 110 shall report in person or by telephone and shall include the following in the report, where the information is known or can be readily obtained by that person:
>
> (a) the location and time of the release;
>
> (b) a description of the circumstances leading up to the release;
>
> (c) the type and quantity of the substance released;

(d) the details of any action taken and proposed to be taken at the release site;

(e) a description of the location of the release and the immediately surrounding area.

The person reporting shall submit his/her report in writing where required by the regulations and provide any additional information that a director requires.

Duty to Take Remedial Measures –Section 112

This section requires that the person responsible for the substance (teacher, principal, superintendent, board) shall take all reasonable measures to

(i) repair, remedy and confine the effects of the substance, and

(ii) remove or otherwise dispose of the substance in such a manner as to effect maximum protection to human life, health and the environment, and

(b) restore the environment to a condition satisfactory to the Director.

It is important to note that a director as outlined in Sections 42 to 56 of the Act may issue an additional environmental protection order calling for further measuring, monitoring or reporting on any matter the director deems to be in accordance with the Act (see Sections 113 to 117).

Identification Number Required for Hazardous Waste – Section 188

Before entering into an agreement with a qualified waste broker, a school board must be issued a personal identification number. This number is required before hazardous waste can be removed or collected from a school. The qualified waste broker cannot accept waste for transportation, treatment or disposal or storage unless it is provided with the district's personal identification number. The superintendent, on behalf of the board (as employer), may make application for a personal identification number by contacting the Regulatory Assurance Division of Alberta Environment.

Investigations and Inspections –Sections 195 to 206

Note: As an investigator for the purposes of the administration of the Act, may, without a search warrant or order to enter and inspect, enter and inspect any place, these sections refer to the nature of investigations and inspections.

Due Diligence Defence –Section 229

The due diligence defence is a legal concept used to ensure that all reasonable steps have been taken to prevent an offence under specified sections of the Act. This legal defence requires that employers and employees attend to all reasonable steps that would prevent the release of a substance under Section 109. Examples may include the provision of necessary training, the obtaining of safety equipment, the anticipation of spills or accidents and the implementation of safe work procedures under the supervision of employees of the school board.

The Environmental Protection and Enhancement Act requires that school boards and their community schools be environmental stewards. As waste generators, demonstrating due diligence requires that a collaborative effort be made by all involved in education so that our environment and health may be preserved. By identifying, minimizing and disposing of hazardous wastes properly, legislative responsibilities are fulfilled; and the result is the protection and wise use of our environment.

Water Act

The purpose of this act is to support and promote the conservation and management of water. Should a situation arise that may affect the quality of water, provisions exist within the Act that enable an inspector, investigator, or director to take emergency measures.

Emergency Measures – Section 105

For schools, an activity that "causes or may cause an immediate and significant adverse effect on the aquatic environment, human health, property or public safety" would fall under this section of the act. An inspector, investigator or director may take any emergency measures they consider necessary. Section 106 is on the recovery of costs and Section 107 is on declaring an emergency.

Hazardous Products Act

The Hazardous Products Act in Canada governs the advertising, sale and importation of hazardous products identified in Part I or II of the schedule of the Act. Parts of the Act are subject to the Hazardous Materials Information Act; however, both acts make reference to requirements for suppliers when providing a controlled product intended for use in the workplace. Since schools are regarded as work places and many of the chemicals used in laboratories are controlled products, the Act is included in this submission.

Part II Controlled Products Prohibition Re: Sale –Sections 13-16

These sections set out the requirements for suppliers to sell to any person, a controlled product intended for use in a workplace in Canada. The Material Safety Data Sheets (MSDS) included with the purchase of any controlled products (many laboratory chemicals) and the necessary information provided on the MSDS is legislated by the Government of Canada. Also, in subsection (b), requirements for the container in which the product is packaged and the displaying of the appropriate hazard symbols and labels, are outlined. In emergencies, physicians may request the information provided on the MSDS sheet for the purposes of making a medical diagnosis of, or rendering medical treatment to a person. More requirements for the availability of MSDS documents are legislated in the Provincial Occupational Health and Safety Act.

Part II Canada Labour Code Amendments –Section 3(1) (Amendment to Subsection 12 (1) of The Canada Labour Code), Section 5 (Amendment to add Subsection 125.1 & 125.2 of the Canada Labour Code)

Section 3 (1) in the part of the Act adds the definition of a hazardous substance to the Canada Labour Code. Section 5 adds Section 125.1 and 125.2 to the Canada Labour Code. Since this addition places requirements on employers who have hazardous products in the workplace, a school board shall, in respect of every workplace controlled by the board, ensure:

-that concentrations of hazardous substances are controlled,

-that hazardous substances are stored and handled properly,

-that all hazardous substances are identified, labelled and display prescribed
hazard symbols,

-that all MSDS documents are available to employees and physicians (in case of an emergency).

Occupational Health and Safety Regulation and Code

This Act is one of the most applicable pieces of legislation to the development of a provincial science safety resource. Practical in nature, the Act contains requirements for employers and employees with major sections on: the application of the Act, first aid, hazard assessment, chemical hazards and harmful substances, emergency preparedness, fire and explosion hazards, personal protective equipment, ventilation, and the Workplace Hazardous Materials Information System (WHMIS). All educational leaders are encouraged to read the Act as it clarifies the obligations that must be met in order for due diligence to be demonstrated. Students are regarded as workers under the Act and levels of administration may have responsibilities as both employee and employer.

Duties of Employers – Section 5

Employers must ensure the availability of all equipment intended to protect a worker and that the worker is competent in the application, use and limitations of that equipment. Safety equipment must be properly maintained in good working order and suitable for the function for which it is intended. Workers required to fulfill duties under the Act must also be supervised by employers to ensure that the worker fulfills that duty. Where personal protective equipment is required, the employer must ensure that it is available.

Direction and Instruction of Workers –Section 6

The definition of direct supervision is introduced in this section and requires that workers who are competent must provide continual visual supervision of workers who are not competent. Workers (teachers and students) must be able to communicate readily and clearly with each other. As science educators work with hazardous and controlled substances, specialized education and training are necessary for them to be considered as competent. Where codes of practice, procedures or measures (policies) are developed, an employer must ensure that all workers are made familiar with them before work commences. Personal protective or other equipment, and the training necessary to maintain and operate the equipment in a safe manner, must also be provided by the employer.

Duties of Workers – Section 7

Under this section, workers are given areas of occupational responsibility. A worker who is not competent must always be under the direct supervision of a competent worker and any worker who becomes aware of equipment that does not comply with Section 5 (6) must immediately report this to the employer.

Worker Training – Section 8

Employers must ensure that workers are trained and that they use that training. Workers are required to participate in the training provided by employers and where a worker may be exposed to a harmful substance, the employer must establish procedures to minimize exposure. In addition, the worker must be instructed regarding the health hazards associated with exposure to that substance. All school boards are required to provide site specific training programs for new and existing staff and update that training as necessary. Staff must participate in ongoing training/professional development programs.

Part 3 – First Aid

Employer Responsibilities – Section 16

This section simply states that employers "must meet the applicable requirements of Tables 3 through 8 of Schedule 1 to provide first aid services and maintain first aid equipment and supplies and a first aid room as required by this part or the director of medical services."

Tables 3 through 8 (pages 312 to 320) designate the type and contents of first aid kits, first aid room requirements and first aid requirements for low, medium, and high hazard sites. School principals and district administrators may use these tables to determine their first aid needs.

Location of First Aid Services, Equipment, Supplies –Section 19

This part of the legislation requires employers to ensure that first aid services, equipment, supplies, and a room (when necessary) are available during all working hours. Equipment and supplies must be maintained, clearly identified with signage to indicate the location of first aid services, equipment and supplies. In the absence of signage, every worker must know the location of first aid services, equipment and supplies and, an emergency communication system must be in place to summon first aid services.

Duty to Report Accident, Illness –Section 23

Simply stated, "A worker must, on suffering an acute illness or injury, report it to the employer as soon as practicable."

Record of Accident, Illness – Section 23

Employers must create a record of every acute illness or injury as soon as practicable after reporting and this record must be retained for three years from the date of record. The record must include the information required in Subsection 2, Parts A to H. A guide to reporting accidents and injuries is included in the regulations and code. Note: Access to Records, Section 25, outlines first aid records and procedures.

Part 4 Hazard Assessment, Elimination and Control

Hazard Assessment – Section 29

Hierarchy of Elimination and Control –Section 30

These two sections apply together to introduce requirements on hazard assessment, elimination and control. Employers must identify hazards, involve workers in the identification, and communicate the results of hazard assessments to employees. Intervals must be reasonable and practicable so as to prevent the development of unsafe and unhealthy working conditions. Where hazards are identified, they must be eliminated or controlled using engineering or administrative controls and wear necessary personal protective equipment. Should emergency action be required to correct a hazardous condition, competent workers must carry it out and the hazard must be controlled until the condition corrected.

Part 6 Chemical Hazards, Biological Hazards and Harmful Substances

Worker Exposure to Harmful Substance – Section 39

It is important to note that the Act contains a list of substances for which occupational exposure limits are provided (Table 2 of Schedule 2). An employer must ensure that a worker's exposure is kept as low as reasonably possible and does not exceed a harmful substances occupational exposure limit. Should a harmful substance not be listed in Table 2 of Schedule 2, the employer must still take all reasonable steps to limit a worker's exposure as low as reasonably possible. Subsections (3) and (4) set out requirements for 15 min. and 8 hr. limits.

Assessing Exposure to Harmful Substances – Section 43

Workers Exposed to a Harmful Substance – Section 44

Where a worker may be exposed to a harmful substance, an employer must:

-identify the hazards and undertake an assessment,

-eliminate the exposure and control the hazard,

-ensure that the worker is informed of the health hazards, be provided with training and use that training.

Section 44 in Parts A to E sets out the requirements for when a worker is exposed to a substance in excess of its occupational exposure limit.

Skin and Eye Protection – Section 46

Worker Decontamination – Section 47

Emergency Baths, Shower, Eye Wash Equipment – Section 48

Hygiene at the Work Site – Section 49

These sections require the employer to provide equipment and the employee to use equipment necessary for skin and eye protection, decontamination and emergency baths, shower and eye wash. In addition, Section 49 does not permit eating, drinking or smoking in areas contaminated by a harmful substance.

Storage of Harmful Substances – Section 51

As stated in the Act, "Where a harmful substance is stored at a work site, an employer must ensure that (a) the harmful substance or its container is clearly identified, and (b) the harmful substance is stored in a manner that does not present a hazard to workers.

Part 9 Emergency Preparedness and Response

Emergency Response Plans –Section 143

Training – Section 144

Equipment – Section 145

As employers must, with the participation of workers, develop an emergency response plan. Each school principal who reports to the superintendent and board must develop a plan that includes the minimum requirements as outlined in subsection 2, Parts A to J. The plan must be kept up to date and communicated to all workers affected by it. Training must be provided and repeated at regular intervals so that workers remain competent and able to carry out their duties. The equipment necessary to perform emergency response activities must be provided by the employer as well as any necessary personal protective clothing.

Part 10 Entrances, Walkways, Stairways and Ladders –Sections 146 to 148

Note: This is provided in the appendix for reference only.

Part 12 Fire and Explosion Hazards

General Requirements

General Protective Procedures and Precautions – Section 188

As flammable substances are stored, handled and located at schools, an employer must adopt appropriate procedures and precautionary measures that will prevent the unintentional ignition of the substance. Parts a to i specifically presents the requirements the employers must ensure.

Contamination of Clothing and Skin – Section 189

Should a worker's clothing become contaminated with a flammable or a combustible substance, this section requires that the worker must "refrain from any activity that may cause a spark," remove the clothing and decontaminate the clothing before reuse. Contamination of a worker's skin requires immediate washing of the affected area.

Part 18 Personal Protective Equipment

General Employer and Worker Duties – Section 235

The proper personal protective equipment, where necessary, must be provided for by the employer, and the employer must ensure that workers properly use and wear it. Worker must also be trained in the use, limitations and maintenance of personal protective equipment and inspect it before use and not use it if it is unable to perform the function for which it was designed.

Eye Protection

Compliance with CSA Standard -- Section 243

Contact Lenses -- Section 244

Where eye protection is required, an employer must provide properly fitting eye protection that meet CSA Standard Z 94.3 – 99. This information will aid in the ordering of eye protection. Section 244 requires that workers [students] are advised of the hazards of wearing contact lenses and that an alternative is provided.

Part 25 Ventilation

Worker Exposure Requiring Ventilation Control –Section 367

Design and Use – Section 368

Since it is reasonable to suggest that exposures to harmful and flammable substances may occur in storage rooms, preparation areas, laboratories and science classrooms, appropriate ventilation is required.

School districts must ensure that systems are designed, installed and maintained in accordance with established engineering principles. Depending on the size of school and the nature of the science areas, these ventilation requirements may vary. Although the Act does not mention fume hoods specifically, employers would be advised to consult the Act and appropriate competent manufacturers and installers of ventilation equipment.

Duty to Comply With Other Regulations – Section 370

Simply stated, "Nothing in this Part is to be construed as relieving an employer from any duty the employer may have under the Alberta Building Code, Alberta Electrical Code and other regulations made under the Uniform Building Standards Act."

Part 29 Workplace Hazardous Materials Information Systems (WHMIS)

Use or Storage of Controlled Products – Section 404

Controlled products may not be used, stored or handled unless the requirements of Part 29 are met by employers. As Part 29 contains 20 sections and ten pages of legislation, it should be read and followed in its entirety. The following sections are highlighted for the purposed of this submission but are not intended to be a complete summary of the Act or Part.

Instruction of Workers – Content – Section 405

Instruction of Workers – Application – Section 406

Workers must receive instruction from employers and that instruction must include:

-hazard information from a supplier,

-any other hazard information,

-information on the content of supplier and work site labels,

-information on the content of Material Safety Data Sheets and the purpose of MSDS's,

-procedures for safe use, storage and handling,

-methods for identification,

-procedures to be followed in case of emergency.

Subsection (3) requires that the instruction be work site specific, therefore, every school would have site specific training program. Section 406 requires that the employer ensure that the worker be able to apply the instruction he/she receive and that the worker must attend the instruction provided under Section 405 of the Act.

Labelling of Containers – Section 407

Application of Work Site Labels – Section 408

All controlled products or containers containing a controlled product must be labelled with a supplier label when received at a work site. As long as the container has any amount of a controlled product, the complete supplier label must remain legible and should it become illegible, be immediately replaced. At the very minimum, a work site label must always be in place.

Decanted Products – Section 409

When a controlled product is decanted into another container other than the original container it was received in, the employer must ensure that a work site label is applied to the container.

Material Safety Data Sheets (MSDS) –Section 413

Availability of Material Safety Data Sheets – Section 415

MSDS's are essential components and an employer must obtain a MSDS for every controlled product. They are to be updated every three years and readily available to workers who may be exposed to a controlled product. They contain specific information on the product, its properties, precautionary measures, ingredients, toxic logical information and first aid treatment.

Information to Medical Professionals – Section 420

This section requires an employer to provide information regarding any controlled product to any medical professional who may require it for the purpose of making a medical diagnosis of or rendering medical treatment to a person in an emergency.

Dangerous Goods Transportation and Handling Act

School boards must decide if they wish to transport dangerous goods internally within their own divisions or districts. Normally, contracted transporters deliver science orders, chemicals and hazardous materials to schools and they are required to have the necessary training, manifests and placards. Large divisions or districts wanting to warehouse and distribute chemicals would be advised to pursue specialized training, personnel, policies and procedures to comply with the Dangerous Goods Transportation and Handling Act. Smaller school divisions or districts with sparsity and distance concerns may not wish to transport dangerous goods as they are delivered by contractors and dangerous chemicals for disposal may be picked up, and transported by, the district's qualified waste broker. As the Act and its accompanying regulations and requirements are exhaustive for the purpose of this submission, additional inquiries will have to be made by districts wanting to transport dangerous goods.
(The entire Act is provided in the Appendices; however, only a few parts of the Act are elaborated upon.)

Powers of Inspectors – Generally – Section 7

Inspectors may inspect any means of transport and enter and inspect any facility on grounds that on, or in the means of transport or facility, there are:

-"dangerous goods being handled, offered for transportation or transported,"

-books, shipping records, emergency response assistance plans and computer systems that may provide information relevant to the administration of the Act.

Inspectors may open and inspect any means of containment, take reasonable quantities and examine any information as it relates to the handling, transportation or containment of dangerous goods.

Prohibitions as to Handling, Offering or Transporting Goods – Section 19

This part of the Act requires a person to not handle, offer for transport or transport any dangerous goods unless all applicable safety requirements are met, the goods are accompanied by all applicable documents and the means of containment comply with all safety standards and applicable safety marks.

Defence – Section 24

Similar to the due diligence defence, provided the accused took all reasonable measures to comply with the provisions of the Act or the Act generally, he/she may be deemed to have made a suitable defence to a charge under the Act.

Schedule (Section 1 (c))

Since the Dangerous Goods and Transportation Act used a different classification system for hazardous materials, this schedule outlines the nine major classes used by this system.

The Alberta Building Code

The Alberta Building Code sets out the current standards required for new and renovated buildings (structures). Every school building must meet the "standards of the day" for the time in which it was built. The code contains specific and detailed information on requirements for materials, equipment, storage, fire alarm systems, occupant loading, access and emergency routes, safety for hazardous substances, and ventilation. The following sections of the code are highlighted as they offer insights on science safety in our classrooms, laboratories, storage rooms, and schools.

Section 2.4. Materials, Appliances, Systems and Equipment

This section requires that all materials, appliances, systems, and equipment be installed and meet the requirements of the code. Science facilities contain equipment of this nature and it would be expected that specialized storage cabinets, fume hoods, eye wash stations, and other appliances or devices, meet the code. Furthermore, the storage of materials, appliances and equipment shall be in a manner so as to prevent deterioration or impairment. During renovations, used materials, appliances and equipment are permitted provided that they meet current standard requirements and their equivalence has been demonstrated by past performance, test or evaluation.

Section 3.1.16. Occupant Load

Occupant load is determined by a number of factors. Floor area, the number of persons for which the area is designed and the type of use are specific examples. Table 3.1.16.1. requires that classrooms provide a minimum of 1.85 m^2 per person and laboratories in schools require 4.60 m^2 per person. This presents a number of issues that schools need to address. Class size is certainly a concern when science laboratory activities are required as part of the Program of Studies for Science Education. Some schools have formal school laboratories but must have dual purpose science facilities where both classroom instruction and laboratory activities occur. As a result, schools may need to examine how their science program is structured and further consult with infrastructure officials to determine if concerns exist.

Section 3.2.4. Fire Alarm and Detection Systems

Each school, depending upon size and design, will have its own unique requirements for fire alarm and detection systems. The code provides specific requirements for:

-Types of Fire Alarm Systems (3.2.4.2.)

-Descriptions of Fire Alarm Systems (3.2.4.4.)

-Installation and Testing of Fire Alarm Systems (3.2.4.5.)

-Silencing of Alarm Signals (3.2.4.6.)

-Signals to Fire Department (3.2.4.7.)

-Annunciator and Zone Indication (3.2.4.8.)

-Electrical Supervision (3.2.4.9.)

-Fire Detectors (3.2.4.10.)

-Smoke Detectors (3.2.4.11.)

-Prevention of Smoke Circulation (3.2.4.12.)

-System Monitoring (3.2.4.16.)

-Manual Pull Stations (3.2.4.17.)

-Alert and Alarm Signals (3.2.4.18.)

-Audibility of Alarm Signals (3.2.4.19.)

-Visual Signals (3.2.4.20.)

-Smoke Alarms (3.2.4.21.)

It is important to note that storage rooms and rooms designed for the storage of hazardous substances have specific requirements for fire detectors (see Section 3.2.4.10.). Also, air handling systems may be required to prevent the spread of smoke by shutting down when a signal from a duct type smoke detector is triggered. (This is advantageous for air handling systems as they often move through chemical storage rooms where smoke caused by chemical fire can be extraordinarily toxic, see Section 3.2.4.12.).

Section 3.2.5. Provisions for Fire Fighting

Planning for the fighting of a fire is an essential part of every building design. The code requires that design allows for access, access routes and that an adequate water supply be available for the fighting of fires. Specific sections are:

-Access to Above Grade Storeys (3.2.5.1.)

-Access to Basements (3.2.5.2.)

-Access Routes (3.2.5.4.)

-Location of Access Routes (3.2.5.5.)

-Access Route Design (3.2.5.6.)

-Water Supply (3.2.5.7.)

Please note that additional provisions are required under the Fire Code.

Section 3.2.7. Lighting and Emergency Power Systems

Emergency lighting must be provided for in all corridors serving classrooms. Minimum levels of lighting must be met and special equipment in the form of self contained emergency lighting units that conform to CSA Standards is required. Subsections essential to the planning of science facilities include:

-Minimum Lighting Requirements (3.2.7.1.)

-Emergency Lighting (3.2.7.3.)

-Emergency Power for Lighting (3.2.7.4.)

-Emergency Power for Fire Alarm Systems (3.2.7.8.)

Section 3.3. Safety Within Floor Areas

3.3.1. All Floor Areas

3.3.1.2. Hazardous Substances, Equipment and Processes

The Building Code requires that the storage, handling and use of hazardous substances be in conformance with this section and the Alberta Code. Should a school have a room that exceeds the storage of 1500 L of flammable or combustible liquids, the room must meet additional code requirements for fire separation, spill containment, portable extinguishers, and aisle widths.

Section 3.3.1. also contains a number of subsections that may be useful in planning science facilities. These include:

-Means of Egress (3.3.1.3.)

-Public Corridor Separations (3.3.1.4.)

-Travel Distance (3.3.1.6.)

-Headroom Clearance (3.3.1.8.)

-Corridors (3.3.1.9.)

-Door Swing (3.3.1.10.)

-Sliding Doors (3.3.1.11.)

-Doors and Door Hardware (3.3.1.12.)

-Ramps and Stairways (3.3.1.13.)

-Capacity of Access to Exits (3.3.1.16.)

-Transparent Doors and Panels (3.3.1.18.)

-Exhaust Ventilation (3.3.1.19.)

-Obstructions (3.3.1.22.)

-Storage Rooms (3.3.1.25.)

-Drapes, Curtains and Decorative Materials (3.3.1.26.)

Section 6.2.2. Ventilation

Schools must meet specific ventilation and air quality requirements. Since science laboratories and storage rooms contain hazardous chemicals and substances, ventilation is a major concern. This part of the code contains three subsections that would apply to science facilities. These are:

-Required Ventilation (6.2.2.1.)

-Air Contaminants (6.2.2.4.)

-Hazardous Gases, Dusts or Liquids (6.2.2.5.)

The Alberta Building Code is influenced significantly by the Alberta Fire Code. Throughout the document, building standards and designs are made so that in the event of a fire, human life, health, and building integrity can be maintained. Standards are developed as safeguards for all who use our science facilities in schools. The next legislative section on the Alberta Fire Code further identifies requirements pertaining to the delivery of science education programs in Alberta's schools.

The Alberta Fire Code

The Alberta Fire Code contains regulations that affect schools, science laboratories and storage rooms which contain hazardous materials. Requirements will differ depending upon the size of the school and the quantities of materials being stored. Of particular importance to science safety is Section 5.7 on laboratories which will have specific requirements for laboratories that may be reasonably extended into science classrooms, teacher preparation areas and storage rooms where science chemicals are being kept. The code also contains other sections (general or specific) that address issues such as: inspections, combustible and flammable materials, storage, the use of dangerous goods, fire safety plans, emergency procedures, fire drills, reactive substances, fire extinguishers, fire department access, training, and ventilation.

Section 1.1. General

Two particular subsections of this part of the code must be noted. The first is 1.1.1.1. Responsibility, where the "owner" is identified as being responsible for carrying out the provisions of the act. In the case of schools, these responsibilities would be incumbent upon the school boards as the employers. The second is 1.1.2.3. which links requirements of the Fire Code to those of the Alberta Building Code.

Section 2.4. Fire Hazards

This section of the Fire Code has three subsections that schools should pay particular attention to:

2.4.1. Combustible Materials

2.4.2. Smoking

2.4.4. Use of Dangerous Goods.

Combustible materials are not permitted to accumulate in quantities that will constitute an undue fire hazard (Section 2.4.1.1.). These materials cannot be stored in concealed spaces or alongside buildings so as to create a fire hazard. Special receptacles may be required and these receptacles must meet specific guidelines (Section 2.4.1.4). Furthermore, storage rooms used for combustible recyclable materials must meet the additional combustible refuse storage requirements of the Alberta Building Code (Section 2.4.1.5.).

Smoking is not permitted in most schools or on school property in Alberta. Should any school or school division permit smoking for students or staff, they should consult subsections 2.4.2.1. (Smoking Areas) and 2.4.2.2. (Signs).

The use of dangerous goods is briefly introduced in the section on flammable and combustible liquids (2.4.4.1.). The code makes reference to part 4 where further regulations are provided. However, emergency shut off valves are identified as potential fire hazards in this part of the code. Section 2.4.4.4. states that "the person in charge of a school shall ensure that the emergency shut off valves that control multiple gas outlets that are not equipped with automatic shut off valves are in a closed position when the gas outlets are not in use." As science laboratories often have these multiple gas outlets, special procedures are required to prevent gas discharges.

Fire safety plans are required for Alberta schools. Section 2.8.2.3. addresses the need for at least one supervisory staff member to perform the tasks outlined in the Fire Safety Plan when 60 occupants are in the building. Furthermore, the retention and review requirements for fire safety plans are outlined in Section 2.8.2.5. The distribution of a copy of the fire emergency procedures to all supervisory staff is set out in Section 2.8.2.6. and the posting of fire emergency procedures is described in Section 2.8.2.7.

Section 2.8.3. Fire Drills

The person in charge of a school, the principal, is required to develop the procedures for conducting fire drills as per the considerations outlined in Section 2.8.3.1. Specifically, schools must conduct total evacuation fire drills at least three times in the fall and spring school terms (Section 2.8.3.2.). A written record must be kept showing:

a) the date of the drill,

b) the evacuation time, and

c) comments and recommendations.

Part 3 Indoor and Outdoor Storage

Section 3.1. General

This part of the code sets out requirements for the storage of combustible products and dangerous goods both inside and outside of a building. Subsection 3.1.2. on dangerous goods outlines the following key areas:

-Classification (3.1.2.1.)

-Packages and Containers (3.1.2.3.)

-Compressed Gases (3.1.2.4.)

-Reactive Substances (3.1.2.5.)

-Fire Safety Plan (3.1.2.6.)

Section 3.2. Indoor Storage

Depending upon the type and quantities of materials being stored, storage requirements will vary for schools. Fire safety plans must account for storage areas and the location of hazardous materials must be incorporated within the plan. Size limits exist for storage areas and schools may be exempt from some requirements provided that they fall within the small quantity exemptions for dangerous goods (see Section 3.2.7.1.). Specific sections for reference are as follows:

-Application (3.2.1.1.), (3.2.2.1.), (3.2.3.1.), (3.2.7.1.)

-Access Aisles (3.2.2.2.)

-Clearances (3.2.2.3.)

-Portable Extinguishers (3.2.2.5.)

-Fire Safety Plan (3.2.2.6.)

-Location of Hazardous Materials (3.2.2.7.)

-Ignition Sources (3.2.7.2.)

-Ambient Conditions (3.2.7.3.)

-Housekeeping (3.2.7.4.)

-Storage Arrangements (3.2.7.5.)

-Separation From Other Dangerous Goods (3.2.7.6.)

-Corrosion Protection (3.2.7.7.)

-Flooring Materials (3.2.7.8.)

-Smoke Venting (3.2.7.10.)

-Spill Control (3.2.7.11.)

-Fire Department Access (3.2.7.12.)

-Labels (3.2.7.13.)

-Training (3.2.7.15.)

-Unauthorized Access (3.2.7.16.)

-Separation From Combustible Products (3.2.7.17.)

Section 4.1.7. Ventilation

Ventilation requirements for rooms or enclosed spaces where flammable liquids and combustible liquids are processed, handled, stored, dispensed or used, must conform to this part of the code and the Alberta Building Code. Ventilation measures and maintenance vary according to the conditions in individual schools (see Section 4.1.7.2.). Also, the type of system being used and the way in which air is circulated may be subject to specific regulations.

Section 4.2. Container Storage and Handling

The most important sections in this part of the code are 4.2.6.2. on Storage Cabinets and Storage Rooms, 4.2.6.3. Maximum Quantities, 4.2.6.4. Containers, and 4.2.6.5. The Separation of Dangerous Goods. These are additional requirements that apply to the storage, handling and use of flammable liquids and combustible liquids in schools. Storage cabinets are further regulated in subsection 4.2.10. where the following requirements for container storage apply:

-Containers (4.2.10.1.)

-Maximum Quantities per Cabinet (4.2.10.2.)

-Maximum Quantity per Fire Compartment (4.2.10.3.)

-Labelling (4.2.10.4.)

-Fire Endurance (4.2.10.5.)

-Ventilations (4.2.10.6.)

Section 5.7. Laboratories

Within the Alberta Fire Code, this entire section is the most relevant to science education programs. Laboratory activities are an essential part of science. As outlined in the Program of Studies for Alberta, student experience and concept development are tested in the laboratory. Students are expected to learn scientific skills and develop attitudes towards inquiry through a safely implemented laboratory program.

Section 5.7.1. Scope

Subsection 5.7.1.1. Application

The code clearly states that this section applies only to laboratories where dangerous goods, including flammable liquids and combustible liquids are used. It is important to note that the use, handling and storage of dangerous goods, including flammable liquids and combustible liquids must also conform to parts 3, 4 and 5 of the code.

Section 5.7.2. Construction

In the construction of laboratories, all interior finish materials, floors, fixed furniture and equipment must be chemically resistant to dangerous goods (5.7.2.1. Interior Finish Materials). Laboratories require fire separations as per this code and the Building Code.

Section 5.7.3. Fire Prevention and Protection

Subsection 5.7.3.1. Emergency Planning

The emergency planning covered in Sections 2.8. and 5.1.5. applies to all laboratories. Fire drills must be conducted in time intervals that do not exceed three months and all staff working in the laboratory must be trained in the safe handling and use of dangerous goods. All dangerous goods must be clearly identified and the laboratory designated as an area containing dangerous goods. Supervision is essential and measures must be taken to prevent access by unauthorized persons.

Subsection 5.7.3.1. Combustible Materials

Combustible materials in the laboratory are restricted to quantities necessary for only one day of normal operation. Any combustible materials in excess are required to be stored outside of the laboratory.

Subsection 5.7.3.3. Spill Control

This part of the code simply requires that absorbent and neutralizing materials be provided in laboratories and storage rooms where dangerous goods are located.

Depending on the size of laboratory and the concentration of flammable vapours, laboratories may be required to meet additional requirements for electrical equipment (see 3.7.3.4.). Smoking is not permitted in any laboratory and the code requires that signs be posted. Ignition sources are a serious concern and any equipment that may overheat or provide an ignition source is regulated in subsection 3.7.3.5.

Laboratories require additional inspections, maintenance and fire protection (see 5.7.3.6. and 5.7.3.7.). Ventilation systems are to be cleaned and inspected depending on the type of system serving the laboratory and dangerous goods storage areas (see Section 5.7.4.).

Section 5.7.5. Dangerous Goods

Maximum quantities of dangerous goods and volumes of flammable liquids and combustible liquids are regulated in Section 5.7.5.1. It is important to note that Section 4.2. be cross referenced to determine how materials are located and stored between storage rooms and laboratories. Individual schools should consult the code for further details.

Containers for flammable and combustible liquids must meet additional requirements (see 5.7.5.2.) and be closed at all times. Should a laboratory have a compressed gas cylinder and piping system or refrigeration for class I liquids, Sections 5.7.5.3. and 5.7.5.4. apply. Chemical wastes must be clearly identified and in quantities specified in Article 5.7.5.1. (see 5.7.5.6.).

Part 6 Fire Protection Equipment

Part six of the Alberta Fire Code provides for the installation, inspection, testing, maintenance, and operation of extinguishing systems, extinguishers, water supply systems, fire alarm systems and emergency power installations. Schools or school divisions must consult this part to examine their individual needs. Some key areas include:

-Maintenance (6.1.1.2.)

-Notification (6.1.1.3.)

-Records (6.1.1.5.)

-Portable Extinguishers (6.2.)

-Fire Alarm and Voice Communication Systems (6.3.)

-Stand Pipe and Hose Systems (6.4.)

Conclusion

As the province adopts a Provincial Science Safety Resource, there is a strong desire to promote safe practices and demonstrate due diligence. The legislation presented within this section is summarized so that it may aid in broadening the awareness of all connected to science education and safety in schools. Laboratory work and instruction is an essential component in science education and the education of all children. By practicing due diligence in schools, science instruction may be enhanced and the quality of instruction will continue to improve. By identifying legislation, the direction is to increase laboratory use and reduce potential hazards and the likelihood of accidents. Professional development combined with sound pedagogical instruction and the guidance provided by the Provincial Science Safety Resource will serve to advance excellence in Alberta's science education program.

Chapter 4

Methodology

Using Action Research to Study Science Safety

Selecting a methodology for the type of research being conducted is one of the "cornerstones" of any study. Action research was selected for my work on science safety because opportunities existed to work with Alberta Education. From my previous contract writing on the draft of the Provincial Science Safety Resource, I approached department staff to see if they would be interested in a collaborative project which could potentially bring research at the university together with department initiatives in this area. The research would benefit from this association as a focused questionnaire would be able to reflect Alberta's needs and the department would benefit as outcomes could be used to update future revisions and aid in the professional development in-servicing process.

Action research embraces a relational collaborative view where encounters with others are seen as opportunities for learning and growth (McNiff & Whitehead, 2002). The purpose of this research project is to improve science safety practices and conditions in Alberta's schools. This project uses a "purpose" statement rather than a research question or problem. The approach is to collaboratively advance science safety instead of adopting a questioning of current practices perspective.

As a systematic inquiry process designed to improve practice, teaching and learning, (Mills, 2000; Creswell, 2002) action research engages the researcher in a dialectical interplay revealed through the research process (McNiff & Whitehead, 2002). There are two distinct "spirals" being conducted in the project design. The first is a revision of a proposed questionnaire with the Department of Education. The second is a collection of data from a purposeful sample of "experts".

John Elliot (1991) states, "The fundamental aim of action research is to improve practice rather than to produce knowledge". The focus for this research is to improve science safety in Alberta and examine potential areas for growth and professional development. As a result, the project will draw upon the collective experiences of educators from across the province so that their unique perspectives can be represented in future directions on science safety. Improved practice results in safer working teaching and learning conditions. School boards, superintendents, district and school administrators, teachers, teacher aides, laboratory technicians, students, and parents can all benefit from research in this area. Ultimately, the use of action research as a methodology that is designed to improve practice is not only appropriate, it is essential.

Action Research Spirals

As a matter of process, action research uses evolving spirals or cycles. Each twist contains successive stages of planning, acting, observing, and reflecting (McNiff & Whitehead, 2002).

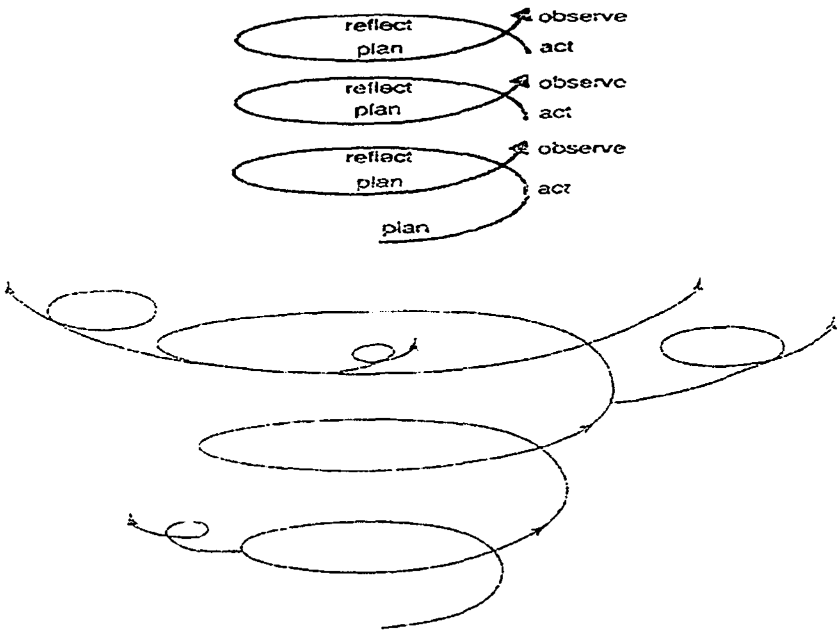

Illustration 1: Action Research Spirals (Stages of planning, acting, observing, and reflecting)

The Alberta Teachers' Association's *Action Research Guide for Alberta Teachers* uses a similar approach where a systematic process is used to reflect, consider options, implement, and evaluate potential solutions.

Using the above as examples of action research frameworks individual spirals can be developed to define stages within the research. Proposed are two such spirals whereby collaborative interactions will guide the research questionnaire development, delivery, and collection of data.

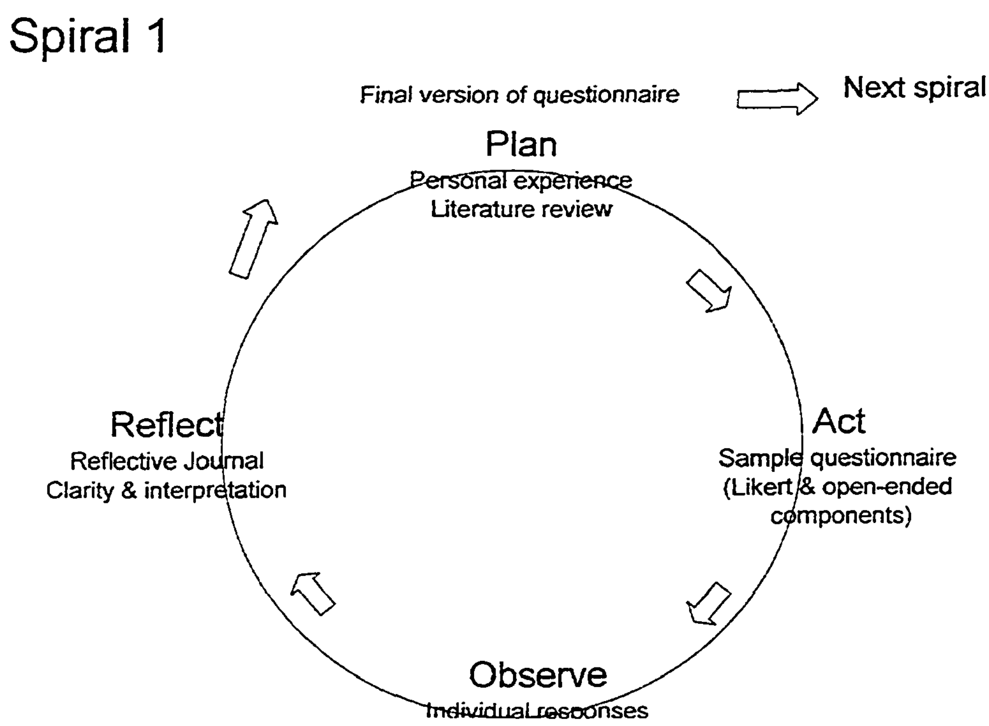

Illustration 2: Action Research Spiral 1 (Research process)

Using my personal experience as a chemist and District WHMIS Coordinator, a draft questionnaire was developed (plan). The literature review and work thus far, with the Provincial Science Safety Committee was also a major contributing factor in the draft development. The sample was sent to Alberta Education Staff (after the ethics process) for revision and comments by individual participants (act). Individual responses were gathered and analyzed (observe), and through a reflective journaling and collaborative meeting, the final version of the questionnaire was developed.

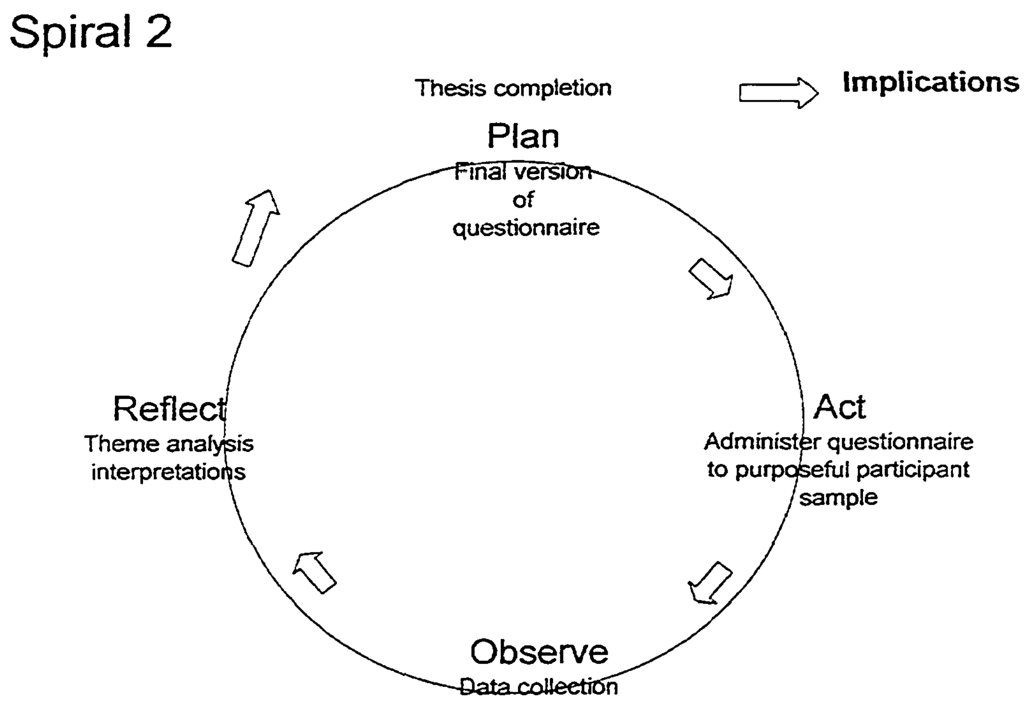

Illustration 3: Action Research Spiral 2 (Research process)

After submitting the revised version of the questionnaire to the Ethics Committee for approval, the questionnaire was sent out to a purposeful participant sample of members connected to the Provincial Science Safety Resource development initiative. These individuals serve as a panel of experts that have demonstrated a strong commitment to science safety in Alberta's schools. Responses were gathered and the researcher engaged in a reflective journaling process. When questions of clarity or interpretation arose, follow up with the participant occurred before theme analysis began.

A Revised Version of Lewin's Model of Action Research

Below is a revised model for action research developed by John Elliott in his 1991 book, *Action Research for Educational Change.* Kurt Lewin developed the Action-Reflection Cycle of Planning in 1946 (as represented in Spirals 1 & 2). His work was later revised by Stephen Kemmis in 1986 and further by Elliott in 1991. This revised model is also used by Jean McNiff and Jack Whitehead (2002) in their second edition of *Action Research, Principles and Practice.*

Action Research Model (Elliott, p. 71)

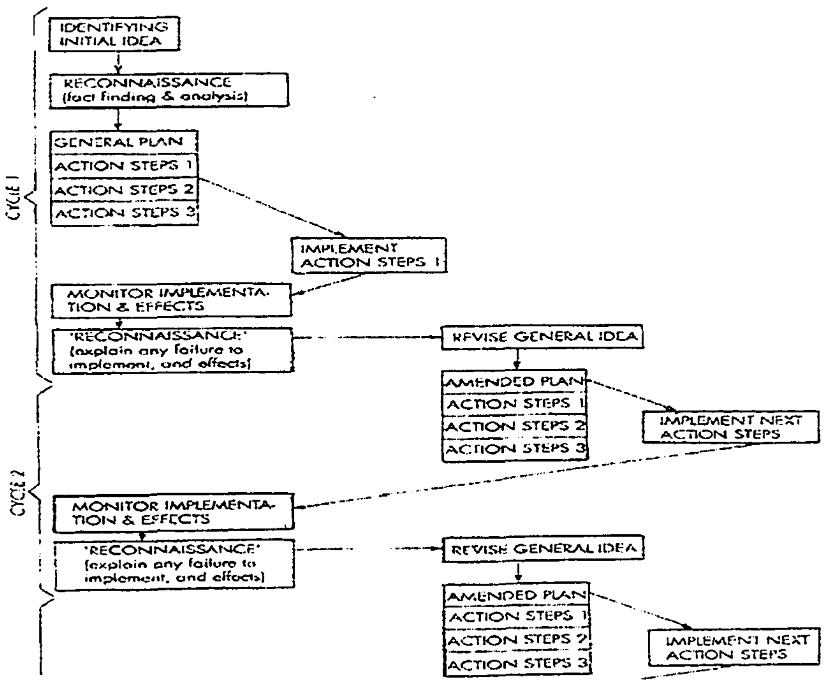

Illustration 4: Action Research Model (Elliott)

Using Elliott's revised model for action research, then, the proposed process outlines the stages for the research into science safety.

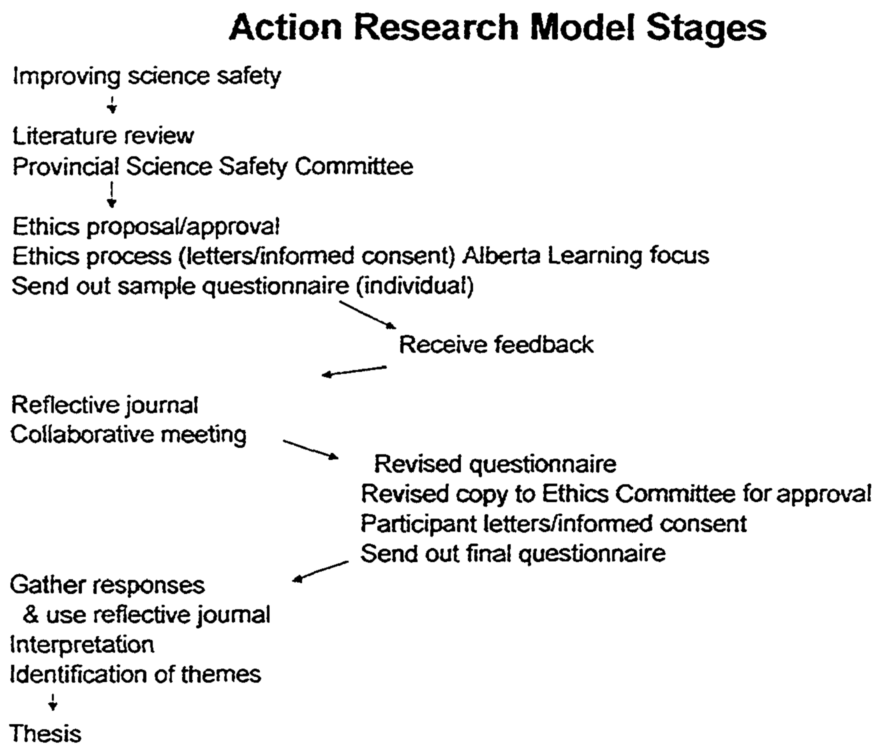

Illustration 5: Action Research Model Stages

The Research Questionnaire

The questionnaire; Science Safety: Examining Issues, has two main parts. The first is a Likert Scale designed to be used qualitatively only. The second is a series of open ended questions. As the science safety resource is designed to address many areas already identified by the provincial committee, there are three major components that this research project will focus on.

Areas for improvement in science safety are identified by conducting a needs assessment and gap analysis. This section is linked to due diligence as it is described on pages 10 to 16 of the safety resource. Participants are asked to provide three ways in which individuals at different educational levels could improve science safety. A rank order is also requested so that priorities can be later examined in the data collection stage.

The second emphasis of the questionnaire asks participants to identify areas of science safety that they would describe as exemplary current practices (and elaborate). This question provides an opportunity to focus on strong positive initiatives being used in Alberta. Many districts are taking positive steps to address safety concerns and conditions. It is hoped that these exceptional practices can be shared with the rest of the province and potentially serve as innovative programs for others to build upon. Another prospective outcome would be that some of these practices may make their way into a second revision of the provincial resource or be hyperlinked to the Alberta Education Website.

Professional development is a significant component to the questionnaire. Participants are asked to provide a structure for professional development that includes:

- planning models and timeframes,
- a list of topics to be addressed,
- a list of resources that would be used or required.

As the provincial resource is to be released for the fall of 2004, the responses will be used to provide Alberta Education with potential frameworks for the 2004/2005 in-servicing initiative.

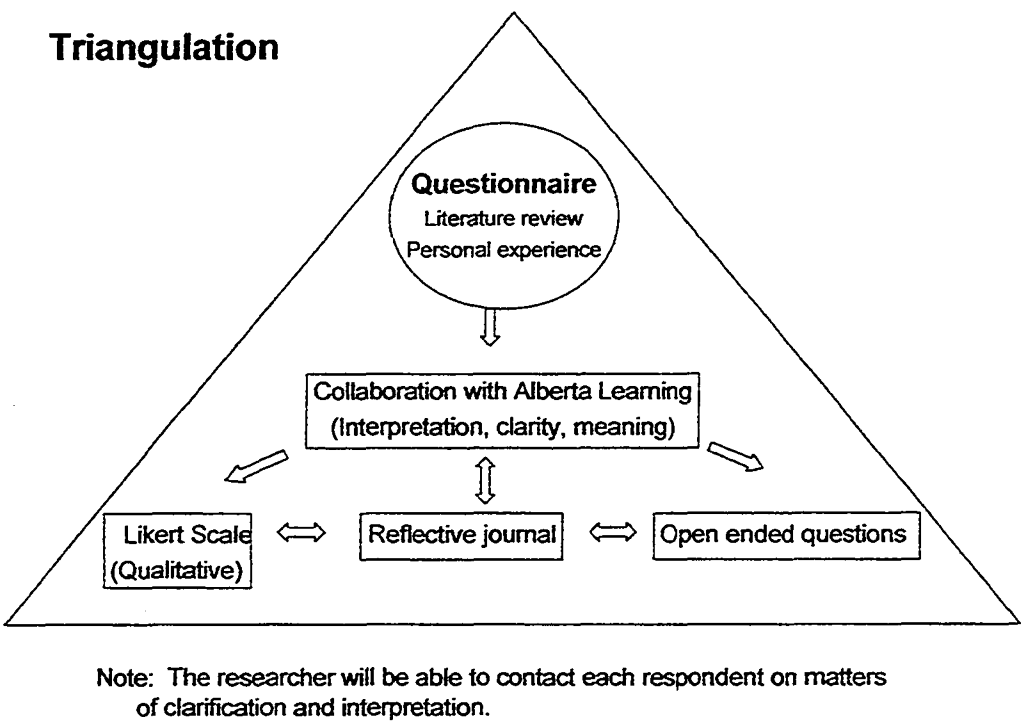

Illustration 6: Triangulation

Triangulation, as a technique of cross checking a number of information sources so as to produce a full and balanced study, is essential to the research being conducted. There are four major components that pertain to this research project:

- The questionnaire and its revision through a developmental process with Alberta Education focus the research on areas specific to Alberta. Personal experiences, input from the literature review and a shared progression will help to bring both clarity and meaning to the data subsequently collected.
- The qualitative Likert Scale part of the questionnaire will be used to develop a priority of issues and can be cross referenced to other questions for similarities and discrepancies.
- Open ended questions provide for in-depth responses that inform and enrich priority research areas. Each participant's own unique perspectives can be elaborated upon and thereby provide a broad range of experiences that will enhance the analysis and implications of the study.
- Reflective journaling will be used by the researcher as a way of examining each participant's responses. Built into the study is the opportunity for the researcher to contact the participant on matters of clarity and interpretation. This integrates a degree of internal validity within the study and will serve to aide in the theme identification and data analysis process.

Action research as a methodology is well suited to the practical outcomes and implications of this research process. By embracing professional perspectives from a variety of educational levels, improved practice as it relates to science safety in Alberta's schools is the realization of this collaborative action research project.

Chapter 5

Analysis of Data

Science Safety: Examining Issues

Please provide a response for each statement by checking the appropriate box using the following as a guideline: **SD** (strongly disagree), **D** (disagree), **N** (neutral), **A** (agree), **SA** (strongly agree).

Statement			SD	D	N	A	SA
1. There is a need to improve science safety in Alberta's schools.			0	0	1	5	10
2. Classroom practice and science instruction will be enhanced through professional development on science safety.			0	0	0	5	11
3. Science safety is an essential component for student learning.			0	0	0	2	14
4. Adequate information on science safety is available to administrators and teachers.			3	5	4	2	2
5. Employers and employees are aware of their legislated responsibilities in the area of science safety; specifically:	a) School board trustees	(1)	3	10	2	0	0
	b) Superintendents		1	6	6	2	1
	c) Administrators	(1)	1	5	6	3	0
	d) Science teachers		2	5	6	3	0
	e) Teacher aides		2	9	4	1	0
	f) Laboratory technicians		0	3	5	5	3
6. Policy development related to science safety is needed in Alberta's school divisions.		(2)	0	0	1	4	8
7. Schools can improve science safety in the following areas:	a) inventory control		0	0	1	7	8
	b) waste management		0	0	1	9	6
	c) classroom procedures		0	0	2	7	7
	d) use of alternative chemicals		0	0	1	8	7
8. Professional development on science safety is required for:	a) School board trustees	(1)	0	2	2	8	3
	b) Superintendents		0	2	2	8	4
	c) Administrators		0	0	1	9	6
	d) Science teachers		0	0	1	5	10
	e) Teacher aides		1	0	2	4	9
	f) Laboratory technicians		0	0	1	4	11

Note: ( ) indicates no response

Illustration7: Science Safety Survey Results

Survey Results

Participants were asked to provide a response for each statement by using the following Likert scale.

SD	D	N	A	SA
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

As a component of triangulation, the Likert scale portion of the questionnaire was used to cross reference each respondent's submission so that both similarities and discrepancies could be identified. Survey results helped to reveal a respondent's own unique perspective on science safety and provide a context for the open ended questions which followed.

The results, when examined together, also provide insights on science safety issues in Alberta's schools. Many participants wrote in comments next to their responses or further explained their positions later in the questionnaire. From a qualitative perspective, the following examination of the survey results summarizes the overall position of the sixteen participants on each question and provides statements consistent with their responses.

1. There is a need to improve science safety in Alberta's schools.

SD	D	N	A	SA
0	0	1	5	10

With strong support for this statement, it is essential to note that participants in the strongly agree category were closer to schools and science laboratory instruction. The one respondent who indicated a neutral position had many years of laboratory experience, however did not work in schools or school divisions and felt that she could not comment.

2. Classroom practice and science instruction will be enhanced through professional development on science safety.

SD	D	N	A	SA
0	0	0	5	11

Professional development in science safety was strongly supported by the participants. They provided a planning model, list of topics, and resources in the open ended part of the questionnaire and clearly indicated that classroom practice and science instruction could be enhanced through initiatives in this area.

3. Science safety is an essential component for student learning.

SD	D	N	A	SA
0	0	0	2	14

Students learn safety through the science instruction they receive. There is exceptional support for the inclusion of science safety in a student's learning. Teachers, aides, and laboratory technicians all serve as role models for students and the safety practices they demonstrate are an essential component of the science education program.

4. Adequate information on science safety is available to administrators and teachers.

SD	D	N	A	SA
3	5	4	2	2

It is recognized by participants that the new Provincial Science Safety Resource, *Safety in the Science Classroom,* will help to improve conditions in Alberta's schools. However, there is a concern that this information along with well developed policy based upon legislative requirements is not available to administrators or teachers. Participants also noted that there is a need for legislation awareness so that roles and responsibilities could be clarified. Many administrators and teachers do not know how legislation related to science safety provides specific requirements for school, classroom and laboratory procedures and practices. Participants noted that adequate information is available, but it is not often made available to administrators and teachers.

5. Employers and employees are aware of their legislated responsibilities in the area of science safety, specifically:

a) school board trustees

	SD	D	N	A	SA
(1)	3	10	2	0	0

b) superintendents

SD	D	N	A	SA
1	6	6	2	1

c) administrators

	SD	D	N	A	SA
(1)	1	5	6	3	0

d) science teachers

SD	D	N	A	SA
2	5	6	3	0

e) teacher aides

SD	D	N	A	SA
2	9	4	1	0

f) laboratory technicians

SD	D	N	A	SA
0	3	5	5	3

( ) No Response

Legislation enacts specific responsibilities on both employers and employees. Awareness of these responsibilities further enhances role identification, policy development and science safety practices. The highest area of concern expressed was for school board trustees. Trustees functioning as the school board are the "employer" and research participants clearly felt that trustees needed to be better informed about legislations as it pertains to science safety.

It is also appropriate to note that research participants were primarily from an urban setting and that these results should not be applied to rural school divisions.

Superintendents, administrators and science teachers were all seen as requiring an improved level of awareness of their legislated responsibilities in the area of science safety. Respondents indicated that professional development should involve a collaborative approach to in-servicing initiatives where there is an opportunity for dialogue on science safety policies and procedures.

Teacher aides were another group that the participants identified as needing an increased awareness of their legislated responsibilities. This study does not investigate the way in which science teachers, their aides and laboratory technicians interact. Teacher aides under the direction and supervision of teachers and administrators need to be well informed about legislation and related policies and procedures. Further study will be required to determine how teacher aides are being used in science classrooms and laboratories. However, research participants agree that teacher aides should be informed and guided by legislation.

Laboratory technicians are a specialized group often working in larger high school settings. These staff members have additional training and education related to many aspects of science safety. It is important to note that not all respondents had experience with laboratory technicians. Where they were being employed, laboratory technicians were seen as individuals who were aware of their legislated responsibilities.

6. Policy development related to science safety is needed in Alberta's school divisions.

	SD	D	N	A	SA
(2)	0	0	1	4	8

( ) No Response

Participants clearly indicated that policy development is necessary in the area of science safety. It must be informed and guided by existing legislation, discussed at all levels, and incorporate a school division's special needs. By identifying roles and responsibilities, protocols and procedures, policy is an essential component for the demonstration of due diligence in science safety.

7. Schools can improve science safety in the following areas:

a) inventory control

SD	D	N	A	SA
0	0	1	7	8

b) waste management

SD	D	N	A	SA
0	0	1	9	6

c) classroom procedures

SD	D	N	A	SA
0	0	2	7	7

d) use of alternative chemicals

SD	D	N	A	SA
0	0	1	8	7

Improving science safety in these four areas was strongly supported by the research participants. These and additional ways of improving science safety are explained in detail in the written response part of the questionnaire.

8. Professional development on science safety is required for:

a) school board trustees

	SD	D	N	A	SA
(1)	0	2	2	8	3

b) superintendents

SD	D	N	A	SA
0	2	2	8	4

c) administrators

SD	D	N	A	SA
0	0	1	9	6

d) science teachers

SD	D	N	A	SA
0	0	1	5	10

e) teacher aides

SD	D	N	A	SA
1	0	2	4	9

f) laboratory technicians

SD	D	N	A	SA
0	0	1	4	11

( ) **No Response**

Professional development on science safety as a requirement was strongly supported across all educational levels and a collaborative approach is certainly preferred. The written response part of the questionnaire further provides insights on both the common themes and unique differences that each group may have. Professional development planning models and topics needed to be adjusted for each group and the participants recognized this in their responses. Trustees may be more focused on legislation and policy development while teachers, aides and laboratory technicians need to work on the more practical procedures and practices.

Questionnaire Results

For each of the following educational levels, identify three ways which the demonstration of due diligence, in the area of science safety, could be improved. Please rank these areas of improvement indicating 1 as your highest priority.

School Board/Trustees

Policy development, as a way of demonstrating due diligence is a fundamental responsibility of a school board and its trustees. Policy clearly represents legislated responsibilities and provides a framework that filters through all levels of administration and education to those who have direct contact with students. As a local/district document, policy assigns accountability to all operational levels within a school division. Specific safety policies avoid general terms while defining procedures that outline safety methods and practices. Examples of policy areas that would help a school board and its trustees demonstrate due diligence include:

- chemical storage/disposal,
- chemical purchasing procedures,
- inventory maintenance,
- a dangerous goods policy,
- waste minimization procedures including the reuse and recycling of materials, and
- transportation procedures and a district waste management policy/plan.

Policy also establishes the relative roles of district personnel. Local school boards have unique structures and make decisions regarding staffing. Districts can examine their own needs, and where necessary, use policy to outline the responsibilities, qualifications, and/or educational requirements of science consultants, district WHMIS personnel, and all levels of administration and staff. As policy is cyclical in process, demonstrating due diligence would also require that policy be periodically reviewed and used to facilitate ongoing improvements.

Increased awareness of science safety issues and a knowledge of the legislation governing safety further enables a school board to make sound decisions that demonstrate due diligence. Trustees need to understand how "hands on" science activities are critical to a science program. By becoming thoroughly familiar with the legislation governing the safety of employees and students, legalities are clarified and the potential hazards that relate to science classroom/laboratory activities can be identified. Boards need to understand the role of WHMIS and MSDS documents in science safety and they must provide WHMIS training for all of their employees.

Providing direction to the superintendent, district personnel, and all levels of administration and staff requires funding for both human resources and infrastructure. School boards need to initiate and support the professional development (training) of all levels of staff. Site specific training in WHMIS is needed as well as in-servicing on the new science safety manual *Safety in the Science Classroom.* Specific district resources may need to be purchased and/or developed, and where necessary, a health safety supervisor may need to be hired.

The ongoing operations of a board also reflect its obligations to administer due diligence. Trustees who give health and safety management systems priority in the planning/implementation of district operations demonstrate their responsibility for, and commitment to, safety in school science laboratories/classrooms. Communication is essential, as is accountability. By questioning the science safety practices in their schools, trustees can establish accountability for the superintendent and all levels of staff on related health and safety issues. Where necessary, results review measurements or performance review processes can be used and a publicly recognized program for responsible health and safety practices could also be implemented. Respondents also clearly identified some methods for a school board to demonstrate due diligence in science safety. Specifically, these are:

- annual monitoring via reports to the board,
- ongoing safety audits,
- trustee tours of schools,
- appropriate accident reporting systems including documentation.

- safety audit compliance processes,
- clear and direct accountability processes,
- regular evaluations of health and safety programs,
- continuous improvement processes using safety audits.

Also recommended is the adoption of all science safety resources developed by Alberta Education and the use of *Safety in the Science Classroom* as a basis for safety policy development.

Superintendent/Central Office Administration

The advisory and directive role of superintendents and central office administration facilitates the development of policy that demonstrates due diligence in the area of science safety. The need for policy development is often assessed by these individuals, and draft policies are taken to board meetings and policy committees through initiatives involving the superintendent. Central office administrators can also include science and safety personnel who have been designated specific roles and responsibilities. Having a knowledge of policy (globally) and being able to apply resources towards local policy development is a function of the superintendent in collaboration with the board. Science safety policy that demonstrates due diligence includes:

- a framework that filters through all levels of administration and staff through to the student,
- procedures that hold other levels of administration, teachers and staff accountable,
- procedures that outline acceptable safety practices in areas such as:
    - safety audit compliance,
    - chemical disposal, and
    - waste management.

Once established, the superintendent and central office administration also have additional responsibilities related to policy. Awareness is essential and school based administrators, science teachers, and the staff/students in their care need to be familiar with safety policies, procedures, and practices. Personnel must be qualified to supervise the handling of chemicals, and staffing policies may need to be developed or reviewed as they pertain to the knowledge and skills base required for science teachers and senior level science staff in particular.

Being well informed on legislation is key to understanding the responsibilities governing the safety of employees and students. Legislation should be carefully researched and discussed (documented) at the district level to ensure that safe practices throughout district schools are in place. These practices should take into account: appropriate professional development processes, the allocation of human resources, and the necessary infrastructure requirements of safe science environments. Areas of particular attention should include the legislation and regulations pertaining to:

- the role of WHMIS and the need for training in both WHMIS and the use of MSDS documents,
- hazard identification as it relates to science classrooms and laboratory activities.

As a starting point, respondents recommended *Safety in the Science Classroom* as an appropriate reference when identifying key legislative acts and regulations.

The leadership role modeling and directive nature of central office staff and the superintendent were recognized (and respected) by research participants. With this understanding, the following roles and responsibilities were viewed as ways in which due diligence in the area of science safety could be demonstrated by these individuals. The superintendent and central office staff should:

- promote the importance of science safety (and policy awareness) in the district,
- appoint or ensure that each school or district division has at least one WHMIS coordinator,
- direct human resources (safety officer or designates) to provide educators with training on WHMIS, chemical management and waste management,
- provide for the recognition of safe schools (practices),
- receive a chemical waste management summary including details on:

- annual chemical waste inventories,
- waste pick up and disposal,

- create a health and safety committee to address science safety,
- address the need for: safety audits, accident reporting systems and documentation,
- develop a district user manual specifically designed for use in their district schools,
- have a health and safety program that includes: contractors, temporary workers, students and volunteers,
- provide direction to departments responsible for infrastructure when designing, building, and renovating science classroom/laboratory facilities,
- hold administrators and supervisors accountable for the health and safety of staff and students under their care by using performance reviews,
- have programs that facilitate review and improvement procedures.

Leadership from central office also clearly requires the allocation of resources (human and monetary) towards legislated requirements such as science safety. Respondents clearly indicated that support for the implementation of science safety programs must include adequate funding and time for professional development. Furthermore, programs should be initiated from central office and contain site specific (school based) training in WHMIS.

School Administrators

The highest priority for the improvement of due diligence in science safety for school administrators involves the need for them to be educated about science safety. They must be knowledgeable about science safety issues and understand the legislated responsibilities pertaining to the staff and students under their care and control. Professional development specific to administrators is essential and it is expected that they are informed on laws specific to WHMIS and health and safety practices.

Demonstrating leadership by supporting the implementation of health and safety programs demonstrates due diligence. A strong commitment to safety for school administrators, models health and safety practices that:

- ensures staff and students know their roles and responsibilities in providing a safe science learning environment,
- clearly establish the involvement of site based administration in the development, implementation, reviewing and supervision of safety programs,
- demonstrate a knowledge of the measures to be taken in the event of an accident in the science classroom/laboratory (emergency preparedness),
- ensure coordinated practices are in place for:
    - acquiring chemicals,
    - inventory management,
    - disposal of materials,
    - waste management.

Policy development is another way in which due diligence can be established. School based administrators should have an active role in the area and they can provide specific procedures and protocols that represent their local needs. Specific school based policy that supports district policy may also need to be developed as it would be relevant to their own school science classrooms and laboratories. Administrators should devise and monitor a school plan for health and safety and be aware of the kinds of science activities (and their potential hazards) that are used in their schools. *Safety in the Science Classroom*, Alberta Learning's science safety resource, would be instrumental in providing information for administrators pursuing initiatives related to the development of health and safety programs/policies.

Due diligence in science safety also requires the application of resources including people, money (budgeted) and time. Administrators should implement professional development programs that ensure the adequate training of all personnel in WHMIS and related procedures/policy. Additional funding may be required for safety supplies, personal protective equipment and first aid training. Teachers may need to be provided with professional development opportunities specific to science safety.

The role of site based administrators in the hiring of staff is also recognized. Science and safety personnel must be qualified in the handling of chemicals and the understanding of their supervisory roles should they be assigned these duties. Safety programs should be part of a "regular routine" that fosters awareness and supports the development and maintenance of best practices. Schools may want to create health and safety committees with representatives from all areas including science.

The specific actions of school administrators can also be a powerful way of demonstrating the practice of due diligence related to science safety. Research participants identified a range of procedures/responsibilities that could be used by administrators. These include:

- limiting the size of science classes,
- ensuring that hazard assessments are completed and corrective action is taken to control hazards,
- through supervision/evaluation, ensuring that teachers are held accountable for the safety of themselves and the staff and students under their care and control,
- ensuring that teachers know and enforce the safety rules in their science teaching, classroom activities and laboratory activities,
- establishing safety audit and accident reporting procedures for their schools,
- the establishment of a chemical waste storage facility/plan and the regular pick up and disposal of chemical wastes (toxic round up).

Science Teachers

Demonstrating due diligence in the area of science safety for teachers starts with professional development on the legislation, protocols, procedures, policies, and regulations related to health and safety. Teachers must be informed about district policies and administrative procedures so that they may carry out (demonstrate) their day to day duties in a manner consistent with these policies. In-servicing and workshops must be provided on first aid and WHMIS training and appropriate resource materials must be available. Procedures set out by the board/district should be followed and incorporated into daily lesson plans. Enacting a 'cradle to grave' approach for all materials is suggested and science teachers must be accountable for their actions.

Science teachers are key stakeholders in health and safety initiatives and they need to work together with administrators when applying safety requirements and procedures. When health and safety committees are formed, science teachers need to be involved in the decision making processes. Larger schools may have a science teacher appointed as a WHMIS coordinator who can help in the training of staff and the ordering of chemicals. By having regular department meetings (involving administrators), science teachers can profile safety programs and use safety as part of a daily routine that provides proper health and safety procedures.

Teachers are role models for students and their actions and attitudes must demonstrate due diligence and promote a positive attitude towards safety. Teachers must be able to communicate safety procedures to students and make informed decisions regarding risk and hazard identification, the use of materials, and safe work practices. Teaching skills to students is also an essential part of the curriculum. Safety equipment must be in place and students should be trained how to use it. Students should be informed of any potential safety concerns and made aware of appropriate procedures related to science classroom and laboratory activities.

Science teachers also require specialized training. By learning more about best practices, safety can be improved in science classrooms. Research participants identified the following areas of improvement or actions that would further science safety initiatives.

Teachers should:

- be aware of the hazards and risks related to the use of chemicals, materials, and equipment used in the science classroom/laboratory,
- complete a course on the proper use and disposal of chemicals,
- check and see if "old" lab and demo procedures (and materials commonly used for many years) are still currently acceptable,
- attempt to use more environmentally friendly chemicals,

- avoid the stockpiling of chemicals and hazardous wastes,
- be knowledgeable about alternative chemicals and methods that are safer for the student and environment,
- minimize the use of hazardous materials by utilizing microchemistry experiments,
- promptly report all hazards, unsafe conditions and work related injuries,
- speak up about poor lab conditions, poor room conditions, too many students, and inappropriate facilities.

Science Support Staff (Teacher Aides)

Teacher aides, as science support staff, work together with teachers to contribute to safe activities in the classroom and laboratory. Due diligence can be demonstrated by teacher aides when they are able to assist the teaching staff in preparing materials and equipment for science activities. As role models with a positive attitude towards knowing and practicing safe procedures, aides also provide guided supervision for all students under their care and control. In carrying out their assigned duties, due diligence requires that responsibilities such as minimizing risks, transferring materials, labeling containers/solutions and waste disposal be carefully conducted.

Support staff need to be knowledgeable and aware of both district and school policies. In order to ensure the safety of themselves and students, teacher aides must receive in-servicing on WHMIS and Occupational Health and Safety Regulations. Actions and responsibilities must display a knowledge of policy; and staff, when unsure, must be able to seek help or refuse an activity if there are health and safety concerns. Specific science safety policies may need to be developed for teacher aides and it is suggested that *Safety in the Science Classroom* be the basis for policy related to science safety.

Training is a highly recognized way of enabling staff and demonstrating due diligence. Teacher aides working in science classrooms and laboratories must be trained in classroom procedures and science safety. Training should include each of the following areas:

- delivering student safety orientations,
- WHMIS,
- first aid,
- chemical safety,
- accident prevention/emergency preparedness,
- transportation of dangerous goods,
- accident/evaluation procedures,
- safety audits/inspection,
- hazard assessment.

It is also highly recommended that teacher aides, as science support staff, receive orientation in-services and training workshops before the school year commences.

Defining roles and responsibilities using clear protocols and procedures further exhibits due diligence. Teacher aides not only need to follow safe procedures, they need to be involved in departmental/school occupational health and safety committees. Participating in safety inspections/audits is another way in which aides can contribute to safe practices. When teacher aides help to identify potential risks and select appropriate materials, teachers can be collaboratively engaged in recognizing their own responsibilities. Aides must promptly report hazards, unsafe conditions, and work related injuries while ensuring that students in the lab follow safety procedures. Finally, when situations warrant, teacher aides must have the right to refuse to do anything that is against proper policy and be able to follow up concerns with administration.

A way of demonstrating due diligence also identified by research participants would be to require that all teacher aides providing science support services be certified. Certification could be provided by some sort of government body and this would ensure that qualified personnel would be specifically trained in areas such as:

- accident reporting,
- near miss reporting

- first aid,
- equipment maintenance,
- record keeping,
- chemical use and waste disposal.

This would help to further define the role of teacher aides and introduce a level of accountability consistent with health and safety policies and procedures.

Laboratory Technicians

Laboratory technicians are an essential part of the science education team and their specialized work requires the demonstration of due diligence. With a knowledge of district and school based policies and an understanding of safety rules and procedures, laboratory technicians provide constancy to science activities. Modeling expert skills and behaviors is also a recognized function of technicians and they should be involved in the development and maintenance of health and safety programs. Advocacy is a responsibility assigned to this group of science educators and the goal of demonstrating due diligence can be achieved when laboratory technicians advocate for:

- safe handling procedures, and
- staff and students in the maintenance of health and safety programs for science.

Training is also an essential component and a way of demonstrating due diligence. Laboratory technicians require WHMIS, first aid, transportation of dangerous goods and safety audit training. They need specialized resource materials such as *Safety in the Science Classroom* to help them in selecting appropriate materials, identifying potential risks and hazards, and referencing important data on chemicals. Additional training is also required in chemical inventory, storage, and waste disposal procedures. Where possible, on-going improvement may be realized through the use of self training programs and networking initiatives.

Defining roles and responsibilities was the most effective way of improving the demonstration of due diligence for laboratory technicians. Research participants identified the following roles/action attributable to a laboratory technician when they are demonstrating due diligence. Laboratory technicians should be able to:

- assist teaching staff in preparing materials for safe use by students,
- follow safe practices when preparing materials for experiments,
- follow proper procedures concerning chemical handling inventory and disposal,
- enforce and follow through on proper practices for health and safety in science,
- refuse to do anything that does not meet regulations and proper procedures,
- make requirements and expectations clear and in writing,
- be involved in departmental/school occupational health and safety committees,
- minimize risks; i.e., material transfer, labeling, and waste disposal,
- ensure that science equipment is in safe working order,
- be accountable,
- make teachers aware of proper practices and the non-compliance of staff and students,
- hold teachers and administrators accountable for the establishment of a science health safety program at their school,
- implement health and safety management tools such as:
    - hazard assessment,
    - safety orientations, students safety contracts,
    - worksite inspections and investigations,
    - emergency preparedness,
- promptly report
    - hazards,
    - unsafe conditions,
    - work related injuries.

Clear and concise roles and responsibilities demonstrate due diligence for laboratory technicians. Improvements in the areas will help to ensure a safe work/learning environment for all involved in science education.

The issue of certification is also identified by research participants as a way of improving due diligence. The need for qualified personnel with specialized training is recognized by the respondents. Some sort of certification by a governing body could ensure that an acceptable level and breadth of training was provided to laboratory technicians and consequently delivered to students under their care and control.

Identify areas of science safety that you would describe as exemplary current practices.

Exemplary current practices are already being demonstrated in school districts throughout the province. The following represents a collection of some of the excellent science safety programs that research participants are aware of.

Some school districts have led the way in demonstrating due diligence related to science safety. By mandating health and safety programs in all areas (not just science) these jurisdictions profile the importance of safety. Policies and procedures are well established to assist districts in complying with Occupational Health and Safety Regulations. Large jurisdictions have well trained laboratory technicians who are familiar with legislation, regulations and relevant safety issues. Some school districts have hired specialized personnel and placed them in charge of the collection and disposal of chemicals from school sites (toxic round up). Specific examples of district initiatives include: the periodic review and culling of science materials, the updating of chemical inventories, and the removal of chemicals which present an unjustifiable hazard.

Research participants also recognized that some school divisions or specific schools demonstrated exemplary practices in each of the following science safety areas:

- knowledge of legislation,
- training in WHMIS,

- training in emergency preparedness,
- provisions for first aid training and the purchasing of supplies,
- the availability of personal protective equipment.

Exemplary science teachers, administrators and laboratory technicians work collaboratively to make science safety a priority. By having regular "science team" meetings to review safety, these individuals continually demonstrate due diligence. Many science teachers carry out a science safety presentation at the start of every course where they review lab safety and chemical disposal.

Laboratory technicians are currently taking on a key role in assisting teachers and other school staff on science safety policies and procedures. Technicians are "staying current" on new regulations, procedures, and proper practices. A specific exemplary practice has laboratory technicians acting as a professional association advocating for procedural and structural changes, and developing outreach activities. At the high school level, laboratory technicians also have regular meetings to discuss science safety issues.

Schools that exhibit current exemplary practices demonstrate due diligence in many ways. With an emphasis on "practices", research participants were able to identify specific procedures that they knew were being used in schools.

Schools demonstrate exemplary safety practices when they:

- do not stock pile chemicals,
- have a chemical waste storage system,
- have well marked and labeled chemicals,
- regular waste disposal programs,
- budgets in place for the proper disposal of hazardous wastes using qualified waste brokers,
- follow legislation,
- maintain a staff record of safety concerns and near misses,
- order small quantities of chemicals,
- have science classes that use less harmful chemicals,
- increase the staff to student ratio in science classes,

- use microscale quantities of chemicals,
- have all caretakers WHMIS trained with additional safety courses annually.

Schools and the science staff in charge of instruction also exhibit some exemplary practices when working with students. Specific programs and procedures were recognized by research respondents as they pertain to the delivery of health and safety conscious science programs. Some schools required the training of students in WHMIS and safe practices. Students also received documented safety orientations that outlined health and safety rules and expectations. Specific training programs are in place and often implemented at the beginning of science courses.

How safe are our current practices?

Identify areas of science safety that are in need of improvement.

Areas of science safety in need of improvement have been arranged into four groups:

1. Improvements that encompass the broad area of science safety.
2. Specific improvements related to professional development and training.
3. Improvements dealing with staffing.
4. Specific practices in need of improvement.

1. Improvements that encompass the broad area of science safety.

Science safety needs:

- knowledgeable leadership,
- to be understood,
- to be practiced,
- a coordinated plan at the district and school level,
- schools/districts that are up to standard,
- a broader knowledge of legislation and correct procedures,
- districts to provide safety policies,

- every school board/district to have a chemical waste management policy,
- accountability,
- approaches to safety that are not ad hoc.

2. Specific improvements related to professional development and training.

Science safety needs:

- to be a significant component of professional development,
- comprehensive teacher training, pre-service through to continued employer training,
- basic health and safety training in:
    - WHMIS,
    - transportation of dangerous goods,
    - emergency preparedness,
    - legislation
    - storage, preparation, use and disposal of chemicals,
    - lasers,
- training for teachers with a minimal science background when they are required to teach science,
- training programs for students,
- qualified personnel to deliver science programs.

3. Improvements dealing with staffing.

Science safety needs:

- science teachers, administration and laboratory technicians to work together to make safety a priority,
- clear roles and responsibilities for school administration and staff,
- clear and concise
    - district health and safety policies,
    - protocols and procedures for hazard and injury reporting,
- qualified supervisor, teachers and personnel who are:
    - trained in handling of chemicals,

- have WHMIS training,

- informed of legislation, safety policies and chemical management,
- teachers who are willing to change their practices (be monitored) and eliminate old, unsafe activities,
- newer/safer laboratory activities and procedures,
- schools to have access to trained laboratory technicians,
- science staff to have access to safety resources,
- administration and teachers to take safety seriously.

4. Specific practices in need of improvement.

Science safety needs:

- closer attention given to all health and safety practices,
- improved laboratory practices and procedures,
- unsafe laboratory conditions corrected,
- to use safety audits and have policy,
- emergency response plans,
- hazard assessment procedures,
- accident reporting systems with documentation,
- adequate chemical storage facilities (especially in junior high),
- adequate maintenance and preventative maintenance,
- improved laboratory storage, chemical storage and ventilation,
- improved inventory control and chemical preparation/handling procedures,
- improved chemical disposal and waste management practices with annual toxic round ups, for schools to dispose of "out dated" very old chemicals,
- consistent enforcement for the use of personal protective equipment (specifically eye protection),
- sufficient personal protective equipment (that fits),
- smaller class sizes (for safety and supervision),

- more risk management information for determining class sizes appropriate for science laboratories,
- to have sufficient staff for program delivery,
- for every school to have a chemical coordinator to manage waste,
- science resources with thoroughly vetted materials.

How can professional development on science safety be structured?
Include : -a planning model (time frame),
-a list of topics that would be addressed, and
-a list of resources that would be used or required.

School Board/Trustees

Planning Model

When structuring a professional development program on science safety for school boards and trustees, the suggested planning model/time frame includes immediate initiatives (to be completed within the next year) and long term (ongoing) safety programs. Trustees should receive an initial professional development program when they are first appointed and an annual (half day) informational session can follow. The planning model should allow for a "balanced" presentation/discussion model where trustees have time to ask questions. The program development should be "discussed" by trustees and focus in on what is really required for trustees to know. It is also suggested that a one to two day workshop be developed by any individual or group of professional associations such as:

- The Curriculum Branch (Alberta Education),
- The Alberta School Boards' Association,
- Occupational Health and Safety (Government Department),
- Workers' Compensation Board,
- The Alberta Teachers' Association,

- other health and safety organizations including private industry programs.

The planning model could also include presentations at regular school board meetings (as an agenda item), the use of provincial conferences (the Alberta Teachers' Association Science Council Conference and the Edmonton Regional Science Conference), and teachers' conventions.

Topics

As identified by research participants, a professional development program on science safety for school board trustees should include information on:

- legislation and legislative requirements (legal issues),
- responsibilities of school board trustees,
- due diligence,
- superintendent recommendations,
- policy development,
- elements of a health and safety management system,
- strategies for implementation and integrated planning,
- professional development programs,
- risk management models,
- monitoring frameworks,
- new Occupational Health and Safety Regulations,
- differences between Division 1, 2, 3, and 4 with specific suggestions for implementation,
- accountability plans,
- chemical waste management programs,
- staff WHMIS and TDG training,
- health and safety issues,
- chemical use (coordination),
- procedures for laboratory safety and student safety,
- the costs of injuries and illnesses,

- Workers' Compensation Board premiums/rates and how safety relates to them,
- best practices models,
- chemical
    - transportation,
    - inventory (establishment and maintenance),
    - disposal,
    - labeling,
    - security (limited access),
    - spill clean up,
    - ordering,
- ventilation,
- laboratory equipment,
- annual waste pick up programs (toxic round up) using qualified waste brokers.

Resources

Resources that could assist in the development of a program (as outlined above) would include:

- relevant legal documents,
- sample implementation guides,
- *Safety in the Science Classroom* (Alberta Education),
- other Alberta Learning resources,
- information from the last toxic round up (1990's),
- Alberta Environment Waste Control Regulations,
- documents developed by:
    - Alberta School Boards' Association,
    - Workers' Compensation Board,
    - Occupational Health and Safety,

- other health and safety associations including private industry and external consultants.

Administrators

Planning Model

The broad grouping, "administrators", includes all administrators from the school base level to central office personnel. Due to the interactive nature of work done at these administrative levels, it is reasonable to suggest that a similar professional development be implemented.

The time frame component for professional development in science safety ranges from immediate initiatives to on-going regular programs. Some kind of implementation should occur within the next year and special consideration should be given to newly appointed administrators. Programs should utilize and cooperate with CASS (College of Alberta School Superintendents). Zone meetings for superintendents should have a science safety component that could be shared with other district administrators through central office leadership meetings. Science safety professional development can be placed on the agendas of these meetings and Occupational Health and Safety staff could make presentations. It is suggested that a "team" approach be adopted with all administrators, and that presentations be done at regular school board, administration, and staff meetings as part of the agenda. Consideration should be given to a series of professional development sessions to avoid overload and a "balanced" presentation/discussion model should be used to allow time for questions. Other provincial conferences and teachers' conventions could be used to further complement professional development initiatives in science safety.

Topics

As identified by research participants, a professional development program on science safety for administrators should include information on:

- legislation and legislative requirements,
- policy development,
- planning professional development,

- accountability/monitoring,
- due diligence/compliance,
- responsibilities,
- building requirements,
- basic requirements of the Occupational Health and Safety Act,
- training requirements (plans/funds/costs),
- budgeting/district funding/school based funding,
- purchasing safety equipment,
- strategies for demonstrating leadership,
- personnel requirements,
- risk/safety management,
- current occupational health and safety issues and school district trends,
- chemical
    - transportation,
    - inventory (establishment and maintenance),
    - disposal,
    - labeling,
    - security (limited access),
    - spill clean up,
    - ordering,
- WHMIS and TDG training,
- ventilation,
- laboratory equipment,
- annual waste pick programs (toxic round up) using qualified waste brokers.

Resources

Resources that could assist in the development of a program (as outlined above) would include:

- relevant legislation and regulations,

- sample division policies and legal documents,
- *Safety in the Science Classroom* and other Alberta Education documents,
- curriculum guides,
- safety manuals,
- sample building plans,
- documents from the last toxic round up (1990's),
- Alberta Environment Waste Control Regulations,
- documents available from government and environmental services associations, i.e., qualified waste brokers.

Science Teachers

Planning Model

Professional development in science safety for teachers should include a pre-service training component (possibly as a required module for secondary teachers) with initial programs when they are first appointed to a school district. (In-servicing could be done by September 4 of each year). Annual one or two day workshops are suggested by research participants and staff meetings and site inspections would complement this process. Further training could be provided through the Alberta Teachers' Association Science Council Conference and teachers' conventions held throughout the province. School districts and schools could also establish their own occupational health and safety committees and offer professional development programs through these avenues. Best practices could further be shared between schools and school districts by using electronic distribution lists and website based resources.

Topics

As identified by research participants, a professional development program on science safety for teachers should include information on:

- the new *Safety in the Science Classroom* resource,

- legislation and legislative requirements,
- due diligence,
- policy development (with specific procedures),
- roles and responsibilities,
- district specific requirements and procedures,
- legal liabilities,
- risk management,
- hazard assessment and reporting procedures,
- injury/illness reporting procedures,
- WHMIS, first aid, and TDG training,
- student safety training,
- monitoring frameworks,
- worksite inspections and investigations,
- the right to refuse (unsafe working conditions),
- subject and grade specific issues,
- possible lessons and scenarios,
- activity (equipment, material and chemical) selection, making good choices,
- role modeling,
- safety equipment (maintenance and use),
- how to coordinate science safety (use a coordinator),
- using a 'cradle to grave' approach,
- chemical
  - storage room guidelines,
  - management,
  - ordering,
  - packaging, labeling,
  - security (limited access),
  - spill clean up/response,

- disposal and annual waste pick up (toxic round up) using qualified waste brokers,
- microscale labs,
- safe practices (using practical safety information),
- ventilation,
- using household chemicals,
- how to use a fire extinguisher,
- the culling and disposal of materials.

Resources

Resources that could assist in the development of a program (as outlined above) would include:

- legislation and legislative requirements,
- school district policies,
- *Safety in the Science Classroom* (Alberta Education),
- information from the last toxic round up (1990's),
- Alberta Environment Waste Control Regulations.

Note: It may be necessary for districts/schools to develop their own specific resources that could be used in district/site specific professional development programs.

Teacher Aides and Laboratory Technicians

These two groups have been combined in the research results reporting because many respondents believed that they should be treated equally when considering professional development in science safety. Some respondents also stated that they should receive the same professional development as teachers.

Planning Model

Professional development programs in the area of science safety for teacher aides and laboratory technicians has a similar time frame as teachers and administrators. However, the model suggested is more local in scope. Initial and annual in-services and workshops could be part of work done by district or site based occupational health and safety committees. PD days, staff meetings and site inspections were all identified as opportunities for professional development. Continual "short session" meetings with teachers (as new laboratory activities are being prepared) may also be helpful. "Best practices" may also be shared among staff by using electronic distribution methods.

Topics

As identified by research participants, a professional development program on science safety for teacher aides and laboratory technicians should include information on:

- developing a support plan with emphasis on working with staff and sharing the workload,
- the new *Safety in the Science Classroom* resource,
- legislation and legislative requirements,
- due diligence,
- policy development (with specific procedures),
- roles and responsibilities,
- district specific requirements and procedures,
- legal liabilities,
- risk management,
- hazard assessment and reporting procedures,
- injury/illness reporting procedures,
- WHMIS, first aid, and TDG training,
- student safety training,
- monitoring frameworks,
- worksite inspections and investigations,
- safety equipment (maintenance and use),
- using a 'cradle to grave' approach,
- chemical
    - storage room guidelines,

- management,
- ordering,
- packaging, labeling,
- security (limited access),
- spill clean up/response,

- disposal and annual waste pick up (toxic round up) using qualified waste brokers,
- microscale labs,
- safe practices (using practical safety information),
- ventilation,
- using household chemicals,
- how to use a fire extinguisher,
- the culling and disposal of materials,
- accident reporting (documentation),
- the use of safety audits,
- qualifications identification,
- how to inform administrators about issues,
- preparing materials for use,
- guidelines for keeping equipment in safe working order.

Resources

The resources that could assist in the development of a program (as outlined above) are identical to the resources for teachers (see page 85).

Chapter 6

Conclusion and Recommendations

The following represents a synthesis of the likert scale survey and the open ended questionnaire results. Each participant was able to provide a unique perspective on science safety and bring to the research specific concerns, exemplary practices and professional development processes. Conclusions are both global in nature (district or division wide) and specific, for each of the groups identified in the study.

1. Improving science safety in Alberta's schools is needed and strongly supported.
2. Professional development will advance initiatives in science safety and classroom practice and science instruction can be enhanced through these processes.
3. Science safety is an essential component for student learning. All involved in the delivery of science education programs serve as role models for students. The safety practices they demonstrate are fundamental to student learning.
4. Adequate information on science safety is available; however, it is not often made available to administrators and teachers.
5. There is a need for legislation awareness (a detailed review of legislation and its requirements) so that rules and responsibilities can be clarified.
6. Policy development on science safety in school districts is necessary. This policy must be informed by legislative requirements and clearly identify procedures and practices that demonstrate due diligence in schools, science classrooms and laboratories.
7. Trustees, functioning as the school board and employer, need to be better informed about legislation as it pertains to science safety.
8. Superintendents, administrators and science teachers require professional development to improve their understanding of their legislated responsibilities in the area of science safety.
9. Teacher aides under the direction and supervision of teachers and administrators need to be well informed about science safety legislation and related policies and procedures.
10. Schools can improve science safety in the following areas: (As per Likert survey results).

a) inventory control,

b) waste management,

c) classroom procedures,

d) use of alternative chemicals.

11. Professional development on science safety is strongly supported and a collaborative approach is preferred.

12. Science safety in Alberta's schools can be improved through the demonstration of due diligence. The following identifies ways in which specific educational groups can contribute to this process.

School Board/Trustees

A school board and its trustees can improve science safety by:

- understanding the legislation governing science safety and the safety of employees and students,
- developing policy (informed by legislation) that provides for a framework of safety methods and practices with accountability to all operational levels within a school division. A list of specific safety policies would include policies on:
    - chemical storage/disposal,
    - chemical purchasing procedures,
    - inventory maintenance,
    - dangerous goods,
    - waste minimization procedures including the reuse and recycling of materials,
    - transportation procedures and a district waste management plan.
    - the responsibilities, qualifications, and/or educational requirements of science consultants, district WHMIS personnel, and all levels of administration and staff;
- initiating and supporting professional development programs including site specific training on WHMIS and in-servicing on the new Provincial Science Safety Resource, *Safety in the Science Classroom,*
- purchasing and or developing science safety resources,

- appointing/hiring a health and safety supervisor,
- providing funding for both human resources and infrastructure,
- establishing accountable health and safety management systems with performance review processes,
- publicly recognizing health and safety practices,
- using the following specific methods:
    - annual monitoring via reports to the board,
    - ongoing safety audits,
    - trustee tours of schools,
    - appropriate accident reporting systems including documentation,
    - safety audit compliance processes,
    - clear and direct accountability processes,
    - regular evaluations of health and safety programs,
    - continuous improvement processes using safety audits.

Superintendent/Central Office Administration

A superintendent and other central office administration personnel can improve science safety by:

- understanding the legislation governing science safety and the safety of employees and students,
- developing safety policies (informed by legislation) that include:
    - a framework that filters through all levels of administration and staff through to the student,
    - procedures that hold other levels of administration, teachers and staff accountable,
    - procedures that outline acceptable safety practices in areas such as:
        - safety audit compliance,
        - chemical disposal, and
        - waste management;
- communicating safety policies, procedures and practices to all personnel,

- supporting/funding professional development processes, the allocation of qualified human resources and the necessary infrastructure requirements for safe science education environments. Specific ways in which due diligence could be demonstrated would have the superintendent and central office staff:
    - promoting the importance of science safety (and policy awareness) in the district,
    - appointing or ensuring that each school or district division has at least one WHMIS coordinator,
    - directing human resources (safety officer or designates) to provide educators with training on WHMIS, chemical management and waste management,
    - providing for the recognition of safe schools (practices),
    - receiving a chemical waste management summary including details on:
        - annual chemical waste inventories,
        - waste pick up and disposal;
    - creating a health and safety committee to address science safety,
    - addressing the need for: safety audits, accident reporting systems and documentation,
    - developing a district user manual specifically designed for use in their district schools,
    - having a health and safety program that includes: contractors, temporary workers, students and volunteers,
    - providing direction to departments responsible for infrastructure when designing, building, and renovating science classroom/laboratory facilities,
    - holding administrators and supervisors accountable for the health and safety of staff and students under their care by using performance reviews.

    - having programs that facilitate review and improvement procedures.

School Administrators

School administrators can improve science safety by:

- understanding the legislation governing science safety and the safety of employees and students,
- supporting the implementation of health and safety programs that:
    - ensure staff and students know their roles and responsibilities in providing a safe science learning environment,
    - clearly establish the involvement of site based administration in the development, implementation, reviewing and supervision of safety programs,
    - demonstrate a knowledge of the measures to be taken in the event of an accident in the science classroom/laboratory (emergency preparedness),
    - ensure coordinated practices are in place for:
        - acquiring chemicals,
        - inventory management,
        - disposal of materials,
        - waste management;
- supporting the development of district policy and school based policy with specific procedures and protocols that represent their local needs,
- providing resources (budgeted) for the training of all personnel in WHMIS, first aid and related policies and procedures,
- hiring staff qualified in the handling of chemicals,
- creating health and safety committees with representatives from all areas including science,
- by adopting the following actions or procedures:
    - limiting the size of science classes,

- o ensuring that hazard assessments are completed and corrective action is taken to control hazards,
- o through supervision/evaluation, ensuring that teachers are held accountable for the safety of themselves and the staff and students under their care and control,
- o ensuring that teachers know and enforce the safety rules in their science teaching, classroom activities and laboratory activities,
- o establishing safety audit and accident reporting procedures for their schools,
- o the establishment of a chemical waste storage facility/plan and the regular pick up and disposal of chemical wastes (toxic round up).

Science Teachers

Science teachers can improve science safety by:

- participating in professional development on legislation, protocols, procedures, policies, and regulations related to health and safety,
- working together with administrators to apply safety requirements, programs and procedures that promote a positive attitude towards safety,
- acting as role models for students and continually demonstrating due diligence in the planning and delivery of science instruction,
- incorporating safe practices into their daily lesson plans that are designed to inform students of potential safety concerns and appropriate procedures related to science classroom and laboratory activities.
- being aware of the hazards and risks related to the use of chemicals, materials, and equipment used in the science classroom/laboratory,
- completing a course on the proper use and disposal of chemicals,
- checking to see if "old" lab and demo procedures (and materials commonly used for many years) are still currently acceptable,
- attempting to use more environmentally friendly chemicals,
- avoiding the stockpiling of chemicals and hazardous wastes,

- being knowledgeable about alternative chemicals and methods that are safer for the student and environment,
- minimizing the use of hazardous materials by utilizing microchemistry experiments,
- promptly reporting all hazards, unsafe conditions and work related injuries,
- speaking up about poor lab conditions, poor room conditions, too many students, and inappropriate facilities.

Science Support Staff (Teacher Aides)

Teacher aides can improve science safety by:

- working together with teachers and administrators to contribute to safe activities in the science classroom and laboratory,
- acting as role models who demonstrate a positive attitude towards practicing safe procedures,
- participating in professional development activities that offer specific training in:
    - Occupational Health and Safety Regulations,
    - safety procedures to be used in the classroom or laboratory with students under their care and control,
    - district and school based policy,
    - delivering student safety orientations,
    - WHMIS,
    - first aid,
    - chemical safety,
    - accident prevention/emergency preparedness,
    - transportation of dangerous goods,
    - accident/evaluation procedures,
    - safety audits/inspection,
    - hazard assessment.

Laboratory Technicians

Laboratory technicians can improve science safety by:

- being knowledgeable on district and school based policies and understanding safety rules and procedures,
- modeling expert skills and behaviors,
- participating in professional development on legislation, protocols, procedures, policies, and regulations related to health and safety,
- assisting teaching staff in preparing materials for safe use by students,
- following safe practices when preparing materials for experiments,
- following proper procedures concerning chemical handling inventory and disposal,
- enforcing and following through on proper practices for health and safety in science,
- refusing to do anything that does not meet regulations and proper procedures,
- making requirements and expectations clear and in writing,
- being involved in departmental/school occupational health and safety committees,
- minimizing risks; i.e., material transfer, labeling, and waste disposal,
- ensuring that science equipment is in safe working order,
- being accountable,
- making teachers aware of proper practices and the non-compliance of staff and students,
- holding teachers and administrators accountable for the establishment of a science health safety program at their school,
- implementing health and safety management tools such as:
    - hazard assessment,
    - safety orientations, students safety contracts,
    - worksite inspections and investigations,
    - emergency preparedness;
- promptly reporting
    - hazards,
    - unsafe conditions,

- work related injuries.

13. Some schools and school districts are already leading the way by demonstrating current exemplary practices. Specific examples of how due diligence related to science safety can be demonstrated include initiatives where:

- mandated health and safety programs are being used,
- school districts profile the importance of safety,
- policies and procedures are well established to assist districts in complying with Occupational Health and Safety Regulations,
- well trained laboratory technicians are being used in the delivery of science education programs,
- specialized personnel have been hired to assist in all aspects of science safety and chemical management,
- employees have been informed on legislative requirements and trained in WHMIS, first aid, emergency preparedness, the purchasing of supplies (chemicals and science equipment) and the use of personal protective equipment,
- teachers, administrators and laboratory technicians work collaboratively to make science safety a priority by having "science team" meetings to review safety,
- schools have established health and safety committees.
- schools:
    - do not stock pile chemicals,
    - have a chemical waste storage system,
    - have well marked and labeled chemicals,
    - regular waste disposal programs,
    - budgets in place for the proper disposal of hazardous wastes using qualified waste brokers,
    - follow legislation,
    - maintain a staff record of safety concerns and near misses,
    - order small quantities of chemicals,
    - have science classes that use less harmful chemicals,

- increase the staff to student ratio in science classes,
- use microscale quantities of chemicals,
- have all caretakers WHMIS trained with additional safety courses annually;

- safety orientation programs for new staff are documented and professional development in science safety is supported,
- students receive documented safety orientations at the beginning of their science courses where health and safety rules and expectations are clearly outlined.

14. Areas of science safety in need of improvement can be arranged into four categories.

1. Improvements that encompass the broad area of science safety.
2. Specific improvements related to professional development and training.
3. Improvements dealing with staffing.
4. Specific practices in need of improvement.

Specific improvement for these categories are included in the data analysis chapter.

15. Structuring a professional development program must take into consideration both short term (immediate) and long term needs. The following is a combined list of topics that could be referenced when planning professional development initiatives. It will be up to schools and school districts to access their own particular needs and construct a professional development plan. The following topics were identified by research participants:

- legislation and legislative requirements (legal issues),
- responsibilities of school board trustees,
- due diligence,
- superintendent recommendations,
- policy development,
- elements of a health and safety management system,
- strategies for implementation and integrated planning,
- professional development programs,
- risk management models,

- monitoring frameworks,
- differences between Division 1, 2, 3, and 4 with specific suggestions for implementation,
- accountability plans,
- chemical waste management programs,
- staff WHMIS and TDG training,
- chemical use (coordination),
- procedures for laboratory safety and student safety,
- the costs of injuries and illnesses,
- Workers' Compensation Board premiums/rates and how safety relates to them,
- best practices models,
- chemical
  - transportation,
  - inventory (establishment and maintenance),
  - disposal,
  - labeling and packaging,
  - security (limited access),
  - spill clean up/response,
  - ordering,
  - storage room guidelines,
  - management;
- ventilation,
- laboratory equipment,
- annual waste pick up programs (toxic round up) using qualified waste brokers.
- roles and responsibilities,
- building requirements,
- training requirements (plans/funds/costs),
- budgeting/district funding/school based funding,
- purchasing safety equipment,

- strategies for demonstrating leadership,
- personnel requirements,
- current occupational health and safety issues and school district trends,
- the new *Safety in the Science Classroom* resource,
- legal liabilities,
- hazard assessment and reporting procedures,
- worksite inspections and investigations,
- the right to refuse (unsafe working conditions),
- possible lessons and scenarios,
- activity (equipment, material and chemical) selection, making good choices,
- role modeling,
- safety equipment (maintenance and use),
- how to coordinate science safety (use a coordinator),
- using a 'cradle to grave' approach,
- microscale labs,
- safe practices (using practical safety information),
- using household chemicals,
- how to use a fire extinguisher,
- the culling and disposal of materials.
- developing a support plan with emphasis on working with staff and sharing the workload,
- injury/illness reporting procedures,
- safe practices (using practical safety information),
- accident reporting (documentation),
- the use of safety audits,
- qualifications identification,
- how to inform administrators about issues,
- preparing materials for use.

16. Current resources available for professional development in science safety exist. In addition to the references provided, the following resources would assist schools and school districts in developing science safety initiatives:

- relevant legal documents,
- sample implementation guides,
- *Safety in the Science Classroom* (Alberta Education),
- other Alberta Education resources,
- Alberta Environment Waste Control Regulations,
- documents developed by:
    - Alberta School Boards' Association,
    - Workers' Compensation Board,
    - Occupational Health and Safety,
    - other health and safety associations including private industry and external consultants;
- relevant legislation and regulations,
- sample division policies and legal documents,
- curriculum guides,
- safety manuals,
- sample building plans,
- documents from the last toxic round up (1990's),
- documents available from government and environmental services associations, i.e., qualified waste brokers.

17. Specific professional development models for science safety were suggested by the research participants. The following identifies key areas for each of these groups.

School Board/Trustees

- initial in-servicing when trustees are first elected and annual (half day) informational sessions can follow,
- programs should allow for a "balanced" presentation/discussion process whereby trustees have opportunities to ask questions,

- trustees should have prior input when programs are being developed so that they can focus on topics required for them to know,
- safety presentations and professional development can be a part of regular school board meetings and placed on the agenda for these meetings,
- provincial conferences and teachers' conventions could be utilized by trustees,
- a one to two day workshop to be developed by any individual or group of professional associations such as:
  - The Curriculum Branch (Alberta Education),
  - The Alberta School Boards' Association,
  - Occupational Health and Safety (Government Department),
  - Workers' Compensation Board,
  - The Alberta Teachers' Association,
  - other health and safety organizations including private industry programs.

Administrators (Central Office and School Based)

- initial in-servicing when administrators are first appointed,
- programs should utilize and cooperate with CASS (College of Alberta School Superintendents),
- science safety could be placed on the agendas of:
  - superintendent zone meetings,
  - district administrators' meetings,
  - school staff meetings;
- a balance presentation/discussion model should be adopted where administrators have time to ask questions,
- a series of professional development opportunities should be used to prevent overload,
- a collaborative "team approach" should be adopted.

Science Teachers

- pre-service training (possibly a required module for secondary science teachers) is suggested,
- a district/school in-servicing session should be used as an orientation for new science teachers,
- annual one or two day workshops are suggested and further training could be provided by the Alberta Teachers' Association Science Council Conference and teachers' conventions.
- school districts and schools could establish their own occupational health and safety committees,
- best practices could further be shared by using electronic distribution lists and website based resources.

Teacher Aides and Laboratory Technicians

- initial and annual in-services and workshops delivered by members of district or site based occupational health and safety committees,
- professional development opportunities could utilize professional development days, staff meetings and site inspections,
- continual "short session" meetings with teachers that provide opportunities to discuss safe practices and procedures,
- the sharing of best practices among staff by using electronic distribution methods.

Recommendations for Future Research

Based upon the research conducted in this body of work, the following research questions serve to present possible ideas for further study.

- Using the National Chemistry Teacher Safety Survey as a model (Plohocki 1998).What would be the results of a provincial science teacher safety survey ?

- How will the new provincial science safety resource, *Safety in the Science Classroom*, be implemented in Alberta, and what professional development programs will be provided along with the release of the document?
- Is another toxic round up necessary for Alberta schools, and how has chemical disposal in school districts occurred since 1990?
- Can an expanded pre-service teacher education program on safety be developed in the Faculty of Science or the Faculty of Education?
- Do teachers have the necessary prerequisite undergraduate science courses to teach Chemistry, Physics, Biology, and general science courses in Alberta?
- How will the current shortage of Chemistry and Physics teachers be addressed by Alberta, and what are the implications for safety in science education programs?
- What role can professional organizations play in enhancing professional development for support staff, teachers, administrators, and school boards?
- What differences exist between the science safety needs of rural and urban school districts and how might these differences be accommodated?
- How are teacher aides and laboratory technicians being used in science classrooms ? Should certification requirements be considered for these groups?

Action Research uses successive stages or spirals of planning, acting, observing and reflecting (McNiff & Whitehead, 2002). Each of the above recommendations represents a potential evolving spiral or cycle of further study or action. Collaborative interactions can lead to further science safety initiatives, the implementation of new programs and the evaluation of potential solutions for science safety in Alberta's schools and beyond.

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Appendixes

Appendix A

Towards Developing a Provincial Science Safety Resource by Identifying Opportunities for Professional Development

Introduction

The Province of Alberta, through Alberta Education, is in the process of developing a Science Safety Resource Document for use in the K-12 Science Education Program. The purpose of this section is to identify key administrative and professional development documents for developmental and implementational phases.

Science safety recognizes that reasonable and prudent practices are essential to ensure sound pedagogical instructional strategies that identify potential hazards and reduce the likelihood of accidents. As a major initiative in science education, the provincial resource will be the focus of necessary professional development in-servicing to district administrators, principals, teachers and other staff. By examining opportunities for professional development and linking them to existing educational roles and documents, the goal is to provide insights that may further safety practices and enhance laboratory activities in the science classroom.

The project is composed of four major parts:

Part A: Examining provincial science curricula

Part B: Examining the Teaching Quality Standard and science safety

Part C: Examining the Teacher Growth, Supervision and Evaluation Policy in Alberta

Part A looks the core K to12 science curriculum to identify specific areas within the Program of Studies where professional development opportunities in science safety would enhance teaching and learning. Classroom and laboratory activities, as well as specific references to safety, are highlighted for each grade and course level. Key learner outcomes for knowledge; science, technology and society; skills and attitudes are included so that educators may cross reference a particular science course with other parts of this project.

The Teaching Quality Standard and its supporting Knowledge, Skills and Attributes for Teachers are a foundation for designing professional development programs (Part B). All teachers are expected to meet the standard and by closely examining the opportunities to link this document to teaching and learning, professional development initiatives in science safety can be made more meaningful and effective.

Teacher Growth, Supervision and Evaluation (Part C) is the fundamental accountability policy for teachers in Alberta. Professional growth plans are a part of every teacher's commitment to lifelong learning. Professional development must be informed by this policy so that in-service programs can be fully realized. Administrators have their own unique perspectives on the implementation of safety in their classrooms and schools. Evaluation places additional responsibilities on administrators and professional development must address these requirements.

Part A: Examining Provincial Science Curricula

One of the dimensions of professional development is how teaching and learning can be enhanced by identifying areas within the programs of study which will benefit from professional development initiatives. Laboratory work is an essential component to the entire science program in Alberta. Safety in the classroom is learned by students as they experience and interact with the curriculum. Science safety recognizes that reasonable and prudent practices are essential to ensure sound pedagogical instructional strategies that identify potential hazards and reduce the likelihood of accidents.

By examining the Program of Studies and outlining the goals of science education, educators will be able to link the Provincial Science Safety Resource to professional instruction. Safe practice and laboratory activities in the science classroom are part of the foundation and philosophy of science education. The following programs of study will be examined to outline key opportunities for scientific inquiry as they relate to laboratory activities and safety:

-Elementary Science (Grades 1-6)
-Junior High Science (Grades 7-8-9)
-Science 10
-Chemistry 20-30
-Biology 20-30
-Physics 20-30.

Children have a natural desire to ask questions and find out how things work. Exploring, investigating, and learning about science provides a way for understanding and interpreting the world around us. Processes of inquiry and problem solving are developed throughout the curriculum and activities (in the laboratory/classroom) are fundamental in realizing the objectives of science education. For each of the grades and courses to follow, a summary of major opportunities for inquiry is provided. These summaries represent key areas of program rationale, philosophy, emphasis, structure, learner expectations and knowledge, skills and attitude outcomes that may be informed by professional development in science safety. Each grade/program level requires that opportunities be provided for learning about science and safety through scientific investigation. As a result, an examination of curriculum will serve to inform the design of professional development programs that enhance teaching, learning and evaluation in science.

Elementary Science (Grades 1-6), A Program Overview

The rationale for this Program of Studies focuses on processes of inquiry and problem solving. Learning is stimulated by developing skills and confidence in investigation. Experience is the foundation of learning and students need to be able to "ask relevant questions, seek answers, define problems and find solutions." Philosophy is built upon principles in the program. Curiosity is the starting point for learning and students are encouraged to question, explore and investigate. Abilities to observe, question, test, construct, and create are all part of the investigative skills that students are expected to develop. Being actively involved in inquiry and problem solving is a major focus of elementary science and students are to participate in activities that develop skills and achieve depth in understanding. Program emphasis is broken down into two major areas: science inquiry and problem solving through technology. Each grade has specific skills and attitudes that progress through the grades.

Grade 1

Skills:

Exploratory activities will require teacher direction as patterns of science activity develop. Specific learner expectations require students to manipulate materials and make observations. Recognizing and describing steps as they explore and investigate.

Attitudes:

Students are expected to show growth in acquiring and applying the following traits:

- curiosity,
- confidence in personal ability to explore materials and learn by direct study,
- inventiveness,
- perseverance: staying with an investigation over a sustained period of time,
- appreciation of the value of experience and careful observation.

Understandings:

Some examples of topics and specific learner expectations where activities and professional development on science safety may enhance teaching and learning are:

Topic A: Creating Color

Students will:

- compare the effect of different thicknesses of paint.
- compare the adherence of paint to different surfaces.
- demonstrate at least one way to separate sunlight into component colors.

Topic B: Seasonal Changes

Students will:

- identify and describe examples of plant and animal changes that occur on a seasonal basis.

Topic C: Building Things

Students will:

- select appropriate materials such as papers, plastics, woods; and design and build objects.

Topic D: Senses

Students will:

- identify ways that our senses contribute to our safety and quality of life.

Topic E: Needs of Animals and Plants

Students will:

- observe, describe and compare living things.
- contrast living and non-living things.

Grade 2

Skills:

With guidance from the teacher, investigative activities and the use of procedures are emphasized. Events are studied and students will record procedures and observations. Simple procedures and the manipulating of materials is used to help students make observations as they explore and investigate. Problem solving through technology is developed as students construct and test structures that float and are stable in water.

Attitudes:

Students are expected to show growth in acquiring and applying the following traits:

- curiosity,

- confidence in personal ability to explore materials and learn by direct study,
- inventiveness,
- perseverance: staying with an investigation over a sustained period of time,
- appreciation of the value of experience and careful observation.

Understandings:

Some examples of topics and specific learner expectations where activities and professional development on science safety may enhance teaching and learning are:

Topic A: Exploring Liquids:

Students will:

- recognize and describe characteristics of liquids.
- compare water with one or more other liquids, such as cooking oil. glycerine or water mixed with liquid detergent.

Topic B: Buoyancy and Boats

Students will:

- evaluate the appropriateness of various materials to the construction of watercraft.

Topic C: Magnetism

Students will:

- design and produce a device that uses a magnet.
- compare and measure the strength of magnets.

Topic D: Hot and Cold Temperatures

Students will:

- measure temperature in degrees Celsius (°C).

- describe how heating and cooling materials can often change them: e.g., melting and freezing, cooking, burning.
- design and construct a device to keep something hot and cold.

Topic E: Small Crawling and Flying Animals

Students will:

- compare and contrast small animals that are found in the local environment (invertebrates such as: insects, spiders, centipedes, slugs, worms).

Grade 3

Skills:

Purposeful actions that lead up to observations and inferences are emphasized as students continue to identify patterns and record observations. Possible solutions to practical problems are investigated as rigid and semi-rigid structures are constructed. Students are expected to explain the purpose of steps and attempt a variety of strategies to complete tasks.

Attitudes:

Students are expected to show growth in acquiring and applying the following traits:

- curiosity,
- confidence in personal ability to explore materials and learn by direct study,
- inventiveness and willingness to consider new ideas,
- perseverance in the search for understandings and for solutions to problems,
- a willingness to base their conclusions and actions on the evidence of their own experiences.

Note: In grade 3, students move from experiences and careful observations to basing conclusions and actions on evidence.

Understandings:

Some examples of topics and specific learner expectations where activities and professional development on science safety may enhance teaching and learning are:

Topic A: Rocks and Minerals

Students will:

- use simple tests and tools.
- give a description of the properties of a particular rock or mineral including: color, luster, texture, hardness, presence of carbonates, crystal shape.

Topic B: Building With a Variety of Materials

Students will:

- use, safely, a variety of tools, techniques, and materials in construction activities.
- design, construct and test structures.
- select tools that are suitable to particular tasks and materials, and use them safely and effectively.

Topic C: Testing Materials and Designs

Students will:

- compare and evaluate the strength and stability of different models or objects constructed.
- apply procedures to test:
  - the strength of construction materials,
  - different designs,
  - the strength of different methods of joining.

Topic D: Hearing and Sound

Students will:

- recognize that there are ways of measuring the loudness of sounds and that loud sounds pose a danger to the ear.
- use sound-producing devices that the student has constructed to demonstrate methods for controlling the loudness, pitch and quality of sound produced.
- construct and evaluate different kinds of soundproofing and sound amplifying devices.

Topic E: Animal Life Cycles

Students will:

- observe and describe the growth and development of at least one living animal, as the animal develops from early to more advanced stages.

Grade 4

Skills:

Testing as a way of examining a prediction or a hypothesis is further developed in this grade. As students explore, investigate, identify patterns and record observation, predictions and generalizations are made and evaluated. Structures with moving parts are tested and trouble shooting (technological problem solving) skills are engaged. Accurate observations and measurement are used to evaluate a product and students use the following criteria as they investigate the nature of things:

- effectiveness,
- reliability,
- durability effort,
- safety,
- use of materials.

Attitudes:

Students are expected to show growth in acquiring and applying the following traits:

- curiosity,
- confidence in personal ability to explore materials and learn by direct study,
- inventiveness and willingness to consider new ideas,
- perseverance in the search for understandings and for solutions to problems,
- a willingness to base their conclusions and actions on the evidence of their own experiences.

Understandings:

Some examples of topics and specific learner expectations where activities and professional development on science safety may enhance teaching and learning are:

Topic A: Waste and Our World

Students will:

- identify plant and animal wastes, and describe how they are recycled in nature. The wastes of these animals may be further broken down by molds, fungi and bacteria.

Topic B: Wheels and Levers

Students will:

- construct devices that use wheels and axles, and demonstrate and describe their use in: model vehicles, pulley systems and gear systems.

Topic C: Building Devices and Vehicles That Move

Students will:

- design and construct devices and vehicles that move or have moving parts-linkages, wheels and axles.
- compare two designs, identifying the relative strengths and weaknesses of each.

Topic D: Light and Shadows

Students will:

- recognize that eyes can be damaged by bright lights and that one should not look at the sun-either directly or with binoculars or telescopes.
- class materials as transparent, partly transparent (translucent) or opaque.
- demonstrate the ability to use a variety of optical devices, describe how they are used and describe their general structure.

Topic E: Plant Growth and Changes

Students will:

- recognize that plant requirements for growth; i.e., air, light energy, water, nutrients and space; vary from plant to plant and that other conditions; e.g., temperature and humidity; may also be important to the growth of particular plants.

Grade 5

Skills:

Recognizing the importance of accuracy in observation and measurement combined with careful investigative procedures for testing, is essential for skill development in grade five. The emphasis is on applying suitable methods to record, compile, interpret and evaluate observations and measurements. Attempting a variety of strategies and modifying procedures is linked to identifying variables that need to be held constant or changed during a fair test. Students are expected to solve problems and present possible improvements when evaluating a design or product.

Attitudes:

Students are expected to show growth in acquiring and applying the following traits:

- curiosity,

- confidence in personal ability to learn and develop problem-solving skills,
- inventiveness and open-mindedness,
- perseverance in the search for understandings and for solutions to problems,
- flexibility in considering new ideas,
- critical-mindedness in examining evidence and determining what the evidence means,
- a willingness to evidence as the basis for their conclusions and actions.

Understandings:

Some examples of topics and specific learner expectations where activities and professional development on science safety may enhance teaching and learning are:

Topic A: Electricity and Magnetism

Students will:

- recognize and appreciate the potential dangers involved in using sources of electrical currents.
- demonstrate and interpret evidence of magnetic fields around magnets and around current-carrying wires, by use of iron filings or by use of one or more compasses.

Topic B: Mechanisms Using Electricity

Students will:

- design and construct circuits that operate lights and other electrical devices.
- be given a design task and construct an electrical device that meets the task requirements.

Topic C: Classroom Chemistry

Students will:

- apply and evaluate a variety of techniques for separating different materials.
- distinguish substances that will dissolve in a liquid from those that will not, and demonstrate a way of recovering a material from solution.
- demonstrate a procedure for making a crystal.

Topic D: Weather Watch

Students will:

- describe and demonstrate methods for measuring wind speed and for finding wind direction.
- measure at least four different kinds of weather phenomena; either student-constructed or standard instruments may be used.

Topic E: Wetland Ecosystems

Students will:

- identify some plants and animals found at a wetland sit, both in and around water; and describe the life cycles of these plants and animals.

Grade 6

Skills:

Identifying manipulated, controlled and responding variables when testing is a significant addition to the skills developed in elementary science thus far. Multiple ways of finding answers to questions and having students modify the procedures used when designing and carrying out investigations is essential. In addition to the many learner expectations already developed in the earlier grades, students are expected to identify new applications based upon what was learned, and ask new questions that arise from what was learned.

Attitudes:

Students are expected to show growth in acquiring and applying the following traits:

- curiosity,
- confidence in personal ability to learn and develop problem-solving skills,
- inventiveness and open-mindedness,
- perseverance in the search for understandings and for solutions to problems,
- flexibility in considering new ideas,
- critical-mindedness in examining evidence and determining what the evidence means,
- a willingness to evidence as the basis for their conclusions and actions.

Understandings:

Some examples of topics and specific learner expectations where activities and professional development on science safety may enhance teaching and learning are:

Topic A: Air and Aerodynamics

Students will:

- provide evidence that air takes up space and exerts pressure, and identify examples of these properties in everyday applications.
- provide evidence that air is a fluid and is capable of being compressed, and identify examples of these properties in everyday applications.

Topic B: Flight

Students will:

- conduct tests of glider designs; and modify a design so that a glider will go further, stay up longer or fly a desired way.

- construct and test procedures and other devices for propelling a model aircraft.

Topic C: Sky Science

Students will:

- understand that the sun should never be viewed directly, nor by use of simple telescopes or filters, and that safe viewing requires appropriate methods and safety precautions.

Topic D: Evidence and Investigation

Students will:

- investigate evidence and link it to a possible source by:
  - analyzing the ink from different pens, using paper chromatography,
  - comparing samples of fabrics.

Topic E: Trees and Forests

Students will:

- describe kinds of plants and animals found living on, under and among trees; and identify how trees affect and are affected by those living things.

Junior High Science (Grades 7-8-9), A Program Overview

As students progress into their junior high science education, the sophistication of science activities moves to laboratory settings where safety awareness is essential.

The curriculum reflects this progression by including attitude outcomes for every unit that emphasizes the importance of safety. Rationale and philosophy are centered on four foundations that school programs must provide when preparing students for senior high and graduation. Scientific literacy is developed through a knowledge of science and its relationship to technologies and society. Laboratory activities are a cornerstone of the nature of science which is located in foundation one: Science, Technology and Society (STS). Science safety and the use of laboratory investigation inform each of the other three foundations: Knowledge, Skills and Attitudes. Students are expected to build their scientific inquiry skills (from grades one to six) as they question and design/ conduct experiments, record results and analyze and interpret observations/data with safety in mind. Each unit for each grade has focusing questions, key concepts, skill and attitude outcomes and a unit emphasis from one of three major areas:

- nature of science,
- science and technology,
- social and environmental.

As the focus of this initiative is to provide specific examples where laboratory activities and professional development on science safety may enhance teaching and learning, appropriate outcomes for each unit in each grade will be identified.

Grade 7

Unit A: Interactions and Ecosystems

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

- trace and interpret the flow of energy and materials within an ecosystem.
- monitor a local environment, and assess the impacts of environmental factors the growth, health and reproduction of organisms in that environment.

Skills Outcomes

Students will:

- ask questions about the relationships between and among observable variables, and plan investigations to address those questions,
- conduct investigations into the relationships between and among observations, and gather and record qualitative and quantitative data.

Attitude Outcomes

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities (e.g., select safe methods and tools for collecting evidence and solving problems; assume personal responsibility for their involvement in a breach of safety or in waste disposal procedures).

Unit B: Plants for Food and Fibre

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

- investigate life processes and structures of plants, and interpret related characteristics and needs of plants in a local environment.

analyze plant environments and identify impacts of specific factors and controls.

Skills Outcomes

Students will:

- ask questions about the relationships between and among observable variables, and plan investigations to address those questions.

- conduct investigations into relationships between and among observations, and gather and record qualitative and quantitative data.

Attitude Outcomes

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities (e.g., read the labels on materials before using them, and ask for help if safety symbols are not clear or understood; clean their work area during and after an activity).

Unit C: Heat and Temperature

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

- describe the nature of thermal energy and its effects on different forms of matter, using informal observations, experimental evidence and models.
- apply an understanding of heat and temperature in interpreting natural phenomena and technological devices.

Skill Outcomes

Students will:

- ask questions about the relationships between and among observable variables, and plan investigations to address those questions.
- conduct investigations into relationships between and among observations, and gather and record qualitative and quantitative data.

Attitude Outcomes

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities (e.g., demonstrate concern for self and others in planning and carrying out experimental activities involving the heating of materials; select safe methods for collecting evidence and solving problems).

Unit D: Structures and Forces

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

- investigate and analyze forces within structures, and forces applied to them.
- investigate and analyze the properties of materials used in structures.

Skill Outcomes

Students will:

- ask questions about the relationships between and among observable variables, and plan investigations to address those questions.
- conduct investigations into relationships between and among observations, and gather and record qualitative and quantitative data.

Attitude Outcomes

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities (e.g., readily alter a procedure to ensure the safety of members of the group; carefully manipulate materials, using skills learned in class or elsewhere; listen attentively to safety procedures given by the teacher).

Unit E: Planet Earth

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

- describe and demonstrate methods used in the scientific study of Earth and in observing and interpreting its component materials.
- identify evidence for the rock cycle, and use the rock cycle to interpret and explain the characteristics of particular rocks.

Skill Outcomes

Students will:

- ask questions about the relationships between and among observable variables, and plan investigations to address those questions.
- conduct investigations into relationships between and among observations, and gather and record qualitative and quantitative data.

Attitude Outcomes

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities (e.g., wear safety goggles when testing the cleavage or fracture of rocks; ensure the proper disposal of materials).

Grade 8

Unit A: Mix and Flow of Matter

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

- investigate and describe fluids used in technological devices and everyday materials
    - explain the Workplace Hazardous Materials Information System (WHMIS) symbols for labeling substances; and describe the safety precautions to follow when handling, storing and disposing of substances at home and in the laboratory.
- investigate and describe the composition of fluids, and interpret the behaviour of materials in solution.
- investigate and compare the properties of gases and liquids; and relate variations in their viscosity, density, buoyancy and compressibility to the particle model of matter.

Skill Outcomes

Students will:

- ask questions about the relationships between and among observable variables, and plan investigations to address those questions
  - design an experiment, and identify the major variables (e.g., design or apply a procedure for measuring the solubility of different materials.
- conduct investigations into relationships between and among observations, and gather and record qualitative and quantitative data
  - use instruments effectively and accurately for collecting data (e.g., measure the mass and volume of a given sample of liquid),
  - use tools and apparatus safely (e.g., wear safety goggles during investigations of solution properties).

Attitude Outcomes

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities (e.g., take the time to organize their work area so that accidents can be prevented; read the labels on materials before using them, and ask for help if safety symbols are not clear or understood; clean their work area during and after an activity).

Unit B: Cells and Systems (Nature of Science Emphasis)

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

- investigate living things; and identify and apply scientific ideas used to interpret their general structure, function and organization.
- investigate and describe the role of cells within living things.

Skill Outcomes

Students will:

- ask questions about the relationships between and among observable variables, and plan investigations to address those questions

    - rephrase questions in a testable form (e.g., rephrase a question, such as: "Why this structure?" to become questions such as: "How is this structure used by the organism?", "How would the organism be affected if this structure were absent or did not function?" or "What similar structure do we find in other organisms?".

- conduct investigations into relationships between and among observations, and gather and record qualitative and quantitative data
    - use instruments—including microscopes—effectively and accurately for collecting data (e.g., use a microscope to produce a clear image of cells).
- analyze qualitative and quantitative data, and develop and assess possible explanations.

Attitude Outcomes

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities (e.g., wear proper safety attire, without having to be reminded; follow appropriate safety procedures in handling biological material; clean their work area during and after an activity; ensure the proper disposal of materials).

Unit C: Light and Optical Systems (Nature of Science Emphasis)

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

- investigate the nature of light and vision; and describe the role of invention, explanation and inquiry in developing our current knowledge.
- investigate the transmission of light, and describe its behaviour using a geometric ray model.

- investigate and explain the science of image formation and vision, and interpret related technologies.

Skill Outcomes

Students will:

- ask questions about the relationships between and among observable variables, and plan investigations to address those questions
  - design an experiment, and identify the major variables.
- conduct investigations into relationships between and among observations, and gather and record qualitative and quantitative data
  - use instruments effectively and accurately for collecting data (e.g., measure angles of reflection; use a light sensor to measure light intensity),
  - use tools and apparatus safely (e.g., use lasers only in ways that do not create a risk of light entering anyone's eyes).

Attitude Outcomes

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities (e.g., select safe methods in using optical devices; readily alter a procedure to ensure the safety of members of the group).

Unit D: Mechanical Systems (Science and Technology Emphasis)

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

- illustrate the development of science and technology by describing, comparing and interpreting mechanical devices that have been improved over time.
- investigate and describe the transmission of force and energy between parts of a mechanical system.

Skill Outcomes

Students will:

- ask questions about the relationships between and among observable variables, and plan investigations to address those questions
  - propose alternative solutions to a practical problem, select one, and develop a plan.
- conduct investigations into relationships between and among observations, and gather and record qualitative and quantitative data
  - carry out procedures, controlling the major variables (e.g., ensure that materials to be tested are of the same size and are tested under identical conditions),
  - use tools and apparatus safely.

Attitude Outcomes

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities (e.g., readily alter a procedure to ensure the safety of members of the group; carefully manipulate materials, using skills learned in class or elsewhere; listen attentively to safety procedures given by the teacher).

Unit E: Freshwater and Saltwater Systems (Social and Environmental Emphasis)

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

- investigate and interpret linkages among landforms, water and climate
- analyze factors affecting productivity and species distribution in marine and freshwater environments

Skill Outcomes

Students will:

- ask questions about the relationships between and among observable variables, and plan investigations to address those questions

- design an experiment, and identify the major variables (e.g.; design an experiment to compare the characteristics of two water samples).

- conduct investigations into relationships between and among observations, and gather and record qualitative and quantitative data
    - research information relevant to a given issue.

Attitude Outcomes

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities (e.g., select safe methods and tools for collecting evidence and solving problems; readily alter a procedure to ensure the safety of members of the group).

Grade 9

Unit A: Biological Diversity (Social and Environmental Emphasis)

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

- investigate and interpret diversity among species and within species, and describe how diversity contributes to species survival.
- investigate the nature of reproductive processes and their role in transmitting species characteristics.

Skill Outcomes

Students will:

- ask questions about the relationships between and among observable variables, and plan investigations to address those questions
    - state a prediction and a hypothesis based on background information or an observed pattern of events (e.g., predict changes to an area of local parkland that is subject to intense use;

hypothesize means of impact, such as soil compaction and disturbance of nest sites).

- conduct investigations into relationships between and among observations, and gather and record qualitative and quantitative data
  - estimate measurements (e.g., estimate the population of a given plant species within a study plot).

Attitude Outcomes

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities (e.g., follow safety procedures in outdoor investigations).

Unit B: Matter and Chemical Change (Nature of Science Emphasis)

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

- investigate materials and describe them in terms of their physical and chemical properties.
- describe and interpret patterns in chemical reactions.
- describe ideas used in interpreting the chemical nature of matter, both in the past and present, and identify example evidence that has contributed to the development of these ideas.

Skill Outcomes

Students will:

- ask questions about the relationships between and among observable variables, and plan investigations to address those questions
  - select appropriate methods and tools for collecting data and information and for solving problems (e.g., plan and conduct a search for information about chemical elements, using appropriate print and electronic sources).

- conduct investigations into relationships between and among observations, and gather and record qualitative and quantitative data
    - o demonstrate knowledge of WHMIS standards, by using proper techniques for handling and disposing of laboratory materials.

Attitude Outcomes

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities (e.g., read the labels of materials before using the, and ask for help if safety symbols are not clear or understood; carefully manipulate materials, using skills learned in class; wear proper safety attire without having to be reminded; ensure the proper disposal of materials, readily alter a procedure to ensure the safety of members of the group; immediately advise the teacher of spills, and use appropriate techniques and materials to clean up).

Unit C: Environmental Chemistry (Social and Environmental Emphasis)

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

- investigate and describe, in general terms, the role of different substances in the environment in supporting or harming humans and other living things.
- identify processes for measuring the quantity of different substances in the environment and for monitoring air and water quality.

Skill Outcomes

Students will:

- ask questions about the relationships between and among observable variables, and plan investigations to address those questions
    - o select appropriate methods and tools for collecting data and

information and for solving problems (e.g., design an investigation to compare the chemical characteristics of two soils).

- conduct investigations into relationships between and among observations, and gather and record qualitative and quantitative data
    - use instruments and materials effectively and accurately for collecting data (e.g., measure and compare the pH in household products, foods and environments),
    - use tools and apparatus safely.

Attitude Outcomes

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities (e.g., take the time to organize their work area so that accidents can be prevented; read the labels of materials before using them, and ask for help if safety symbols are not clear or understood; clean their work area during and after an activity; use safety precautions without being reminded).

Unit D: Electrical Principles and Technologies (Science and Technology Emphasis)

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

- investigate and interpret the use of devices to convert various forms of energy to electrical energy, and electrical energy to other forms of energy.
- describe technologies for transfer and control of electrical energy.
- identify and estimate energy inputs and outputs; for example, devices and systems, and evaluate the efficiency of energy conversions.

Skill Outcomes

Students will:

- ask questions about the relationships between and among observable variables, and plan investigations to address those questions

- propose alternative solutions to a given practical problem, select one, and develop a plan.
- conduct investigations into relationships between and among observations, and gather and record qualitative and quantitative data
    - use tools and apparatus safely (e.g., use appropriate sources of electrical energy, and follow procedures to ensure personal and group safety),
    - use instruments effectively and accurately for collecting data (e.g., use ammeters and voltmeters).

Attitude Outcomes

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities (e.g., select safe methods in using electrical devices; readily alter a procedure to ensure the safety of members of the group; stay at their own work area during an activity, respecting others' space, materials and work).

Unit E: Space Exploration (Science and Technology Emphasis)

Outcomes for Science, Technology and Society (STS) and Knowledge

Students will:

- investigate and describe ways that human understanding of Earth and space has depended on technological development.

Skill Outcomes

Students will:

- ask questions about the relationships between and among observable variables, and plan investigations to address those questions
    - propose alternative solutions to a given practical problem, select one, and develop a plan (e.g., design and describe a model of a technology to be used in a space station).

- conduct investigations into relationships between and among observations, and gather and record qualitative and quantitative data
    - o organize data, using a format that is appropriate to the task or experiment (e.g., maintain a log of observed changes in the night sky; prepare a data table to compare various planets).

Attitude Outcomes

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities (e.g., select safe methods and tools for collecting evidence and solving problems; readily alter a procedure to ensure the safety of members of the group).

Grade 10

The Science 10 Program of Studies follows a similar format to the junior high program. Each unit has: STS and Knowledge Outcomes, Skill Outcomes and Attitude Outcomes. Outcomes for each unit provide specific examples where laboratory activities and professional development on science safety may enhance teaching and learning are identified.

Unit A: Energy and Matter in Chemical Change (Nature of Science Emphasis)

STS and Knowledge Outcomes

Students will:

- explain, using the periodic table, how elements combine to form compounds, and follow IUPAC guidelines for naming ionic compounds and simple molecular compounds
    - o illustrate an awareness of WHMIS guidelines, and demonstrate safe practices in handling, storing and disposing of chemicals in the laboratory and at home,

- classify ionic and molecular compounds, and acids and bases on the basis of their properties, i.e., conductivity, pH, solubility, and state.

- identify and classify chemical changes, and write word and balanced chemical equations for significant chemical reactions, as applications of Lavoisier's law of conservation of mass
  - describe the evidence for chemical changes; i.e., energy change, formation of a gas or precipitate, color or odor change, change in temperature,
  - differentiate between endothermic and exothermic chemical reactions (e.g., combustion of gasoline, photosynthesis).

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships, and plan investigations of questions, ideas, problems and issues
  - evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring and decision making (e.g., list appropriate instruments and apparatus that may be required to classify compounds such as litmus paper of conductivity tester).
- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information
  - demonstrate a knowledge of WHMIS standards, by selecting and applying proper techniques for handling and disposing of laboratory materials (e.g., recognize and use MSDS information),
  - select and use apparatus, technology and materials safely (e.g., use equipment, such as Bunsen burners, electronic balances and laboratory glassware, electronic probes, and calculators correctly and safely).

Attitude Outcomes

Students will be encouraged to:

- show concern for safety, and accept the need for rules and regulations (e.g., safely handle and dispose of chemicals; use equipment, such as hot plates and laboratory glassware, correctly and safely).
- be aware of the direct and indirect consequences of their actions (e.g., acknowledge the need for safe methods for handling and disposing of potentially hazardous materials in the home and school laboratory).

Unit B: Energy Flow in Technological Systems (Science and Technology Emphasis)

STS and Knowledge Outcomes

Students will:

- explain and apply concepts used in theoretical and practical measures of energy in mechanical systems
    - describe the evidence for energy as an observable change, including physical and chemical, and changes to motion, shape and temperature.
- apply principles of energy conservation and thermodynamics in investigating, describing and predicting efficiency of energy transformation in technological systems
    - explain quantitatively, efficiency as a measure of the useful work compared to the total energy put into an energy conversion process or device.

Skill Outcomes (Focus on Problem Solving)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas problems, and issues
    - design an experiment, identifying and controlling major variables

(e.g., design an experiment to demonstrate the conversion of chemical potential energy to thermal energy, involving a combustion reaction).

- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information
    - carry out procedures, controlling the major variables and adapting or extending procedures where required (e.g., perform an experiment to demonstrate the equivalency of work done on an object, and resulting kinetic energy; design a device that converts mechanical energy into thermal energy).
- analyze data and apply mathematical and conceptual models to develop and assess possible solutions
    - compare theoretical and empirical values and account for discrepancies (e.g., determine the efficiency of thermal energy conversion systems),
    - construct and test a prototype of a device or system, and troubleshoot problems as they arise (e.g., design and build an energy conversion device).

Attitude Outcomes

Students will be encouraged to:

- show concern for safety, and accept the need for rules and regulations (e.g., consider safety a positive limiting factor in scientific and technological endeavours; keep the work station uncluttered, with only appropriate laboratory materials present).

Unit C: Cycling of Matter in Living Systems (Nature of Science Emphasis)

STS and Knowledge Outcomes

Students will:

- describe the function of cell organelles and structures in a cell, in terms of life processes; and use models to explain these processes and their applications
    - identify the structure and describe, in general terms, the function of the cell membrane, nucleus, lysosome, vacuole, mitochondrion, endoplasmic reticulum, Golgi apparatus, ribosomes, chloroplast and cell wall, where present, of plant and animal cells,
    - describe cell size and shape as they relate to the concept of surface area to volume ratio and how that ratio limits cell size (e.g., compare nerve cells and blood cells in animals; plant root hair cells and chloroplast-containing cells on the leaf surface).
- analyze plants as an example of a multicellular organism with specialized structures at the cellular, tissue and systems level
    - describe how the cells of the leaf system have a variety of specialized structures and functions; i.e., epidermis including guard cells, palisade tissue cells, spongy tissue cells, and phloem and xylem vascular tissue cells.

Skill Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas problems, and issues
    - design an experiment, identifying and controlling major variables (e.g., design an experiment to determine the effect of $CO_{2(g)}$ concentration on the number of chloroplasts found in an aquatic plant cell).
- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information
    - use instruments effectively and accurately for collecting data (e.g., use a microscope to observe movement of water in plants;

prepare wet mounts of tissue from flowering plants and observe cellular structures specific to plant and animal cells; stain cells to make them visible).

Attitude Outcomes

Students will be encouraged to:

- show concern for safety, and accept the need for rules and regulations (e.g., assume responsibility for the safety of all those who share a common working environment, by cleaning up after an activity and disposing of materials in a safe place).

Unit D: Energy Flow in Global Systems (Social and Environmental Contexts Emphasis)

STS and Knowledge Outcomes

Students will:

- analyze the relationships among net solar energy, global energy transfer processes—primarily radiation, convection and hydrologic cycle—and climate
    - o investigate and explain how evaporation, condensation, freezing and melting transfer thermal energy; i.e., use simple calculations of heat of fusion and vaporization and $Q=mc\triangle t$ to convey amounts of thermal energy involved and link these processes to the hydrologic cycle.

Skill Outcomes (Focus on Applying Science to Inform Decision-Making Processes)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems, and issues
    - o design an experiment, identify specific variables (e.g., investigate the heating effect of solar energy, with variables being temperature, efficiency, and materials used).

- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information
  - carry out procedures, controlling the major variables and adapting or extending procedures where require (e.g., perform an experiment to determine the ability of various materials to absorb or reflect solar energy).
  - use instruments effectively and accurately for collecting data (e.g., use a barometer, rain gauge, thermometer, anemometer).

Attitudes Outcomes

Students will be encouraged to:

- be aware of the direct and indirect consequences of their actions.

Chemistry, Biology and Physics 20-30

Each of these six programs begins with a set of attitude outcomes specific to that course. For the purposes of this initiative, safety attitudes will be highlighted. Within each unit there are one or more general outcomes that have specific learner outcomes for: Knowledge; Science, Technology and Society; and Skills. Outcomes that provide specific examples where laboratory activities and professional development on science safety may enhance teaching and learning are identified.

Chemistry 20

Attitude Outcomes: Safety

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities, e.g.,
  - treat equipment with respect and carefully manipulate materials,
  - value the need for safe handling and storage of chemicals,

- recognize the significant role that chemical researchers and the chemical industry play in identifying risks and developing guidelines in safe exposure.
- dispose of used material appropriately.
- use minimal quantities of chemicals when performing experiments.
- assume responsibility for the safety of all those who share a common working environment, by cleaning up after an activity and disposing of materials in a safe place according to safety guidelines.

Unit A: The Diversity of matter and Chemical Bonding

General Outcome 1: Describe the role of modeling, evidence and theory used in explaining and understanding the structure, chemical bonding and behaviour of ionic compounds.

Outcomes for Knowledge

Students will:

- explain why formulas for ionic compounds refer to the simplest whole number ratio of ions that result in a net charge of zero.

Outcomes for Science, Technology and Society (Emphasis on the Nature of Science)

Students will:

- explain that scientific knowledge and theories develop through hypotheses, collection of evidence through experimentation and the ability to provide explanations.

Skill Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by

- designing an investigation to determine the properties of ionic compounds (solubility, conductivity, melting point).

- conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information by
    - performing an investigation to illustrate properties of ionic compounds.

General Outcome 2: Describe the role of modeling, evidence and theory used in explaining and understanding the structure, chemical bonding and behaviour of molecular substances.

Outcomes for Knowledge

Students will:

- relate properties of substances, e.g., melting and boiling points, heats of fusion and vaporization, to the predicted intermolecular bonding in the substance.

Outcomes for Science, Technology and Society (Emphasis on the Nature of Science)

Students will:

- explain that scientific knowledge and theories develop through hypotheses, collection of evidence through experimentation and the ability to provide explanations
    - relate chemical properties to their predicted intermolecular bonding by investigating melting and boiling points.

Skill Outcomes (Focus on Scientific Inquiry)

Students will:

- conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information by

- carrying out an investigation to determine the melting or boiling point of a molecular substance,
- using a thermometer and a conductivity apparatus to collect data,
- carrying out an investigation to compare the properties of molecular compounds.

Unit B: Forms of Matter: Gases

General Outcome 1: Explain molecular behaviour using models of the gaseous state of matter.

Skill Outcomes (Focus on Scientific Inquiry)

Students will:

- conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information by
  - performing an experiment to illustrate the gas laws that identify and control variables,
  - using thermometers, balances and other measuring devices effectively to collect data on gases.

Unit C: Matter as Solutions, Acids and Bases

General Outcome 1: Investigate solutions, describing their physical and chemical properties and explaining the significance of concentration.

Outcomes for Knowledge

Students will:

- list and describe the steps required to prepare and dilute a solution.
- describe the procedures for safe handling, storing and disposal of solutions commonly sued in the laboratory, with reference to WHMIS and consumer product labeling information.

Outcomes for Science, Technology and Society (Emphasis on Social and Environmental Contexts)

Students will:

- explain that the appropriateness, risks and benefits of technologies need to be assessed for each potential application from a variety of perspectives, including sustainability
    - explain the role of concentration in risk/benefit analysis for determining the safe limits of particular substances (e.g., pesticide residues, heavy metals, chlorinated or fluorinated compounds, pharmaceuticals).

Skill Outcomes (Focus on Decision Making)

Students will:

- conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information by
    - performing an experiment to determine the concentration of a solution,
    - using a conductivity apparatus to identify solutions,
    - using a balance and volumetric glassware to prepare solutions of specified concentration,
    - performing an investigation to determine the solubility of a solute in a saturated solution.

General Outcome 2: Describe acid and base systems qualitatively and quantitatively.

Outcomes for Knowledge

Students will:

- use indicators, pH and conductivity to differentiate among acidic, basic and neutral solutions.
- explain how the use of indicators, pH and conductivity can be used to differentiate pH and pOH.
- differentiate between the strength and concentration of strong and weak bases on the basis of empirical properties.

Skill Outcomes (Focus on Problem Solving)

Students will:

- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by
  - constructing a table or graph to compare pH and hydronium ion concentration to illustrate that as the hydronium ion concentration increases, the pH decreases,
  - using a pH meter to determine acidity and/or alkalinity of a solution.

Unit D: Quantitative Relationships in Chemical Changes

General Outcome 1: Explain how balanced chemical equations indicate the quantitative relationships among reactants and products involved in chemical changes.

Outcomes for Knowledge

Students will:

- apply stoichiometry to analyze chemical equations in terms of atoms, molecules, ionic species and moles.
- calculate the quantities of reactants and/or products involved in chemical reactions using gravimetric, solution or gas stoichiometry.

Skills Outcomes (Focus on Problem Solving)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
  - designing an experiment to determine the process to identify an ion (e.g., precipitation, flame test)

General Outcome 2: Use stoichiometry in quantitative analysis.

Outcomes for Knowledge

Students will:

- calculate the concentration of ions in solutions, using gravimetric procedures and evidence from reactions.
- draw and interpret titration curve graphs, using data from titration experiments involving strong acids and strong bases.

Outcomes for Science, Technology and Society (Emphasis on Science and Technology)

Students will:

- explain how the appropriateness and the risks and benefits of technologies need to be assessed for each potential application from a variety of perspectives, including sustainability.

Skills Outcomes (Focus on Problem Solving)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
    - designing a method using crystallization, filtration of titration to determine the concentration of a solution.
- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by
    - performing a titration to determine the concentration of an acid or base.
- analyze data and apply mathematical and conceptual models to develop and assess possible solutions by
    - evaluating an experiment based on a precipitation reaction, to determine the concentration of a solution.

Chemistry 30

Attitude Outcomes: Safety

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities, e.g.,
  - include the safety as a requirement in scientific and technological endeavours,
  - keep the workstation uncluttered, with only appropriate laboratory materials present,
  - use equipment and materials appropriately,
  - assume responsibility for the safety of all those who share a common working environment,
  - clean up after an activity and dispose of materials in a safe place.

Unit A: Thermochemical Changes

General Outcome 1: Determine energy changes in chemical reactions.

Outcomes for Knowledge

Students will:

- use calorimetry to determine the enthalpy changes in chemical reactions.

Outcomes for Science, Technology and Society (Emphasis on Science and Technology)

Students will:

- demonstrate an understanding that technological problems often lend themselves to multiple solutions that involve different designs, materials and processes and have intended and unintended consequences.

Skills Outcomes (Focus on Problem Solving)

Students will:

- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by
    - performing calorimetry experiments to determine the molar enthalpy change of chemical reactions,
    - using thermometers or temperature probes appropriately when measuring temperature changes.

General Outcome 2: Explain and communicate energy changes in chemical reactions.

Outcomes for Knowledge

Students will:

- explain the energy changes that occur during chemical reactions based on chemical bonds breaking and forming.

Skills Outcomes (Focus on Problem Solving)

Students will:

- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by
    - designing and building a heating device.
- analyze data and apply mathematical and conceptual models to develop and assess possible solutions by
    - evaluating a personally designed and constructed heating device, including a calculation of its efficiency.

Unit B: Electrochemical Changes

General Outcome 1: Explain the nature of oxidation-reduction reactions.

Outcomes for Knowledge

Students will:

- compare the relative strengths of oxidizing and reducing agents from empirical data.

- predict the spontaneity of a redox reaction experimentally and theoretically.

Skills Outcomes (Focus on Problem Solving)

Students will:

- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by
    - selecting and correctly using the appropriate equipment to perform an oxidation-reduction titration experiment,
    - creating charts, tables or spreadsheets which present the results of oxidation-reduction.
- analyze data and apply mathematical and conceptual models to develop and assess possible solutions by
    - evaluating data from an experiment to derive a simple reduction table.

General Outcome 2: Apply the principles of oxidation-reduction to electrochemical cells.

Outcomes for Knowledge

Students will:

- calculate the quantities of mass, volume, concentration, current and time in single voltaic and electrolytic cells by applying Faraday's law to solve stoichiometric problems.

Skills Outcomes (Focus on Problem Solving)

Students will:

- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by
    - constructing, observing and identifying products for Voltaic cells.
- analyze data and apply mathematical and conceptual models to develop and assess possible solutions by

- identifying the products produced by an electrolytic cell,
- comparing predictions and observations.
- evaluating experimental designs for Voltaic and electrolytic cells, identifying limitations and suggesting improvements and alternatives.

Unit C: Chemical Changes of Organic Compounds

General Outcome1: Explore organic compounds as a common form of matter.

Outcomes for Knowledge

Students will:

- compare the relative boiling points and solubility of aliphatics, aromatics, alcohols, ketones, carboxylic acids and ethers.

Skills Outcomes (Focus on Decision Making)

Students will:

- conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information by
    - performing an experiment to investigate the properties of organic compounds.
    - testing for the presence of a single bond versus a double or triple bond in aliphatics.

General Outcome 2: Describe the chemical reactions of organic compounds.

Skills Outcomes (Focus on Decision Making)

Students will:

- conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information by
    - performing an experiment to investigate the reactions of organic compounds.

Unit D: Equilibrium in Chemical Changes

General Outcome 1: Explain that there is a balance of opposing reactions in chemical equilibrium systems.

Outcomes for Knowledge

Students will:

- predict, qualitatively, shifts in equilibrium caused by changes in temperature, pressure, volume or concentration, using Le Chatelier's principle, and whether these changes affect the equilibrium constant.

Outcomes for Science, Technology and Society (Emphasis on Nature of Science)

Students will:

- demonstrate an understanding that scientific knowledge and theories develop through hypotheses, the collection of evidence through experimentation and the ability to provide explanations (e.g., research how equilibrium theories and principles developed).

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
  - designing an experiment to show equilibrium shifts through color change,
  - designing a method to prepare a buffer.
- conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information by
  - performing an experiment to test, qualitatively, predictions of equilibrium shifts,
  - investigating the relative abilities of a butter and a control (i.e., water, to accommodate small amounts of acids or bases).

- performing an experiment that illustrates equilibrium shifts through color changes or precipitation.
-

General Outcome 2: Determine quantitative relationships in chemical equilibrium systems.

Outcomes for Science, Technology and Society (Emphasis on the Nature of Science)

Students will:

- develop an understanding that technological development may involve the creation of prototypes and testing, as well as application of knowledge from related scientific and interdisciplinary fields.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
  - designing an experiment to show equilibrium shifts in concentration,
  - designing an experiment to quantify a buffer capacity.
- conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information by
  - performing an experiment to quantify a buffer capacity.

Biology 20

Attitude Outcomes: Safety

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities, e.g.,
  - consider safety a positive limiting factor in scientific and technological endeavours,
  - keep the workstation uncluttered, with only appropriate laboratory materials present.

Unit A: Energy and Matter Exchange in the Biosphere

General Outcome 1: Explain the constant flow of energy through the biosphere and ecosystems.

Outcomes for Knowledge

Students will:

- explain, in general terms, the one-way flow of energy through the biosphere and how stored biological energy in the biosphere, as a system, is eventually lost as heat (e.g., muscle heat generation, decomposition, conduction, radiation).

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by
  - performing an experiment to demonstrate, quantitatively, solar energy storage by plants.

General Outcome 2: Explain the cycling of matter through the biosphere.

Outcomes for Science, Technology and Society (Emphasis on Social and Environmental Contexts)

Students will:

- explain that science and technology have both intended and unintended consequences for humans and the environment
  - analyze the relationship between heavy metals released into the environment and matter exchange in natural food chains/webs, and the impact of this relationship on the quality of life.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
    - designing an experiment to compare the carbon dioxide production of plants with that of animals.

General Outcome 3: Explain the balance of energy and matter exchange in the biosphere, as an open system, and how this maintains equilibrium.

Outcomes for Knowledge

Students will:

- explain how the equilibrium between gas exchanges in photosynthesis and cellular respiration influences atmospheric composition.

Unit B: Ecosystems and Population Change

General Outcome 1: Explain that the biosphere is composed of ecosystems, each with distinctive biotic and abiotic characteristics.

Students will:

- identify biotic and abiotic characteristics and explain their influence in an aquatic and a terrestrial ecosystem in a local region.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues, and define and delimit problems to facilitate investigation by
    - planning a field study to gather and evaluate biotic and abiotic characteristics associated with an ecosystem or ecosystems (e.g., effects that dominant plants have on abiotic conditions such as soil and microclimate).
- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by

- performing a field study to measure, quantitatively, appropriate abiotic characteristics of an ecosystem or ecosystems and to gather evidence for analysis, both quantitatively and qualitatively, of the diversity of life of the ecosystem.

General Outcome 2: Explain the mechanisms involved in the change of populations over time.

Outcomes for Knowledge

Students will:

- summarize and describe line of evidence to support the evolution of modern species from ancestral forms, i.e., fossil record Earth's history, embryology, biogeography, homologous and analogous structures, biochemistry.

Outcomes for Science, Technology and Society (Emphasis on the Nature of Science)

Students will:

- explain that scientific knowledge and theories develop through hypotheses, the collection of evidence through experimentation, observation and the ability to provide explanations
  - discuss the nature of science as a way of knowing (e.g., contributions of Georges Buffon, Charles Lyell, Thomas Malthus and Alfred Wallace to evolution; contribution of Aristotle, Bacon and Popper to the philosophy of science).

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
  - designing an investigation to measure an inherited variation in a plant or animal population.

Unit C: Photosynthesis and Cellular Respiration

General Outcome 1: Relate photosynthesis to storage of energy in organic compounds.

Outcomes for Science, Technology and Society (Emphasis on Science and Technology)

Students will:

- explain that the appropriateness, risks and benefits of technologies need to be assessed for each potential application from a variety of perspectives, including sustainability
    - research and analyze the effects of herbicides on the biochemistry of photosynthesis.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by
    - measuring rates of evapo-transpiration under various environmental conditions and relate to photosynthetic activity.

General Outcome 2: Explain the role of cellular respiration in releasing energy from organic compounds.

Outcomes for Knowledge

Students will:

- in general terms, distinguish between animal and plant fermentation and aerobic respiration.

Outcomes for Science, Technology and Society (Emphasis on Social and Environmental Contexts)

Students will:

- explain that science and technology are developed to meet societal needs and expand human capability

- research applications of cellular biochemistry in health and industry (e.g., aerobic and anaerobic fitness, methane gas production from organic waste, alcohol production, bread making, yogurt).

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
  - designing an experiment to demonstrate that heat is a byproduct of respiration in autotrophs and hetertrophs.
- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by
  - using experimental methods to demonstrate, quantitatively, the oxygen consumption of germinating seeds.

Unit D: Human Systems

General Outcome 1: Explain how the human digestive and respiratory systems exchange energy and matter with the environment.

Outcomes for Knowledge

Students will:

- describe the chemical nature of carbohydrates, fats and proteins and their enzymes, i.e., carbohydrases, proteases and lipases.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
  - designing an investigation to examine
    - food energy through calorimetry,

- the influence of enzyme concentration, temperature or pH on activity of enzymes, e.g., pepsin, pancreatin,
- the mechanics of breathing, e.g., lung volume, breathing rate.

- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by
  - performing experiments, using qualitative tests, to detect the presence of carbohydrates, proteins and lipids.

General Outcome 2: Explain the role of the circulatory and defense systems in maintaining an internal equilibrium.

Outcomes for Knowledge

Students will:

- identify the principal structures of the heart and associated blood vessels, i.e., atria, ventricles, septum valves, aorta, vena cavae, pulmonary arteries and veins, pacemaker.
- describe the action of the heart and the general circulation of the blood through blood vessels.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
  - designing procedures to investigate factors affecting heart rate and blood pressure (e.g., physical activity, emotion, gender and chemicals such as caffeine).
- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by
  - measuring blood pressure and observing blood flow in a living organism (e.g., human, goldfish).

- carrying out a heart dissection to identify the major parts and to determine the directional flow of blood through the organ.

General Outcome 3: Explain the role of the excretory system in maintaining an internal equilibrium in humans through the exchange of energy and matter with the environment.

Outcomes for Knowledge

Students will:

- describe the function of the kidney in excreting metabolic wastes and expelling them into the environment.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by
  - performing a kidney dissection to identify major parts of the organ.

General Outcome 4: Explain the role of the motor system in the function of other body systems.

Outcomes for Science, Technology and Society (Emphasis on the Nature of Science)

Students will:

- explain that concepts, models and theories and often used in interpreting and explaining observations, and in predicting future observations
  - describe the relationship between fitness and efficiency of muscle action.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by

- designing an investigation to determine the relationship between muscle activity and energy.

- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by
    - observing types of human muscle cells under magnification.

Biology 30

Attitude Outcomes: Safety

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities, e.g.,
    - consider safety a positive limiting factor in scientific and technological endeavours.
    - keep the workstation uncluttered, with only appropriate laboratory materials present.

Unit A: Nervous and Endocrine Systems

General Outcome 1: Explain how the nervous system controls physiological processes.

Outcomes for Knowledge

Students will:

- describe the structure and function of the human eye, i.e., cornea, lens, sclera, choroids, retina, rods and cones, pupil, iris and optic nerve.

Outcomes for Science, Technology and Society (Emphasis on the Nature of Science)

Students will:

- explain that scientific knowledge and theories develop through hypotheses, collection of evidence through experimentation and the ability to provide explanations
    - evaluate the impact of photoperiod (light wavelength and duration) on the human organism.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
    - designing an experiment to investigate heat, cold, pressure and touch receptors.
- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by
    - designing and performing an experiment to measure the ability to discriminate objects visually and to hear a range of sounds.
    - using a microscope and prepared slides to observe neurons and neuromuscular junctions.
    - observing the principal features of a mammalian brain, ear and eye, using models, computer simulations or dissections, and identifying the major visible structures of those organs.

Unit B: Reproduction and Development

General Outcome 1: Explain how survival of the human species is ensured through reproduction.

Outcomes for Knowledge

Students will:

- identify the structures in the female reproductive system and describe their functions, i.e., ovaries, fallopian tubes, uterus, cervix, vagina.
- identify the structures in the male reproductive system and describe their functions, i.e., testes, seminiferous tubules, interstitial cells, epididymides, vasa deferentia, seminal vesicles, prostate gland, penis.
- distinguish egg and sperm from their supporting structures, i.e., seminiferous tubules, interstitial cells, Sertoli cells, follicle, corpus luteum.

Skills Outcomes (Focus on Decision Making)

Students will:

- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by
    - o using a microscope and prepared slides of ovaries and testes to observe and distinguish eggs and sperm from their supporting structures (e.g., interstitial cells, Sertoli cells, follicle, corpus luteum, seminiferous tubules).

General Outcome 3: Explain how cell differentiation and development in the human organism are regulated by a combination of genetic, endocrine and environmental factors.

Outcomes for Knowledge

Students will:

- identify major tissues and organs that arise from morphological development of the ectoderm (nervous system, skin); mesoderm (skeleton, muscles, reproductive structures); and endoderm (lining of the digestive and respiratory systems, liver, endocrine glands).

Skills Outcomes (Focus on Decision Making)

Students will:

- analyze data and apply mathematical and conceptual models to develop and assess possible solutions by
    - o observing the changes of embryo development, using preserved material such as chicken embryos, prepared slides, models or computer simulations, and extrapolating these events to the development of a human,
    - o analyzing the stages of embryo development.

Unit C: Cell Division, DNA and Protein Synthesis

General Outcome 1: Describe the processes of mitosis and meiosis.

Outcomes for Knowledge

Students will:

- explain, in general terms, the events of the cell cycle, i.e., cytokinesis, chromosomal behaviour in mitosis and meiosis.

Outcomes for Science, Technology and Society (Emphasis on Social and Environmental Contexts)

Students will:

- explain that science and technology are developed to meet societal needs and expand human capability
    - discuss the types and sources of teratogenic compounds found in the environment and the technological means by which they can be removed or controlled to ensure quality of life for future generations.

General Outcome 3: Explain classical genetics at the molecular level.

Outcomes for Knowledge

Students will:

- explain how a random change (mutation) in the sequence of bases provides a source of genetic variability.

Skills Outcomes (Focus on Problem Solving)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
    - designing an experiment to identify the relationship proteins produced in a cell at a particular point in time or development (e.g., microarrays).
- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by

- designing and performing an experiment to demonstrate how an environmental factor can cause a change in the expression of genetic information in an organism.

Unit D: Change in Populations and Communities

General Outcome 1: Describe a community as a composite of populations, each consisting of a number of individuals contributing to a gene pool.

Outcomes for Knowledge

Students will:

- apply quantitatively, the Hardy-Weinberg Principle to observed and published data
  - $p + q = 1$,
  - $p^2 + 2pq + q^2 = 1$.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by
  - designing and performing an investigation and/or computer simulation to demonstrate population growth and gene pool change.

General Outcome 2: Explain the interaction of individuals in populations with each other and members of other populations.

Outcomes for Knowledge

Students will:

- describe the basis of species interactions and symbiotic relationships and their influences on population changes, i.e.,
  - predator-prey and producer-consumer relationships.
  - symbiotic relationships: commensalisms, mutualism and parasitism and interspecific and intraspecific competition.

Skills Outcomes

Students will:

- conduct investigations into relationships between and among observable variables, and use a broad range of tools and techniques to gather and record data and information by
    - designing and performing an experiment to demonstrate interspecific and intraspecific competition,
    - designing and performing an experiment to demonstrate succession in a microenvironment and record its pattern of succession over time(e.g., hay infusion).

General Outcome 3: Explain, in quantitative terms, the change in populations over time.

Outcomes for Knowledge

Students will:

- describe and explain, quantitatively, factors that influence population growth,
    - mortality, natality, immigration, emigration.
    - change in population size.
- describe capacity, biotic potential, environmental resistance and the number of individuals in the population.

Outcomes for Science, Technology and Society (Emphasis on the Nature of Science)

Students will:

- explain how concepts, models and theories are often used in interpreting and explaining observations and in predicting future observation
    - develop appropriate investigative strategies for analyzing biological issues (e.g., risk/benefit analysis, cost/benefit analysis).

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- conduct investigations into relationships between and among observable variables and use a broad range of tools and techniques to gather and record data and information by
  - designing and performing an experiment to demonstrate the effect of environmental factors on population growth.

Physics 20

Attitude Outcomes: Safety

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities, e.g.,
  - consider safety a positive limiting factor in scientific and technological endeavours,
  - keep the workstation uncluttered, with only appropriate laboratory materials present,
  - treat equipment with respect.

Unit A: Kinematics

General Outcome 1: Describe motion in terms of displacement, time, velocity and acceleration.

Outcomes for Knowledge

Students will:

- define, qualitatively and quantitatively, displacement, velocity and acceleration.
- interpret, quantitatively, the motion of one object relative to another using displacement and velocity vectors.

Outcomes for Science, Technology and Society (Emphasis on the Nature of Science)

Students will:

- explain that the goal of science is knowledge about the natural world, e.g.,
  - identify common applications of kinematics

(e.g., determining the average speed of a run, bike ride or car trip, the acceleration required to launch an aircraft from a carrier).

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information by
  - performing an experiment to demonstrate the relationships among acceleration displacement, velocity and time using available technologies (e.g., interval timers, photo gates),
  - performing an experiment to determine the local value of acceleration due to gravity.

Unit B: Dynamics

General Outcome 1: Explain the effects of balanced and unbalanced forces on position and velocity.

Outcomes for Knowledge

Students will:

- apply Newton's second law of motion to explain, qualitatively, the relationships among net force, mass and acceleration.
- apply Newton's third law of motion to interactions between two objects, recognizing that the two forces, equal in magnitude and opposite in direction, act on different bodies.

Outcomes for Science, Technology and Society (Emphasis on Social and Environmental Contexts)

Students will:

- explain that science and technology are developed to meet societal needs and that society provides direction for scientific and technological development (e.g., the use of seatbelts in school buses).

Skills Outcomes (Focus on Problem Solving)

Students will:

- conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information by
  - conducting experiments to determine relationships among acceleration, force and mass using available technologies (e.g., using interval timers to gather data).

General Outcome 2: Explain that gravitational effects extend throughout the Universe.

Outcomes for Knowledge

Students will:

- identify the gravitational force as one of the fundamental forces in nature.
- describe, qualitatively and quantitatively, Newton's law of universal gravitation.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- conduct investigations into relationships among observable variables, and use a broad range of tools and techniques to gather and record data and information by
  - determining, empirically, the local value of acceleration due to gravity.

Unit C: Periodic Motion

General Outcome 1: Describe the conditions that produce periodic motion.

Outcomes for Knowledge

Students will:

- explain, quantitatively, the relationships among displacement, acceleration, velocity and time for simple harmonic motion as illustrated by a frictionless horizontal mass-spring system or a pendulum, using the small angle approximation.

- explain, qualitatively, the relationships among kinetic, potential and total mechanical energies of a mass executing simple harmonic motion.
- describe wave motion in terms of the simple harmonic motion of particles.

Outcomes for Science, Technology and Society (Emphasis on the Nature of Science)

Students will:

- explain that the goal of science is knowledge about the natural world by
  - analyzing, qualitatively, the forces in real-life examples of simple harmonic motion (e.g., action of springs in vehicle suspensions; mechanical resonance in cars, bridges and buildings; seismic waves in the Earth's crust).

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
  - designing an experiment to demonstrate that simple harmonic motion can be observed within certain limits and relating the frequency and period of the motion to the physical characteristics of the system (e.g., a frictionless horizontal mass-spring system or a pendulum),
  - predicting and verifying the conditions required for mechanical resonance.
- conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by
  - performing an experiment to determine the relationship between the length of a pendulum and its period of oscillation.
  - performing an experiment to illustrate the phenomenon of mechanical resonance.

- performing an experiment to determine the spring constant of a spring.

General Outcome 2: Explain circular motion using Newton's laws of motion.

Outcomes for Knowledge

Students will:

- describe uniform circular motion as a special case of two-dimensional motion.
- explain, quantitatively, the relationships among speed, frequency, period and radius for circular motion.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by net force acting on an object in uniform circular motion and the objects' frequency, mass, speed
  - performing an experiment to investigate the relationships among net force acting on an object in uniform circular motion and the object's frequency, mass, speed, and path radius.

Unit D: Conservation of Energy

General Outcome 1: Explain that work is a transfer of energy and that conservation of energy in an isolated system is a fundamental physical concept.

Outcomes for Knowledge

Students will:

- analyze, quantitatively, the relationships among kinetic, gravitational potential and total mechanical energies of a mass executing simple harmonic motion.
- analyze, quantitatively, kinematics and dynamics problems that relate to the conservation of mechanical energy.

Outcomes for Science, Technology and Society (Emphasis on the Nature of Science)

Students will:

- explain that the products of technology are devices, systems and processes that meet given needs but that these products cannot solve all problems, e.g.,
    - o evaluate the design and efficiency of energy transfer devices in terms of the relationship among mechanical energy, work and power.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
    - o designing an experiment to demonstrate the conservation of energy (e.g., is energy conserved in a collision?).
- conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by
    - o performing an experiment to demonstrate the law of conservation of energy.

General Outcome 2: Explain that waves are a means of transmitting energy.

Outcomes for Knowledge

Students will:

- describe mechanical waves as particles of a medium that are moving in simple harmonic motion.
- describe how the speed of a wave depends on the characteristics of the medium.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by
  - determining the speed of a mechanical wave.
  - performing an experiment to illustrate the phenomenon of acoustical resonance.

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Attitude Outcomes: Safety

Students will be encouraged to:

- show concern for safety in planning, carrying out and reviewing activities, e.g.,
  - consider safety a positive limiting factor in scientific and technological endeavours,
  - keep the workstation uncluttered, with only appropriate laboratory materials present,
  - treat equipment with respect.

Unit A: Momentum and Impulse

General Outcome 1: Explain how momentum is conserved when objects interact in an isolated system.

Outcomes for Knowledge

Students will:

- explain, quantitatively, that momentum is conserved in one- and two-dimensional interactions.

Outcomes for Science, Technology and Society (Emphasis on Science and Technology)

Students will:

- explain that technological problems often lend themselves to multiple solutions that involve different designs, materials and processes and have both intended and unintended consequences.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues
    - designing an experiment and identifying and controlling major variables (e.g., demonstrating the conservation of linear momentum; illustrating the relationship between impulse and change in momentum).
- conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by
    - performing an experiment to demonstrate the law of conservation of linear momentum, using available technologies (e.g., air track, air table, strobe lights and photography).

Unit B: Forces and Fields

General Outcome 1: Explain the behaviour of electric charges at rest using the laws that govern electrical interactions.

Outcomes for Knowledge

Students will:

- compare the methods of transferring charge: friction, conduction and induction.
- explain the distribution of charge on the surfaces of conductors and insulators.
- explain, qualitatively, the principles pertinent to Coulomb's torsion balance experiment.

Outcomes for Science, Technology and Society (Emphasis on the Nature of Science)

Students will:

- explain that concepts, models and theories are often used in interpreting and explaining observations and in predicting future observations, e.g.,
  - explain that the electric model of matter is fundamental to the interpretation of electrical phenomena.
  - explain that charge separation and transfer from one object to another are fundamental electrical processes.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
  - designing an experiment to examine the relationships among magnitude of charge, electric force and separating distance between point charges.
- conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by
  - performing an activity to demonstrate methods of charge separation and transfer,
  - performing an experiment to determine the relationships among magnitude of charge, electric force and separating distance between point charges, using available technologies.

General Outcome 2: Describe electric phenomena using the electric field theory model.

Outcomes for Knowledge

Students will:

- compare forces and fields.
- compare, qualitatively, gravitational potential energy and electric potential energy.

- describe, quantitatively, the motion of an electric charge in a uniform electric field.

Skills Outcomes (Focus on Problem Solving)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
  - evaluating and selecting appropriate procedures and instruments for collecting data and information and for solving problems.
- conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by
  - plotting electric fields, using field lines, for fields induced by discrete point charges, combinations of discrete point charges (similarly and oppositely charged) and charged parallel plates.

General Outcome 3: Explain how the properties of electric and magnetic fields are applied in numerous devices.

Outcomes for Knowledge

Students will:

- compare gravitational, electric and magnetic fields (caused by permanent magnets and moving charges) in terms of their sources and directions.
- describe how the discoveries of Oersted and Faraday form the foundation of the theory relating electricity to magnetism.
- describe, qualitatively, a moving charge as the source of a magnetic field and predict the orientation of the magnetic field from the direction of motion.
- describe, qualitatively, how a uniform magnetic field affects a moving electric charge, using the relationships among charge, motion and field direction.

- describe and explain, qualitatively, the interaction between a magnetic field and a moving charge and between a magnetic field and a current-carrying conductor.
- describe, quantitatively, the effect of an external magnetic field on a current-carrying conductor.

Outcomes for Science, Technology and Society (Emphasis on the Nature of Science)

Students will:

- explain that concepts, models and theories are often used in interpreting and explaining observations and in predicting future observations, e.g.,
  - discuss, qualitatively, Lenz's law in terms of conservation of energy, giving examples of situations where Lenz's law applies.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
  - designing an experiment demonstrating the effect of a uniform magnetic field on a current-carrying conductor,
  - designing an experiment demonstrating the effect of a uniform magnetic field on a moving conductor,
  - designing an experiment demonstrating the effect of a uniform magnetic field on a moving electric charge.
- conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by
  - performing an experiment to demonstrate the effect of a uniform magnetic field on a current-carrying conductor, using the appropriate apparatus effectively and safely,

- performing an experiment to demonstrate the effect of a uniform magnetic field on a moving conductor, using the appropriate apparatus effectively and safely,
- predicting, using the left- and right-hand rules, the relative directions of motion, force and field in electromagnetic interactions.

Unit C: Electromagnetic Radiation

General Outcome 1: Explain the nature and behaviour of electromagnetic radiation using the wave model.

Outcomes for Knowledge

Students will:

- calculate the speed of electromagnetic radiation, given experimental data of various methods employed to measure it.
- describe, quantitatively, the phenomena of reflection and refraction (including total internal reflection).
- describe, quantitatively, simple optical systems consisting of no more than two lenses or one mirror and one lens.
- describe, qualitatively, diffraction, interference and polarization.
- compare and contrast the visible spectra produced by diffraction gratings and triangular prisms.

Outcomes for Science, Technology and Society (Emphasis on the Nature of Science)

Students will:

- explain that scientific knowledge may lead to the development of new technologies and new technologies may lead to scientific discoveries, e.g.,
  - describe measurement procedures for the speed of electromagnetic radiation
  - investigate the design of greenhouses, solar collectors, fibre optics, effects of light on the growth of plants.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
    - predicting the conditions required for diffraction to be observed,
    - predicting the conditions required for total internal reflection to occur.
- conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by
    - performing experiments to demonstrate refraction at plane and uniformly curved surfaces,
    - performing an experiment to determine the index of refraction of several different substances,
    - carrying out an investigation to determine the focal length of a thin lens or of a curved mirror,
    - observing the visible spectra formed by diffraction gratings and triangular prisms,
    - performing an experiment to determine the wavelength of a light source in air or in a liquid using a double-slit or a diffraction grating,
    - performing an experiment to verify the effects on an interference pattern due to changes in any one or more of the following variables: wavelength, slit separation or screen distance.

General Outcome 2: Explain why the photoelectric effect requires the adoption of the photon model of light.

Outcomes for Knowledge

Students will:

- describe the photoelectric effect in terms of the intensity and wavelength of the incident light and surface material.

- describe, quantitatively, photoelectric emission using concepts related to the conservation of energy.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
  - designing an experiment to measure Planck's constant, using either a photovoltaic cell or a light-emitting diode.
- conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by
  - performing an experiment to demonstrate the photoelectric effect,
  - measuring Planck's constant, using either a photovoltaic cell or a light –emitting diode.

Unit D: Atomic Physics

General Outcome 1: Describe the electric nature of the atom.

Outcomes for Knowledge

Students will:

- explain Millikan's oil drop experiment and its significance relative to charge quantization.

Outcomes for Science, Technology and Society (Emphasis on the Nature of Science)

Students will:

- explain that scientific knowledge may lead to the development of new technologies and new technologies may lead to scientific discoveries, e.g.,
  - analyze the operation of cathode-ray tubes and mass spectrometers.

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- ask questions about observed relationships and plan investigations of questions, ideas, problems and issues by
  - evaluating and selecting appropriate procedures and instruments for collecting evidence and information, including appropriate sample procedures (e.g., using electric and magnetic fields to determine the charge-to-mass ratio of the electron).
- conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by
  - performing an experiment, or using simulations, to determine the charge-to-mass ratio of the electron.

General Outcome 2: Relate energy levels in nature to support modern atomic and nuclear theory.

Outcomes for Knowledge

Students will:

- describe that each element has a unique line spectrum.
- explain, qualitatively, the characteristics of and the conditions necessary to produce continuous, line emission and line absorption spectra.
- calculate the energy difference between states, using the observed characteristics of an emitted photon.

Outcomes for Science, Technology and Society (Emphasis on the Nature of Science)

Students will:

- explain that scientific knowledge may lead to the development of new technologies and new technologies may lead to scientific discoveries, e.g.,
  - investigate and report on the application of spectral or quantum concepts in the design and functioning of a practical device such as street lights, advertising signs, electron microscopes, lasers).

Skills Outcomes (Focus on Scientific Inquiry)

Students will:

- conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information by
  - observing line emission and line absorption spectra.
  - observing the representative line spectra of selected elements.

Part B: Examining the Teaching Quality Standards and Science Safety

The Teaching Quality Standard applies to all teachers who hold interim or permanent professional certificates. Teachers, in the first two years of their career, are under a separate set of Knowledge, Skills, and Attributes (KSA's) as they possess an interim professional certificate. Once teachers have been granted a permanent professional certificate, a second set of KSA's applies.

For the purpose of this study, both sets of KSA's will be included. As careers change and evolve, teachers are expected to direct their professional development so that pedagogical skills may be applied to optimize student learning. The Provincial Science Safety Resource is a document that will have both professional and pedagogical impacts. By examining KSA's, opportunities for growth can be identified and teaching and learning can be enhanced.

Teachers with Interim Professional Certificates

Supervisors and evaluators are directly involved with the professional development of beginning teachers. Below are the key KSA's that can be linked to professional development initiatives in science safety. Each KSA is written and an explanation follows.

As situations warrant, teachers who hold an Interim Professional Certificate are expected to demonstrate consistently that they understand:

a) contextual variables affect teaching and learning. They know how to analyze may variables at one time, and how to respond by

making reasoned decisions about their teaching practice and students' learning.

Beginning science teachers interacting with the curriculum (often for the first time) are conducting science activities and labs. Safety is a professional responsibility where making reasoned decisions is essential. The Provincial Science Safety Resource, as an adopted curriculum support reference, will help teachers in understanding their responsibilities and give them direction and confidence to pursue scientific investigations in the classroom or laboratory. Safety, as a "contextual variable" affecting teaching and learning, is unquestionably important and must be included in professional development and evaluation.

As situations warrant, teachers who hold an Interim Professional Certificate are expected to demonstrate consistently that they understand:

c) the purposes of the Guide to Education and programs of study germane to the specialization of subject disciplines they are prepared to teach. They know how to use these documents to inform and direct their planning, instruction and assessment of student progress.

d) the subject disciplines they teach. They have completed a structured program of studies through which they acquired the knowledge, concepts, methodologies and assumptions in one or more areas of specialization or subject disciplines taught in Alberta schools.

KSA's 'C' and 'D' have been put together because they both make reference to the Program of Studies. This has also been the starting point for identifying professional development opportunities in this paper. Science teachers are subject specialists and teacher planning and instruction must follow the Program of Studies. Laboratory investigations and safety are clearly referenced in curriculum documents for all grades. Professional development on safety is part of acquiring the knowledge, concepts and methodologies required to teach science. Understanding and demonstrating safety in science is part of this subject's discipline. Science teachers are expected to bring forward their knowledge of the Program of Studies from their teacher education experiences and apply it to both teaching and learning.

As situations warrant, teachers who hold an Interim Professional Certificate are expected to demonstrate consistently that they understand:

e) all students can learn, albeit at different rates and in different ways. They know how (including when and how to engage others) to identify different learning styles and ways students learn. They understand the need to respond to differences by creating multiple paths to learning of individuals and groups of students, including students with special learning needs.

Creating multiple paths for learning is essential so that all students can learn. Science, as a subject area, has many ways of achieving this. Laboratory investigations and science inquiry activities present different learning styles and ways students can be engaged. by involving teachers in professional development initiatives on science safety they can explore and grow in the multiplicity of instructional strategies that can be used to cultivate teaching and learning. Safe laboratory activities clearly move beginning teachers into realizing and demonstrating this KSA.

As situations warrant, teachers who hold an Interim Professional Certificate are expected to demonstrate consistently that they understand:

f) the purposes of short, medium and long term range planning. They know how to translate curriculum and desired outcomes into reasoned, meaningful and incrementally progressive learning opportunities for students. They also understand the need to vary their plans to accommodate individuals and groups of students.

Short, medium and long term planning brings organization to teaching and learning. Curriculum outcomes are fully realized when planning guides instruction. In science, outcomes where students are required to conduct science activities and investigations can be realized as careful planning incorporates safe inquiry processes. Specific attitude outcomes for safety can be achieved when planning and professional development on the Provincial Science Safety Resource can be brought together.

As situations warrant, teachers who hold an Interim Professional Certificate are expected to demonstrate consistently that they understand:

> **i) there are many approaches to teaching and learning. They know a broad range of instructional strategies appropriate to their area of specialization and the subject discipline they teach, and know which strategies are appropriate to help different students achieve different outcomes.**

This KSA focuses on beginning teachers knowing a broad range of instructional strategies appropriate to their subject discipline. The position being put forward in this paper is that professional development in science safety is required for the full range of instructional strategies available to science teachers. . Decisions on safety must be made before strategies can be seen as "appropriate". By understanding safety and utilizing the provincial resource, teachers can move towards the requirements of this KSA. This also ensures that teachers will serve as "safety role models", thereby enabling students to fully achieve Science, Technology and Society (STS); Knowledge, Skills and Attitude Outcomes.

As situations warrant, teachers who hold an Interim Professional Certificate are expected to demonstrate consistently that they understand:

> **k) the purposes of student assessment. They know how to assess the range of learning objectives by selecting and developing a variety of classroom and large scale assessment techniques and instruments. They know how to analyze the results of classroom and large scale assessment instruments including provincial assessment instruments, and how to use the results for the ultimate benefit of students.**

Student assessment in science using a variety of techniques and instruments can be enriched through safety and attitude outcomes related to safety can be assessed in the classroom. Rubrics should include safety components when doing investigations in the lab and safety questions can be placed on unit exams. By providing professional development on science safety, schools and school divisions create opportunities for advancing assessment. Many scientific skills related to skill outcomes can be evaluated by using safety as part of the performance assessment.

As situations warrant, teachers who hold an Interim Professional Certificate are expected to demonstrate consistently that they understand:

> **o) the importance of career-long learning. They know how to assess their own teaching and how to work with others responsible for supervising and evaluating teachers. They know how to use the findings of assessments, supervision and evaluations to select, develop and implement their own professional development activities.**

Career-long learning through professional development is essential to this KSA and the Teaching Quality Standard. As a new curriculum support document, the Provincial Science Safety Resource is as important as Guides to Education and the Program of Studies. Supervision and evaluation should examine a teacher's interaction with this document and, where necessary, ongoing professional development in this area should be considered a component of a science teacher's career-long learning.

As situations warrant, teachers who hold an Interim Professional Certificate are expected to demonstrate consistently that they understand:

> **p) the importance of guiding their actions with a personal, overall vision of the purpose of teaching. They are able to communicate their vision, including how it has changed as a result of new knowledge, understanding and experience.**

Safety, as outlined in the Program of Studies, is part of the overall vision and purpose of science education. Teachers who demonstrate their knowledge, understanding and experience in science use safety to guide their actions. As part of an overall vision and purpose of teaching, safety contributes to the way we communicate our personal vision for science teaching and learning. As science teacher progress through their careers, the safe laboratory programs they develop and deliver are a significant part of the way they communicate their vision of science education.

Teachers with Permanent Professional Certificates

Teachers with permanent professional certificates are expected to demonstrate teaching and learning practices that expand upon the interim KSA's already developed. This section will reference three more detailed KSA's and build upon the previous understandings already outlined. As KSA's from this part overlap with the interim section, only the extended portion will be identified and commented on.

a) Teachers' application of pedagogical knowledge, skills and attributes is based in their ongoing analysis of contextual variables. Teachers' analysis of contextual variables underlies their reasoned judgments and decisions about which specific pedagogical skills and abilities to apply in order that students can achieve optimum learning.

- **Student variables**
  - **subject area of study**
  - **prior learning**
- **School variables**
  - **resource availability and allocation**
  - **teaching assignment**
  - **physical plant**
- **Regulatory variables**
  - **School Act and provincial regulations; policies and Ministerial Orders**
  - **school authority policies**
  - **Guide to Education**
  - **Programs of Study**
- **Teacher variables**
  - **teaching experience**
  - **learning experiences.**

Experienced teachers are expected to be able to analyze contextual variables when making reasoned judgments and decisions. Safety, as a pedagogical skill, can be used to help students achieve optimum learning. By considering student, regulatory, school, and teacher variables in the context of science safety, teachers will be able to further demonstrate the requirements of this KSA. Being aware of a student's prior learning (through an understanding of Guides to Education and the Programs of Studies) teachers are expected to combine an expanded knowledge on the School Act, provincial regulation (legislation), Ministerial Orders, and provincial and school district policies to enhance learning. Professional development on the Provincial Science Safety Resource addresses many of these variables and extends them. As a result, teachers should be able to look at their specific school and teacher variables to make sound pedagogical judgments and decisions.

b) Teachers understand the legislated, moral and ethical frameworks within which they work. Teachers also function within a policy-based and results oriented education system authorized under the School Act and other legislation. Teachers also function within policy frameworks established by school authorities. This includes policies which require: a commitment to teaching practices that meet their school authority's teaching quality standards(s); and that teachers engage in ongoing, individual professional development.

Teachers recognize they are bound by standards of conduct expected of a caring, knowledgeable and reasonable adult who in entrusted with the custody, care or education of students or children. Teachers recognize their actions are bound in moral, ethical and legal considerations regarding their obligations to students, parents, administrators, school authorities, communities and society at large. Teachers acknowledge these obligations and act accordingly.

The Provincial Science Safety Resource, as an adopted curriculum support document, will effectively be a legislated, policy based resource. Teachers are obligated to recognize that their actions must take into account the moral, ethical and legal considerations associated with this initiative. Science teachers are held to a higher standard of conduct and safety is an essential component of that conduct. In meeting the requirements of this KSA, it would be reasonable to expect that science safety would be part of a teacher's ongoing and individualized professional development. (It is important to note that school boards are legislatively required to provide ongoing safety education and teachers are required to participate in these programs.)

f) Teachers create and maintain environments that are conducive to student learning. Teachers establish learning environment wherein students feel physically, psychologically, socially and culturally secure. They are respectful of students' human dignity, and seek to establish a positive professional relationship with students that is characterized by mutual respect, trust and harmony. They model the beliefs, principles, values, and intellectual characteristics outlined in the Guide to Education and programs of study, and guide students to do the same.

Teachers work, independently and cooperatively, to make their classrooms and schools stimulating learning environments. They maintain acceptable levels of student conduct, and use discipline strategies that result in a positive environment conducive to student learning. They work with students to establish classroom routines that enhance and increase students' involvement in meaningful learning activities. They organize facilities, materials, equipment and space to provide students equitable opportunities to learn, and to provide for students' safety.

Modeling safety during all science classroom and laboratory activities demonstrates the principles, values and intellectual characteristics outlined in the Guide to Education and science programs of study. A student's safety is specifically referenced in this KSA and science teachers are expected to organize their facilities, materials, equipment and space so that opportunities to learn can be realized. Many parts of the safety resource are designed to help teachers with this KSA. Professional development in this area is part of a teacher's cooperative contribution to create and maintain stimulating learning environments in their classrooms and school. It is reasonable to expect that safety be used as a guide for student conduct and discipline and that a safely run classroom and laboratory program demonstrate (in part) the achievement of this KSA.

The Teaching Quality Standard with its appropriate KSA's outlines the requirements that teachers are expected to demonstrate in Alberta. As indicated, knowledge in the area of safety is an essential part of an overall pedagogical approach to realizing the goals of science education. By linking the Program of Studies to the Teaching Quality Standard, the objective is to illustrate how teaching and learning are so intricately connected. Science teachers who meet the quality standard are modeling safety in their laboratories and classrooms. Students are expected to achieve attitude outcomes and learn to demonstrate safe practices themselves. Optimal learning and science education can be advanced as professional development in safety contributes to teacher growth and student achievement.

Part C: Examining the Teacher Growth, Supervision and Evaluation Policy in Alberta

The Teaching Quality Standard and its related KSA's are central to teacher growth, supervision and evaluation. Accountability in education involves ensuring that optimal learning is achieved when the standard is met. A teacher's actions, judgment and decisions must always be made with the students' best interests in mind. Through this policy, a collaborative approach is adopted towards growth, supervision and evaluation. Teachers are expected to demonstrate the standard and school authorities, superintendents, and principals are to work with teachers to continually achieve the standard.

Teacher Growth

Annually, a teacher is required to complete a Professional Growth Plan. The plan must: **(i) reflect goals and objectives based on an assessment of learning needs by the individual teacher**

(ii) show a demonstrable relationship to the teaching quality standard, and

(iii) take into consideration the education plans of the school, the school authority and the government, or the program statement of an ECS operator.

In part (i), the individual teacher's learning needs in the areas of science safety and the conducting of laboratory activities could be identified. The Program of Studies would be helpful in referencing learner outcomes within particular courses that a teacher may want to work on. Specific goals and objectives could be listed depending on a teacher's unique requirements.

Part (ii) requires that a teacher demonstrate that there is a relationship between the area of growth and the Teaching Quality Standard. Teachers could use any or all of the relationships developed in the previous section of this paper. By examining science safety and the individual KSA's of the Teaching Quality Standard, cross referencing this information into a professional growth plan should be more apparent.

Each school district's teacher growth, supervision and evaluation policy sets out the number of goals that must be identified in a teacher's professional growth plan. Usually a minimum of three are required. The goals must take into consideration the education plans of the school, school district, and the government as outlined in part (iii). This is a critical component as there are many areas that a growth plan could address. If the government placed professional development in the area of science safety directly into its three year business plan, science teachers could be able to identify it as a high priority in their own growth plans. This does not preclude that individual school districts and schools could affect the same result by inserting this initiative in their respective three year plans and identifying it as a goal for science educators.

Section 4 of the policy states that:

> **An annual teacher professional growth plan:**
>
> **(a) may be a component of a long-term, multi-year plan; and**
>
> **(b) may consist of a planned program of supervising a student teacher or mentoring a teacher.**

Some teachers may want to adopt a long-term, multi-year approach to science safety. This could be combined with a progressive safety program where other activities, such as developing a detailed inventory of chemicals and the conducting of a toxic round up, could be done over time. Also, as the senior high science program is changing in Alberta, a multi-year approach to safety as it relates to instruction and laboratory activities may be appropriate.

Supervising a student teacher or mentoring a beginning teacher with a planned science program that includes components of safety and laboratory instruction is an opportunity often not taken advantage of. A collaborative approach would bring together experienced science teachers and beginning teachers to share instructional strategies and methodologies. Professional development opportunities, where in-servicing is provided on science safety, could be extended through mentoring initiatives and a progressive transition to enhanced teaching and learning may be accomplished.

It is important to note that the government (through the Department of Education) in conjunction with school districts and individual schools must provide professional development in-servicing opportunities in order to fully realize science safety initiatives. Provincial in-servicing sessions, district and school P.D. days, specialist council conferences, and teacher convention sessions are some of the ways that the science safety objectives in a professional growth plan cold be achieved.

If a teacher agrees, safety initiatives in a professional growth plan could be part of an evaluation process. Some science teachers may wish to take advantage of this and target safety within their own practice and laboratory programs. Many dimensions of safety could be evaluated and both teacher and student growth could be documented through successive formative and summative evaluations. Administrators may benefit from this approach as well since science teachers possess the situational, curricular and pedagogical knowledge to assist them in interpreting many of the implications of this provincial resource.

Teacher Supervision

A fundamental component of the policy must be ongoing supervision of teachers by the principal, including:

(a) providing support and guidance to teachers;

(b) observing and receiving information from any source about the quality of teaching a teacher provides to students; and

(c) identifying the behaviours or practices of a teacher that for any reason may require an evaluation.

As the educational leader of the school, the principal, under the authority of the School Act, is responsible for ensuring that the Teaching Quality Standard is being met.

By providing support and guidance to teachers, administrators play a dual role in science safety. They must demonstrate leadership by: ensuring that teachers have the necessary opportunities to achieve their professional growth plan goals, assisting in the interpreting of the implications of the new provincial resource, and providing ongoing supervision. For this reason, all principals should be in-serviced on science safety. Other legislative requirements identify the principal as the person for developing an emergency response plan for the school. Administrators need to be informed matters of: legal liability, insurance, employer and employee responsibilities and procedures for monitoring and compliance. As a result, the professional development they receive will focus on different perspectives related to science safety. Within the context of their own administrator professional growth plans, initiatives on safety are clearly required. With an in-depth understanding on these issues, a principal can, effectively, provide guidance and support, observe and evaluate information about science teaching and learning, and identify behaviors and practices that may require evaluation.

It is important to note that support for administrators on science safety enables them to carry out their professional responsibilities. District policies may provide clarity on these issues and in-servicing through regular administrator meetings and conferences such as Blueprints (a major professional development opportunity for administrators) is necessary. The cross referencing on the Program of Studies and the Teaching Quality Standard KSA's (completed in earlier sections) would also be beneficial to administrators.

Teacher Evaluation

Evaluations can be requested by a teacher or conducted by district administrators (usually the principal) for:

- gathering information related to specific employment decisions,
- assessing growth in a specific areas of a teacher's practice, and
- reasons to determine whether or not a teacher is meeting the Teacher Quality Standard.

Teachers on an interim professional certificate are required to be formally evaluated at least twice before they can be recommended for their permanent professional teaching certificate.

As science safety informs teaching and learning, the evaluation of a science teacher and the instruction he/she provides should also include an emphasis on how safety is modeled and demonstrated. Specific KSA's can serve as a framework for the assessment, and links to the Program of Studies can provide insights on components of evaluation. A teacher's laboratory and classroom activities provide a basis of information that can be used in the evaluation process. This is particularly crucial since the new Provincial Science Safety Resource will identify specific areas of growth that should be assessed throughout the coming years and beyond.

All three areas of growth, supervision and evaluation can be enhanced through professional development on science safety. Student learning and achievement are acknowledged when safe science activities and laboratory investigations are conducted by teachers and both supervised and evaluated by administrators. The goals of a science education embedded in the outcomes of the Programs of Study are realized when a collaborative approach to assessment is adopted and supported through professional development.

Conclusion

Cultivating safety involves all those connected to science education. Opportunities exist to merge professional development with the: Program of Studies, the Teaching Quality Standard, and the Provincial Policy on Teacher Growth, Supervision and Evaluation. Improved student learning can be achieved as curriculum outcomes and the goals of science education are fulfilled through the delivery of safe classroom and laboratory activities. By adopting a pedagogical approach to safety, teachers model and students learn a pervasive attitude about the importance of safe practices. Pre-service teacher education programs build a foundation that can be extended to in-service teachers as they enter the classroom and collaboratively work with other teachers and administrators. All levels of education can participate in the designing, delivery and implementation of professional development programs so that optimal teaching and learning can guide Alberta's students as they explore the nature of science and the relationships between science, technology and society.

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Appendix B

A Quick Guide to Legislation

School Act

Students	Section 12
Teachers	Section 18
Principals	Section 20
Inspections	Section 43
Responsibilities to Students	Section 45
Emergency Closure of School Buildings	Section 57
Powers of Boards	Section 60
Delegation of Power	Section 61
Superintendent of Schools	Section 113

Teaching Profession Act

Powers	Section 4
Unprofessional Conduct	Section 23

Labour Relations Code

Inquiries, Investigations and Inspections	Section 13

Environmental Protection and Enhancement Act

Certificate of Qualification Required	Section 79
Prohibited Release Where No Approval or Regulation	Section 109
Duty to Report Release	Section 110
Manner of Reporting	Section 111
Duty to Take Remedial Measures	Section 112
Identification Number Required for Hazardous Waste	Section 188
Investigations and Inspections	Sections 195 – 206
Due Diligence Defence	Section 229

Water Act

Emergency Measures	Section 105

Hazardous Products Act

Part II Controlled Products Prohibition Re: Sale	Sections 13 - 16

Part II Canada Labour Code Amendment

Section 3 (1)	(Amendment to Subsection 12 (1) of the Canada Labour Code)
Section 5	(Amendment to add Subsection 125.1 & 125.2 of the Canada Labour Code)

Occupational Health and Safety Regulation and Code

Duty of Employers	Section 5
Direction and Instruction of Workers	Section 6
Duties of Workers	Section 7
Worker Training	Section 8
Part 3 First Aid	
Employer Responsibilities	Section 16
Location of First Aid Services, Equipment, Supplies	Section 19
Duty to Report Accident, Illness	Section 23
Record of Accident, Illness	Section 24
Part 4 Hazard Assessment, Elimination and Control	
Hazard Assessment	Section 29
Hierarchy of Elimination and Control	Section 30
Part 6 Chemical Hazards, Biological Hazards and Harmful Substances	
Worker Exposure to Harmful Substances	Section 39
Assessing Exposure to Harmful Substance	Section 43
Worker Exposed to a Harmful Substance	Section 44
Skin and Eye Protection	Section 46

Availability of Material Safety Data Sheets	Section 415
Information to Medical Professional	Section 420

Dangerous Goods Transportation and Handling Act

Powers of Inspectors – Generally	Section 7
Prohibitions as to Handling, Offering or Transporting Goods	Section 19
Defence	Section 24
Schedule	Section 1 (c)

The Alberta Building Code

Materials, Appliances, Systems and Equipment	Section 2.4.
Occupant Load	Section 3.1.16.
Fire Alarm and Detection Systems	Section 3.2.4.
Provisions for Fire Fighting	Section 3.2.5.
Lighting and Emergency Power Systems	Section 3.2.7.
Safety Within Floor Areas	Section 3.3.
Ventilation	Section 6.2.2.

The Alberta Fire Code

General	Section 1.1.
Fire Hazards	Section 2.4.
Fire Drills	Section 2.8.3.
Indoor and Outdoor Storage	Part 3
Indoor Storage	Section 3.2.
Ventilation	Section 4.1.7.
Container Storage and Handling	Section 4.2.
Laboratories	Section 5.7.
Fire Protection Equipment	Part 6

Appendix C

Science Safety: Examining Issues

Please provide a response for each statement by checking the appropriate box using the following as a guideline: **SD** (strongly disagree), **D** (disagree), **N** (neutral), **A** (agree), **SA** (strongly agree).

Statement		SD	D	N	A	SA
1. There is a need to improve science safety in Alberta's schools.		☐	☐	☐	☐	☐
2. Classroom practice and science instruction will be enhanced through professional development on science safety.		☐	☐	☐	☐	☐
3. Science safety is an essential component for student learning.		☐	☐	☐	☐	☐
4. Adequate information on science safety is available to administrators and teachers.		☐	☐	☐	☐	☐
5. Employers and employees are aware of their legislated responsibilities in the area of science safety; specifically:	a) School board trustees	☐	☐	☐	☐	☐
	b) Superintendents	☐	☐	☐	☐	☐
	c) Administrators	☐	☐	☐	☐	☐
	d) Science teachers	☐	☐	☐	☐	☐
	e) Teacher aides	☐	☐	☐	☐	☐
	f) Laboratory technicians	☐	☐	☐	☐	☐
6. Policy development related to science safety is needed in Alberta's school divisions.		☐	☐	☐	☐	☐
7. Schools can improve science safety in the following areas:	a) inventory control	☐	☐	☐	☐	☐
	b) waste management	☐	☐	☐	☐	☐
	c) waste disposal	☐	☐	☐	☐	☐
	d) use of alternative chemicals	☐	☐	☐	☐	☐
8. Professional development on science safety is required for:	a) School board trustees	☐	☐	☐	☐	☐
	b) Superintendents	☐	☐	☐	☐	☐
	c) Administrators	☐	☐	☐	☐	☐
	d) Science teachers	☐	☐	☐	☐	☐
	e) Teacher aides	☐	☐	☐	☐	☐
	f) Laboratory technicians	☐	☐	☐	☐	☐

Illustration 8: Science Safety Survey (Likert Scale)

Science Safety: Examining Issues

For each of the following educational levels, identify three ways in which the demonstration of due diligence, in the area of science safety, could be improved. Please rank these areas of improvement indicating 1 as your highest priority.

School Board/Trustees

Superintendent/Central Office Admin.

School Administrators

Science Teachers

Science Support Staff (Teacher Aides)

Laboratory Technicians

Illustration 9: Science Safety Questionnaire, Examining Issues (Due Diligence)

Science Safety: Examining Issues

Identify areas of science safety that you would describe as exemplary current practices. Please elaborate.

How safe are our current practices? Identify areas of science safety that are in need of improvement.

Illustration 10: Science Safety Questionnaire, Examining Issues (Exemplary current practices and areas in need of improvement)

Science Safety: Examining Issues

How can professional development on science safety be structured for each of the following groups.

Include: **-a planning model (time frame),**

-a list of topics that would be addressed, and

-a list of resources that would be used or required.

School Board/Trustees

Administrators

Science Teachers

Teacher Aides

Laboratory Technicians

Illustration 11: Science Safety Questionnaire, Examining Issues (Professional Development)