JUNIOR SCIENCE FOR GENERAL EDUCATION

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ABSTRACT

The focus of this project is the development of a unit of study in Science for junior students (ages 9-11), in the Elementary School and the assessment of its implementation. The actual participants in the programme were students at the grade five level.

There are two areas of student learning that have been identified as significant in science education: the cognitive-process skills, and the communicative skills. Through application and assessment of the proposed programme, "Junior Science For General Education", it was discovered that active "hands-on" participation resulted in an increased capacity for problem solving.

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INTRODUCTION

Science education has been a major concern of the Ontario Ministry of Education throughout the last decade. In the mid-seventies, the Ministry published the report, Pl Jl: The Formative Years. This report provided important directives on teaching science at the elementary level. Subsequent literature from the Ontario Ministry of Education has probed such aspects as the value of science, the general goals of education, the role of science, and the appropriate methodology.

With a few exceptions, such as the Canadian Science Council (1984) reports, empirical research on teaching science at the elementary level has been noticeably lacking. In addition, the absence of effective teacher training has diminished the teachers' confidence towards this subject.

Keeping these problems in mind, the primary concern of the project, "Junior Science For General Education" is to demonstrate that a science programme promotes certain valuable student knowledge that fulfills the general educational goals. As a result, the author created a science curriculum which emphasized both cognitive-process skills and social interaction skills, skills which enhance the pupils' awareness of the world around them.

The text which follows is comprised of five chapters. The initial two chapters deal with the educational concerns of teaching elementary science. Chapter One outlines some of the influences which were instrumental in the development ot the programme. This includes a short synopsis of the field-study research which was conducted to discern the attitudes of several elementary teachers and students towards the subject of science. Chapter Two highlights the theoretical basis which influenced the programme design.

Chapter Three provides a detailed account of the actual implementation of the "Junior Science For General Education" programme itself, a unit tested in a grade five classroom in Hamilton. The specific objectives, lesson content, resources and activities are included in the manuscript.

The last two chapters contain an assessment of the programme. Chapter Four describes an evaluation of the programme as it was being implemented by the author, while Chapter Five, the final chapter, advances ideas for extended activities, before arriving at some general recommendations and conclusions.

CHAPTER I

THE PLACEMENT OF SCIENCE IN EDUCATION

Young children are naturally curious about the world they inhabit. To realize this, one need only listen to the persistent questions of any three year old. Glenn O. Blough and J. Schwartz (1968) postulate that when children come to school they deserve to encounter an environment in which their natural sense of wonder and curiosity are nurtured. While attending school, this inquisitiveness should be channelled to fields about which the youngsters are unfamiliar, in order to expand the parameters of their knowledge. In a tangible way, effective science instruction should build upon the curiosity and sense of wonder inherent to all children.

EDUCATION AND SOCIETY

In the 1960's, several factors drew the attention of the government to the Canadian educational system. Henry Johnson (1968) holds that one such event was the launching of Sputnik by the Soviets. This historic occurrence raised doubts about western science curricula, and eventually these uncertainties resulted in a greater emphasis being placed upon science and mathematics in Canadian schools. At about the same period of time, there was some concern about the importation of skilled labour from European countries. Canadians became worried about their own employment opportunities.

This concern about labour importation eventually led to government action. According to H. Johnson (1968), in 1964, the Economic Council of Canada strongly suggested that the Canadian educational system be able to instruct its students in sophisticated industrial and scientific skills.

It is evident from this brief account, that science curricula have changed in response to the concerns of society. The technical advances of society have underlined the importance of relevant science curricula.

THE GOALS OF EDUCATION AND THE ROLE OF SCIENCE

The Ontario Ministry (1987) document, Science, Intermediate and Senior Divisions makes a case for the primacy of science instruction at the elementary level:

> The characteristics of science and the needs of society indicate that science education should be given high priority in the schooling of all young people. In one way or another practically every vocation, practical or professional, is affected by science (p. 7).

School boards are responsible for assuring that science programmes reflect the goals of the Ministry of Education. They should help "individual learners realize their potential in intellectual, social, emotional, moral, cultural and physical development" (p. 7). The learning opportunities for science should be consistent with the goals of education for the province.

The Ontario Ministry of Education (1987) has established fourteen fundamental aims for all students in the primary and junior divisions. For the sake of brevity, only four of the fourteen priorities will be discussed below, these four having been selected for their particular relevance to the role of science in education. They suggest that students acquire the following attitudes, skills and knowledge:

a) develop a responsiveness to the dynamic processes of learning.

    This responsiveness includes observing, inquiring, analyzing, synthesizing, evaluating and communicating. These appear to be quite ambitious skills for young children, but one must remember that the Ministry always delineates the ideal situation.

    In science, opportunities for student activities which further encourage these priorities are often mandatory. The intrinsically experimental nature of science makes it a particularly suitable vehicle for abetting a dynamic process of learning.

b) acquire the basic knowledge and skills needed to comprehend and express ideas through words, numbers and other symbols.

These skills assist the learner in the identification and solution of problems in a number of ways, including using language as a means of communication, reading and listening with insight, and understanding and applying mathematical concepts.

During science activities, students learn to identify and solve problems while they investigate experimentally. Communicating, reading, listening, thinking, evaluating, and the understanding and use of mathematics are all important aspects of science. Language use and development are an integral part of science education, in that the reporting of observations and the explanations of phenomena are included in the scientific method.

c) develop a feeling of self-worth.

Internally, self-worth is nurtured by realistic self-appraisal, confidence and conviction in the pursuit of excellence, self-discipline and achievement. Externally, it is buttressed by encouragement, respect and supportive evaluation.

Science activities and projects can inspire confidence and satisfaction. Students are encouraged ot perform work with their hands as well as their minds. Hence, they can find satisfaction by exercising both their physical and intellectual skills.

d) develop a sense of personal responsibility in society at the local, national and international level.

Awareness of responsibility grows out of knowledge and understanding of one's community, one's country and the rest of the world. It is based on a respect for the law, the rights of others and a concern for the quality of life. Matters related to scientific issues such as pollution, nutrition, safety, and animal and plant care effectively help students realize the responsibility of individuals, communities and governments.

This summary has outlined several priorities of general education and their corresponding relationship to science instruction. The entire fourteen objectives of education are delineated and explained in a similar manner in the Ministry (1987) document, Science, Intermediate and Senior Divisions. From the above brief account, the case for using science to fulfill the educational goals appears valid.

Science covers the communications skills of speaking, reading, writing, and understanding. The essence of science itself involves "questions, discoveries, interpretations, applications, implications and more questions" (Ministry, 1987, p. 6). Also, its experimental nature demands that children use their five senses to observe any changes in their environment. An added bonus is that the children enjoy the manual manipulation of the equipment. As a result, they are motivated to "learn by doing", by being actively engaged in enjoyable activities.

Thus, the basic "3 R's" are developed through science education. Many mathematical concepts are also used when compiling data and organizing it into chart form. In addition, the use of small-group activities provide ample opportunities for children to develop such social skills as co-operation, compromise and communication; skills that are generally required for successful daily interaction.

THE AIMS OF SCIENCE CURRICULA

In teaching the Science curriculum, the teacher is faced with the problem of blending content with context. Although scientific knowledge may change constantly, the investigative process or inquiry model still remains the consistent means for developing basic scientific thinking skills. This is science. Ultimately, students should realize that science develops logically and continuously, from a broad overview to a progressively specialized way of analyzing the world.

Science is not merely scientific knowledge - it is a process that can lead to knowledge. For example, the alchemists believed lead could be changed into gold, but they gained that information through tradition and superstition. Today, chemists also believe that lead can be transformed into gold, but this knowledge is based on scientific experimentation. The knowledge is the same, but the processes by which it is obtained are different. According to Thomas Kuhn (1962), the major leaps in scientific thinking are achieved through inspired "guesswork" or intuitive leaps, framed upon the knowledge already available. The "scientific method" is used merely to flush out the details. Thus, luck, imagination and creativity are crucial to the development of science, as this is where the "hypotheses" originate. Proving or disproving them is relatively routine for a scientist.

In the Primary and Junior Divisions, the scientific method must be emphasized out of necessity. Any pupil "discoveries" will be new only in the eyes of the young learners. The Ministry (1987) directives suggest that the focus of science education is to have students "appreciate, understand, and relate to the science and technology in the world around them" (p. 8). Through each learning opportunity, the learners develop the ability to evaluate and make judgments about their lives and the environment. According to the Ministry (1987), they "develop the ability to manage their own lives, an acceptable attitude towards the world of work, and an understanding of the nature of science" (p. 10).

Science education then, is valuable for the individual student who feels the excitement of gaining scientific expertise and the satisfaction of knowing how to use scientific knowledge in understanding their world. The greater comprehension of their environment offers an intellectual satisfaction, while the children's natural curiosity is enhanced to include previously unknown knowledge.

ONTARIO MINISTRY GUIDELINES

During the last decade, there has been a shift in emphasis in the Ontario Ministry of Education's directives for science education at the elementary level. Previous Ministry of Education documents, emphasizing the importance of this subject have met with limited success. The value of science was first introduced in the early seventies with the document entitled The Formative Years (1975). This orientation was stated in Science in the Primary and Junior Divisions (1983) and again reiterated with Shared Discoveries: Teaching and Learning in the Primary Years (1985).

The major difference between the current guidelines and the earlier directives lies in the emphatic use of the verb forms. Contrary to earlier documents, it is no longer the case that the Board or teacher **"may"** provide science education. According to the Ministry's (1986) policy, the teachers and the Boards **"will"** provide students with activities and experiences to develop scientific attitudes, skills and concepts. More recently, in 1987, The Ministry put forth a new draft entitled Science Is Happening; A Policy Statement in the Primary and Junior Divisions, a document which places science education as a priority for the province of Ontario.

The increased number of Ministry publications within the last five years demonstrates the shift in Ministry priorities. The fact that there has been a basic document followed by several renewal documents may suggest a problem. The Boards and teachers seem to be having difficulty with implementing the provincial guidelines. There appears to be a need for these governmental reminders. The Ontario Ministry has now mandated the requirement for early science education. Provincial support for science education is evident and the documents are in place. Whether they are neglected or implemented remains in the hands of Ontario Boards, teachers and the public.

The Canadian Council (G. W. F. Orpwood and J. P. Souque, 1984) surveyed a sample of Canadian teachers in an attempt to investigate the practical problems related to science instruction. The findings are illuminating. In the elementary schools and during the first years of high school, the teachers believed that the development of scientific skills, attitudes and social skills were top priorities.

According to the research findings however, the acquisition of scientific content occupied only the sixth or seventh priority position. But, in practice, content was the focal point. Clearly, a discrepancy exists between the teachers' attitudes and practice. Why is this happening?

TEACHERS' ATTITUDE

In an attempt to uncover the cause of this discrepancy and to clarify further the question of science instruction at the junior level, this author approached several junior teachers. An informal dialogue with six classroom teachers (teaching junior science in a homeroom situation) revealed that the majority of these teachers expressed a lack of confidence with the subject. What was the cause of this uneasiness? The feeling was associated with several factors: a weak background in the subject (since there is no science specialist at the elementary level), unfamiliarity with the science programme at a specific grade level, and the lack of support materials at the Board level. The vague guidelines provided by the Ministry and the insufficient curriculum aids were other factors. A study by W. J. Jacobson and A. B. Bergman (1980) arrived at similar conclusions.

Furthermore, the sample of six classroom teachers surveyed felt pressed for time to cover the basic junior programme. As a result, the majority delayed science instruction until the end of the day. Complicating the problem was the fact that the subject of science itself was not considered to be that important at the junior level. Moreover, it was integrated with other subjects which made specific evaluation difficult.

More significantly, although all six teachers approached were teaching the appropriate Board programme, dissimilar methodologies were in use. This meant that different classes received assorted instruction in the subject, since each teacher taught in his or her own way. While personal teaching styles will vary from one teacher to another, a "hands-on" approach is necessary for effective science instruction. Despite the Ministry and Board recommendations for teaching science actively in a small group situations, four of the six teachers consistently employed whole-class instruction and teacher-demonstration lessons.

If teachers verbally agree that the best methodology for science is a "hands-on" transaction approach, but the reality of their classroom situation does not reflect this belief, then the basic understanding of educational change could be lacking. The decision to practise a particular teaching approach should be examined. More in-service training is required if teachers are to practice the transactional pupil-centred approach.

Teachers working from the traditional transmission approach will resist the transaction orientation. Such instructors will have a difficult time learning new techniques because they do not believe that the children will comprehend more effectively than when instructed in this manner. Perhaps the transaction approach is too different from the way other junior subjects are usually taught, or perhaps the topic-coverage and teacher-student roles do not fit the conventional view of what should take place in the classroom.

Without doubt, discovery-oriented programmes require more preparation time for ordering and gathering materials, and more classroom time than traditional teacher-demonstration lessons. In short, the teacher's beliefs can limit the change from a transmission-oriented teaching mode to a transaction-instruction approach. Miller and Seller (1985), claim that change must be incorporated in the subjective world of the teacher in order for it to be effective.

The Canadian Science Council's research also supports these observations. It studied science education in eight Canadian schools to discover what really happened in the classroom. The report, Science For Every Student (1984) recommends that:

> ...few Canadian elementary schools offer science teaching during a prescribed period, by a confident teacher, and with the support of adequate facilities. When science is taught at the elementary level, it is mostly done in an integrated fashion. That is to say

> by reading a book about science or by introducing scientific...aspects of a theme subject (like "water") and trying to respond to the interests of the students. In the junior high schools, science teachers are constrained by the limited time available...and also by the energy they spend on discipline and on encouraging good work habits in their students. Thus, content is given priority over all the other educational objectives (pp. 30-31).

Despite evidence of an increasingly better qualified teaching force where the majority of teachers have university degrees, the improvement in training is less pronounced when education in specific subjects is examined. According to statistics compiled by G. W. F. Orpwood and Isme Alam (Science Council, 1984), over one-third of all middle years teachers have taken no university level science or mathematics. Even more telling is the fact that over half the teachers at all levels have not taken a university-level course in these subjects for over ten years (p. 35).

These findings paint a more sombre picture of the national Canadian scientific scene that the one suggested by the local Hamilton situation. The teachers surveyed complained about the lack or ineffectiveness of in-service programmes for professional development. The Science Council (1984) reports that two out of three teachers concurred this observation. Since the average teacher's age is currently about forty-two, these staid teachers may have little incentive to innovate or strive for excellence, if they are not encouraged and supported at the school level by in-service programmes. Therefore, useful in-service programmes are a necessity.

In summary then, the teachers' attitude to science instruction is complicated by various factors. Pressed for time, science is considered an unimportant topic in junior education. Secondly, teachers tend to devote more time to subjects like English and Mathematics with which they feel more comfortable. The emphasis remains on the three "R's" of reading, 'riting and 'rithmetic. The general lack of training and skill in Science makes it intimidating while the lack of support materials is an added obstacle. This results in traditional large-group instruction where the learning experiences are generally directed and executed by the instructor. Consequently, staff development appears to be an essential ingredient to resolving the problem. This conclusion has also been reached by the Ontario Ministry (1986) which is specifying both a preservice and an in-service programme. A better prepared staff force should ensure more effective instruction.

STUDENTS' PERCEPTIONS

If we are to serve the needs of today's pupils, it seems sensible to prepare them for the future's technology by promoting cognitive skills through science education. Perhaps we should now consider the views of the children themselves. How do junior pupils view the subject of science?

The author prepared a Student Questionnaire to discern the pupils' feelings towards the subject of science. The questionnaire is provided in Appendix A. To ensure a clear understanding, the teacher read the questions aloud to the children. The pupils were then given class time to respond to the questions in writing. This strategy assured the completion of the student's responses.

The answers provided by the participating twenty-nine pupils in a grade 5 class provided the following information:

a) All students could define SCIENCE, but not one pupil expressed that it involved all aspects of the physical world around us.

b) Most felt they had not studied science in the primary grades, thus some felt intimidated by the subject.

c) Many had not set up and executed an experiment in a group situation.

d) Only one or two realized that there was a specific format for recording an experiment.

e) All expressed a desire to manipulate materials in a "learning by doing" situation.

f) A few expressed boredom with the subject, and all the writing involved.

g) Almost all offered a reasonable definition of the word SCIENTIST. The definitions ranged from "somebody who solves problems using test tubes", to "a man in a white lab coat and glasses". Half the class offered the distorted images of "a mad scientist" or "magician".

This perversion is probably due to the mass medium of television which depicts a scientist in such an irresponsible manner. Interestingly enough, not one pupil realized that a scientist could be female, although many pupils did specify that a scientist was a **male**. This is understandable: traditionally, most science teachers have been male.

A second survey was then planned to shed more light on the issue of gender. This time the questionnaire included two important questions: "What type of person should become a scientist?" "Should girls become scientists? Why or Why not?" These queries were specifically aimed at promoting student discrimination of any existing social stereo-typing. This revised "Student Questionnaire" was added to Appendix A.

Another grade five class was chosen for the survey to ensure objective responses. The same survey method was also executed. This class arrived at similar responses to the first seven questions; but the responses to the new questions were intriguing. Having encouraged the students to think critically about possible existing stereo-typing, the results were elucidating - over half the class concluded that **both** males and females could become scientists. These results were more promising than those of the first survey, where the students were not stimulated to think critically.

These two surveys helped to identify the students' current attitudes and experiences in the subject of science. Generally, the findings illustrated that the students possessed a positive, enthusiastic attitude towards science education, despite some underlying feelings of uncertainty. This enthusiasm was also observed by the Science Council (1984).

According to the majority of teachers surveyed by the Science Council (Orpwood and Alam, 1984), students are both able and motivated to undertake science studies. About two out of three teachers, moreover, found that students were willing and able to understand science. This was a surprising discovery since the teachers' usual impression of pupils' abilities is generally negative. Many teachers feel that science is too difficult for students to manage, in that the subject matter entails a knowledge of English, Mathematics, manual manipulation of materials and an understanding of scientific concepts. That such a belief is now inaccurate, should be evident.

THE IMPORTANCE OF SCIENCE

Ontario's Ministry of Education and Ministry of Colleges and Universities (1980) views the learner as "an active participant in education who gains satisfaction from the dynamics of learning" and as a "self-motivated, self-directed problem-solver aware of both the processes and uses of learning and deriving a sense of self-worth and confidence from a variety of accomplishments" (pp. 2-3). This image of the learner shapes the goals of education and the objectives of all curricula. The use of direct observation, "hands-on" activities and inquiry, enables the children to develop skills that will help them become the active learners envisaged in the Ministry's image of the learner. It is important that students develop a knowledge of the world, a sense of their place in it, and the belief that they can influence events in it. Students can apply the knowledge derived from science to enhancing their health and environment, and to the attitudes they have towards themselves, and one another. Ideally, children should feel part of both their social and physical environment. T. Brennan, J. McKenzie and A. Di Ianni (1986) believe that the students gain dignity from the knowledge that they are part of the continuous flow of history - individuals whose actions are reflected in some small way, in the world in which they live. Ultimately, it is expected that the in which they live. Ultimately, it is expected that the children will acquire the attitudes and knowledge to actively participate in Canadian society and lead complete, responsible lives.

Is the subject of science an integral aspect of education? After a four-year study involving research and deliberation, the Science Council of Canada (1984) underlined the importance for a quality education in science, for all Canadians. In order for Canadians to cope with the social changes rooted in highly specialized technologies, we need the best **general** education, an education compromised not only of the traditional basics of language and mathematics, but also of the new basics of our contemporary culture - science and technology. Overall, science education is intended to support and contribute to the goals of education and is an excellent way for fulfilling such aims.

INTRODUCING "JUNIOR SCIENCE FOR GENERAL EDUCATION"

In order to satisfy the needs identified in the above theoretical and empirical studies, the findings were considered in preparing the programme, "Junior Science For General Education". The author structured the programme with a view to advancing the development of the students' cognitive-thinking skills as a first priority. The enhancement of the children's interpersonal skills was of secondary importance. Since the students' responses had expressed some social stereotyping, gender discrimination was discouraged by challenging all the students to realize their highest personal level of performance. In regard to this last point, the Ministry's (1983) policy clearly states that children should have the opportunity to develop abilities and aspirations without the limitations imposed by role stereotyping.

Chapter Two will delineate some theoretical concerns which further affected the structural design of the programme.

CHAPTER II

RATIONALE FOR PROGRAMME DESIGN

How does an author create effective curricula? By preparing a detailed implementation plan. Generally, a sound implementation plan provides bridges between the curriculum writer and the teacher. To eliminate any gaps between these two important implementation agents, Miller and Seller (1985) propose several components for effective programming. Among them one can find the three basic dimensions to any educational change: teaching resources, methodologies and teacher beliefs. To implement a programme effectively, all three basic components should be considered.

TEACHING RESOURCES

With respect to these basic dimensions, the first priority in designing the programme "Junior Science For General Education", was to identify the teaching resources, the most identifiable indication of programme change. Various curricula aids from both the Hamilton Board of Education, and the Hamilton-Wentworth Roman Catholic Separate School Board, were collected. All these support materials, including textbooks and library resources were reviewed to ascertain their importance in the project's curriculum design. The author's knowledge helped modify the chosen concepts to accommodate the students' needs. The availability of extra personnel was also considered. Establishing the timeline was another factor. Meticulous long-range planning was the key.

The result of this work was a number of interesting activities which supported the programme. Keeping this in mind, perhaps the Boards should provide "kits" consisting of the programme, equipment and activity sheets in order to free the teacher for teaching duties.

THREE CURRICULUM ORIENTATIONS TO TEACHING

Once the necessary resources were collected, the next step was to select the appropriate teaching approach. The ways in which the learner and the learning process are conceptualized have a major influence on education. Years ago, the concept of learning was drawn from physical training in which the intellectual muscles were developed through exercise and drill (Ministry, 1986). This image stressed the importance of the three "R's" of reading, 'riting and 'rithmetic. This concept slowly changed. In the 1960's, intellectual development was thought to depend on the innate capabilites of the child and the environment into which the child was born. The best sources of information in regard to this selection are usually professional development courses. Since such access is unavailable, a short synopsis of the main teaching methods ensues below.

Miller and Seller (1985) outline three orientations or teaching approaches: transmission, transaction and transformation. The emphasis in transmission orientation is on the subject disciplines, factual knowledge and the existing norms of society. The role of the student is to adapt to the school's academic, social and disciplinary framework and to absorb the dominant cultural norms. The role of the teacher is to direct the learning. Instruction is often didactic with students passively responding to the teachers' initiatives. Put in simpler terms, knowledge is imparted to the student. This is basically the traditional mode of teaching.

The transaction orientation refers to the current hands-on method of instruction. The major assumption underlying the transactional orientation is that the student is rational and capable of problem solving. The aims of such an orientation are to foster democratic citizenship skills through the development of intelligence in general, and in problem-solving skills in particular. The teacher becomes a facilitator who assists students in developing inquiry skills, locating resources, and stimulating investigation in the classroom. The curriculum then can be described as an active interaction between the teacher and the student. This is the recommended approach to teaching science.

The final orientation outlined by Miller and Seller (1985) is the transformational approach which focusses on personal and social change. The goals are self-actualization, self-transcendence and social involvement. The role of the teacher is to help students develop skills in the aesthetic, emotional and spiritual dimensions of life. Simply put, the curriculum and the student "interpenetrate each other in a holistic manner" (p. 8).

While some of these philosophies have been helpful in guiding teachers away from reliance on didactic teaching methods and towards the encouragement of active leaning, it is important to realize that no image is a perfect representation of reality. Keeping this in mind, it is interesting to note that although the project primarily employed the transactional approach to teaching science, it also includes elements of both the transmission and transactional methods of teaching.

THE PREFERRED METHODOLOGY FOR SCIENCE

Since the proposed activities developed for the programme focussed on the transactional activity-centred mode, a more detailed explanation of this teaching method is required. Jean Piaget (David Elkind, 1984) influenced education through his research in child psychology. After years of testing and of observing children, Piaget proposed that the ability to think was a sequential age-related development of various stages, but that not all children developed these capacities at the same time.
In addition, Piaget showed that many children were incapable of comprehending abstract concepts until they reached a certain stage of intellectual development. To clarify this issue, Allan Paivo (1971) stressed the importance of concrete tasks, since the more concrete the task, the more likely it was to evoke memory images that were useful in responding to the learning situation.

As children move through the elementary system, they are in Piaget's concrete development stage. They have an increased desire to discover things, and to add to their vocabulary. "Predicting, measuring, identifying variables and formulating hypotheses" (Brennan, McKenzie, Di Ianni, 1985) are meaningful concepts. Skills associated with accurately verbalizing properties of materials and recording these impressions are now relevant. Children can describe the physical properties of objects, classify them and arrange them in order on the basis of some characteristic. But, J. Hodson (1975) points out that although children can deal with objects in quite sophisticated ways, they have difficult stating hypotheses and making logical deductions. This intellectual obstacle will be anticipated in the proposed programme.

Since junior students like problem solving and controlling variables, the scientific method provides an effectual vehicle for articulating, imagining and testing hypotheses. These children can perceive certain patterns and realize man's impact on the environment. They find satisfaction in making predictions based on their past observations. Clearly, the nature of science demands these skills.

Some children nearing the end of their junior division years are at the abstract stage of development. This also holds true for high-achievers in grade 5, whose language and mathematical skills are developed. Adhering to Piaget's levels of intellectual development, Brennan, McKenzie and Di Ianni (1985) explain that an increased ability to deduce, estimate, hypothesize and mentally manipulate, define this stage. Scientific problem solving remains an ideal method for providing the students with pertinent learning experiences.

Moreover, according to S. Tomlinson (1987), John Dewey believed that too much emphasis is placed on the product without consideration to the process by which this knowledge is obtained. He proposed that students be active learners. "They need to be actively involved in the acquisition of knowledge as opposed to simply being consumers" (p. 150). Consequently, the structuring of the project, "Junior Science For General Education" attempts to reflect the stages of child development and the premise that curricula must be child centred.

Ross and Maynes (Miller and Seller, 1985) state that several studies indicate that teachers allot insufficient class time to skill objectives, only 2%. This is due to the "seduction of the narrative" (p. 99), where the teachers become so involved in presenting ideas and content that inquiry skills disappear from view. Time pressures the teacher to cover a certain amount of material in a given period. Moreover, the teachers naturally spend more time on subjects with which they feel comfortable. As a result, science exploration is shortchanged and problem-solving skills are neglected. This conclusion was also reached by the Canadian Science Council (Orpwood and Souque, 1984) studies.

For those teachers who feel that science places too much stress on children already experiencing difficulty with a modified basic programme, an interesting observation is tendered below. The research findings of the Science Council of Canada (1984) in the report Science For Every Student, concluded that a majority of the teachers (two out of three) believe that children can successfully undertake science studies.

THE TEACHER'S BELIEFS AND ROLE

Since the transaction cognitive-process approach to teaching science was to be emphasized, the teacher's role had to be clarified. According to Fullan (Miller and Seller, 1985), the teacher's beliefs are an integral, if less obvious aspect of implementation. This remains the most difficult component to address in establishing educational change. Beliefs develop over many years; consequently, reasons to change must be very convincing to the teacher. As a result, a teacher will implement a new programme in ways that are consistent with his or her beliefs. As Fullan states, implementation must affect the teacher's subjective world. The instructor must be convinced that children will benefit to a greater degree when taught in a hands-on transactional approach , or at least be sufficiently adventurous to attempt something new in order for a change to occur in the classroom.

If minimal adjustment to a new programme occurs, the teacher may implement only one or more of these components of change: teaching resources or methodology. Such limited implementation will minimize the effectiveness of a new programme. Thus, a basic understanding of the beneficial aspects of educational change is essential.

What is the teacher's role in a transaction orientation? It is as critical in this approach as in any other, if not more so. According to M. J. Cliatt and J. M. Shaw (1985), "the most important element is the teacher whose approach to learning will often be imitated by the students" (p. 14). Effective science teaching occurs when the children are encouraged to learn in an atmosphere where the teacher listens, observes and helps children, without dictating a precise direction.

Risk-taking must be accepted as an essential factor in child-centred, scientific exploration programmes. To a certain extent, the teacher explains the nature of the activities without depriving the children of the possibilities of discovery. According to W. J. Jacobson and A. B. Bergman (1980), children need to be given time and opportunity to reconstruct their understanding of scientific phenomena for themselves. Because of this, the teacher must be aware of the students' development and readiness for learning. This author believes that only through the practical knowledge of children and first-hand experience in teaching can a teacher develop the "sensitivity" and "skill" necessary for stimulating the children's learning, at a relevant speed. This appropriate "pacing" of lessons is instrumental in motivating children to productivity.

The teacher, then, is the planner and the facilitator of the programme by encouraging free exploration, supporting the children's schooling with further experiences, and directing the learning process towards anticipated outcomes. It is the job of the teacher to apportion the skills, processes and content to the activities, and to decide how much student interpretation will be permitted. The instructor must use discretion to initiate new tasks in order to maximize fully the children's schooling. The teacher may also demonstrate how to use and care for certain kinds of equipment. For example, in activity on "Magnets", the proper technique for storing the magnets was explained, in order that they would retain their magnetic power. Thus, the teacher, generally identifies the tasks and provides activities that accommodate to the students' frame of reference.

OBJECTIVES

Elliot Eisner (1979) makes the general statement that, "objectives are the specific goals one hopes to achieve through the educational programme that is provided" (p.93). In addition to this observation, Ralph Tyler's introduction to Basic Principles of Curriculum and Instruction (1949) outlines four fundamental questions that must be answered in developing a plan of instruction. One should contemplate, the educational goals or objectives, the appropriate environment or activity which will stimulate the desired knowledge, the effective organization of these learning experiences, as well as determining whether or not the initial goals were achieved.

At this point we will focus on the educational behavioral objectives.

BEHAVIORAL OBJECTIVES

Tyler (1949) was the original theorist who expounded upon the use of educational, behavioral objectives. He claims that objectives are statements which identify "both the kind of behaviour to be developed in the student and the content or area of life in which this behaviour is to operate" (p. 47). More recently, J. Hodson (1975) also recommends that in science education, the children's understanding be expressed in terms of their behaviour. Simply put, objectives are statements that indicate both the kind of observable behaviors and the content of the learning. The bonus of such phrasing is that it simplifies evaluation and teacher accountability;

hence, the ensuing popularity of such behavioral objectives in education.

In bringing about behavioral change, Tyler (1949) postulates that:

> Shifts in attitudes grow out of the student's change of view and this comes from either a new insight and new knowledge about the situation or from the satisfaction or dissatisfaction he has obtained from particular views previously held or a combination of these learning procedures (p. 79).

It follows that the teacher and the students can both communicate their perspective views of the observable student behaviour by reviewing the consequences of such comportment. This sharing, coupled with the proper modelling, helps shift the students' unacceptable behaviors towards more acceptable norms.

Although this behavioral approach to teaching has been criticized for suggesting that all students respond identically to the same stimuli, the model continues to be popular today. In the proposed project, the Tyler mode of behavioral objectives has been used.

PROBLEM-SOLVING OBJECTIVES

In problem-solving, students are given the question or sometime they themselves formulate a problem to solve.

The criteria to be met in resolving the problem are defined for the students. The solution to the problem is finite and a definite response is expected. Like behavioral objectives, problem solving requires the formulation of goal and student activities. Clearly, both types of approaches view education as a means to an end.

In designing the science programme, the approach included both behavioral objectives and problem-solving objectives.

LEARNING ENVIRONMENT

What class environment is most effective in the transaction approach to science? An environment conductive to encouraging students to participate actively, think diversely and interact in a positive manner with others, is thought to be the ideal situation. Through the active problem-solving teaching mode, the students engage in various learning experiences. According to Tyler (1949), a learning experience refers to "the interaction between the learner and the external conditions in the environment to which he can react" (p. 63). It is the teacher's responsibility to manipulate the environment by organizing situations which evoke the desired student responses.

This raises several important questions. What class atmosphere will be most effective in the hands-on transaction approach to science? What will assist students to attain certain thinking skills, engage in tasks both individually and in small groups and express their conclusions? In principle, the solution appears simple - a combination of both the physical and leaning classroom environment. In practice, the realization of this "simple solution" is quite complex.

THE PHYSICAL CLASSROOM ENVIRONMENT

Various environmental factors are directly controlled by the teacher. The best location for science exploration is in a specifically assigned large room with water, sinks, corrosion-resistant table tops instead of individual desks, and plenty of storeroom for supplies. Since this is often unavailable at the junior level, the instructor must use ingenuity in organizing the regular classroom furniture to facilitate group work, as well as establishing a permanent space for storing equipment and completed projects.

More importantly, a variety of stimuli are used to stimulate the pupils' thirst for scientific knowledge. A miniature resource centre, including visual displays, is expected to arouse the students' interest in asking questions and predicting answers.

Once the "physical" learning environment, the visible sign of change, has been accommodated, the teacher can focus on establishing the more "human" aspects of the learning classroom environment.

THE LEARNING CLASSROOM ENVIRONMENT

H. S. Barrow expounds upon the importance of an openness between students and teachers in problem-based learning, "where students feel free to offer their knowledge and opinions openly, even though they may be naive or wrong" (p. 37). Simply put, learning is most effective when students are able to freely reveal what they know or think.

But, the potential for student achievement is also affected by a variety of learning factors such as pupil readiness, awareness, concentration, motivation, participation and confidence. All these elements of learning refer to the individual's desire to learn. The educator can promote the learning process by using various motivational techniques. It is important to remember the Ministry's (1983) observation that "the way children view themselves will also influence their academic performance" (p. 7). Teachers can strengthen the students' positive attitudes towards science by demonstrating a proper role model towards the children with whom they work. Such positive teacher behaviour makes the children feel good. By communicating and demonstrating care and enthusiasm, a positive learning atmosphere should maximize the pupils' performance.

Gage and Berliner (1975) propose several factors that can create a non-threatening situation. From among their suggestions, the following proposals are particularly useful:

a) students should receive an abundance of reinforcement and feel free from the threat of tests

b) teachers should initiate the learning with familiar material

c) teachers should capitalize on the value of suspense, curiosity, discovery and exploration, and do the unusual to arouse student interest

d) familiar information should be used in examples, in order to extend the student's understanding.

The above suggestions were all considered in designing the programme "Junior Science For General Education." However, after careful consideration, Gage and Berliner's first proposal that students should feel free from the threat of tests was modified. It is the author's belief that life in the classroom should reflect, to some extent, other aspects of real life. To this end, a final consolidating activity was developed to serve as a "test", in order to evaluate the student's personal first-hand scientific exploration.

In the draft of <u>Science Is Happening Here: A Policy Statement for Science in the Primary and Junior Divisions</u>, the Ministry (1987) also advocates a unique environment to promote active learning. The suggested learning environment deals specifically with the transaction orientation to science and is carefully designed to appeal to the students. It is one that:

a) offers children opportunities for direct observation and hand-on experiences with concrete materials
b) contains a variety of appropriate, motivating materials
c) reflects the interests and needs of the children and teacher.
d) encourages safe practices
e) accommodates teacher-selected and child-initiated learning experiences
f) gives children time to explore, reflect and consolidate learning.

These observations delineate some of the necessary factors required for establishing an ideal learning environment. Moreover, the author suggests that students should believe that their active involvement will result in pleasant consequences. Simply put, they should feel that every question is acceptable. This nurturing environment promotes active student learning.

Two different types of learning experiences were anticipated in the programme: problem-solving and group interaction skills. These are outlined in Appendix B. One of the difficulties in teaching problem solving is that people can become confused about the labels associated with the various steps. The Ministry lists an eight-step sequence for problem solving, while Ross and Maynes (Miller and Seller, 1985) extend this outline to a more complex eleven-step model. For the programme, the Ministry's (1983) directives were the fundamental source of the design, modified to accommodate the students' needs. The problem-solving skills are located in Appendix B, as the first learning experience.

It is important to note that the eight-step model of scientific problem solving can be further condensed to address the students' specific learning abilities. In fact, the students' written record of the experiments evoked the four basic steps suggested by J. Hamrick (1985): "forming a hypothesis, designing and describing the method of investigation, gathering and analyzing data, and drawing conclusions" (p. 24). Because the skills used in the new programme corresponded directly to those outlined in the required Hamilton-Wentworth Roman Catholic Separate School Board science units of study, as well as the Ministry (1983) guidelines, the basis for accountability was established.

Given that junior students like problem solving, the scientific method provides a vehicle for satisfying the general educational goals of a "self-motivated thinker" through the medium of science education. Accordingly, real-life problem solving often approximates this model. J. Hodson (1975) stresses that children may need to retrace these steps and repeat some or all of the stages to confirm the learning. This repetition may be required to clarify the problem and may even necessitate teacher input. More importantly, Ross and Maynes (Miller and Seller, 1985) claim that teachers can accommodate this sequence "to a variety of problems and that the students should be able to transfer these skills to different contexts" (p. 100).

Ultimately, the project encourages better oral and written communication skills, since the pupils explained or defended their personal views, and consolidated their learning through written conclusions. Also, structuring the learning for group work draws out the necessary social skills for promoting tolerance of others' differences. The social skills, listed after the thinking abilities in Appendix B, reflect some of the important group skills suggested by the Ministry (1987) in Science Is Happening Here. Such social interactions as communication, co-operation, and compromise were recommended repeatedly.

The teacher or the pupils can determine the basis for grouping such as friendship, shared interests or necessity. The criteria depends on the situation and the pupils' needs. If the children are given the privilege of choice, it is to be clearly understood that the teacher has the final veto power. This technique encourages the pupils to work productively with their chosen partner.

MOTIVATION

Due to the recommended transactional approach to teaching proposed in the project, it was important that the children be motivated so that they would productively engage in the tasks outlined in the lessons. Since the learner was an active participant in the teaching-learning process, various motivational techniques were considered in order to foster learning. Positive reinforcements can include reward, praise and extra privileges. Strategies such as student isolation and teacher-student conference can also be applied, according to the circumstance. These were intended to affect a positive change in the child's attitude.

The teacher indirectly controls many of the above motivational techniques. Ultimately, it is the attitude of the student that determines what the child gets out of the programme. Individuals are motivated to learn when some need has been identified. A supportive learning environment arouses the pupil's interest. However, if no interest in learning is evident, then the teacher faces a real challenge in overcoming this apathy.

PROGRAMME EVALUATION

It is now time to ponder the final phase: monitoring the program. Evaluation of the learning experiences relating to the acquisition of certain behaviours is relatively simple for the teacher. According to Tyler (1949), the desired behaviors are assessed early in the programme by means of an objective assessment such as a test or questionnaire. These behaviors are reassessed at the end of the unit in order to evaluate whether or not progress has been made by the students in attaining the particular behaviours.

However, more is involved in the case of problem-solving evaluation. One must find forms of evaluation which examine the quality of the learning process involved when students are engaged in an activity. Lawrence Stenhouse (1975) claims that the teacher, guided by careful thought, must make a subjective judgement of quality about the students' work.

Elliot Eisner (1979) also expounds upon the idea of a thoughtful and productive evaluation. He intimates that the development of qualitative evaluation rests with "educational connoisseurship", where the teacher is able to "discern qualities and relationships that others, less well differentiated, are less likely to see" (p.14). From this, one is able to discern that the recognition and appreciation of classroom practices involve how to look, see and appreciate the process of learning. In assessing the learning, the teacher should consider Elliot's "educational connoisseurship" as an asset.

Thus, to determine the subjective, qualitative assessment espoused by L. Stenhouse and E. Eisner, several techniques were incorporated: daily record-keeping or formative assessment, the pupils' perceptions, and observers' insights, were expected to be particularly valuable assessment tools in judging how well the students progressed. The eight components of the cognitive-process, the three major social skills, and the criteria for student evaluation were carefully considered. Because the emphasis was on providing children with hands-on experience and encouraging direct observation of phenomena, the author also addressed the development of attitudes, skills and knowledge.

Through the use of these different evaluation techniques, the teacher was able to review the learning outcomes. The assessment monitored the development of the students' skills and provided pertinent information for possible programme revisions and development. It was also used in reporting to parents.

In conclusion, a detailed long-range plan for the creation and execution of curricula eliminates the obstacle of poor planning. Too often, this is the leading cause for failure in implementing a programme. However, with the completion of such a sound implementation plan, the programme, "Junior Science For General Education" was ready for application.

CHAPTER III

PROGRAMME IMPLEMENTATION

Generally, a sound implementation plan provides bridges between the curriculum writer and the teacher. Since, in this particular case, the curriculum writer and the teacher are one and the same, no gap needed to be bridged. Also, by attending to the fine details, the basic implementation plan was expanded to eliminate the obstacle of poor planning. A description of the programme, "Junior Science For General Education" can best be accomplished by examining the specific objectives and the experiences provided in the programme. In other words, the theoretical framework sketched in Chapter Two will now be filled in with further details from the empirical point of view.

TEACHING RESOURCES

When an educator has accepted the premise that the child is central to any planning, it will effect the choice of curriculum which will be introduced into the classroom. Through knowledge of the developmental growth of children and through practical experience, the author chose various topics which were most likely to motivate the majority of the students to engage actively in the learning. The activities chosen in the unit, "Junior Science For General Education" affirmed the different learning styles of the children. The tasks incorporated some of the concepts outlined in the Hamilton-Wentworth Roman Catholic Separate School Board curricula aids entitled The Digestive System, Mystery Powders and Magnets, as well as a few concepts from the Hamilton Board of Education unit, Light. Several new scientific ideas were also included in the programme.

The primary learning experience for the programme remained the problem-solving sequence outlined in each lesson. Indirectly, the interactive group skills were also accommodated.

OBJECTIVES

Specific behavioral and problem-solving objectives, followed by appropriate student activities were established for each lesson. This fulfilled both Tyler and Hodson's recommendations that in science education the children's understanding be expressed in terms of their behaviour. Thus, children were to: "formulate some hypotheses for testing, devise experiments to gather information, and communicate their ideas" (p. 22). Thus, the programme objective of Lesson Two: "To review and list the basic principles of the scientific process" includes an indication of the kind of behaviour - namely, reviewing and understanding the basic principles - and the content with which the understanding is to deal. Such statements of behaviours facilitated objective evaluation of the students' understanding. Each activity clearly stated its objectives so that success was readily ascertained.

Since problem-solving was the major emphasis of the programme, each lesson was carefully structured with respect to objectives and applications. Objectives were introduced and repeatedly reinforced through the execution of several lessons. Initially, Lessons 1-2 were planned to arouse the children's interest in science as part of the world in which they live, while the focus of the programme highlighted in Lessons 3-6 dealt directly with reinforcing the problem-solving sequence. By the end of the programme the scientific method of solving problems was deemed to be well established in the learner's mind.

THREE ORIENTATIONS TO TEACHING

As explained in Chapter Two, Miller and Seller (1985) outlined three basic approaches to teaching:

a) the transmission method: the traditional, teacher-directed approach to instruction

b) the transaction method: the pupil-centred, teacher-guided approach

c) the transformation method: the holistic, emotional approach to teaching.

When these approaches to teaching are applied to the programme, they provide a basis for analyzing the learning process.

THE PREFERRED METHODOLOGY FOR SCIENCE

Although the initial lessons of the project emphasized the transmission approach to teaching, the emphasis remained on the "hands-on" mode to instruction. As familiarity with the curriculum increased, the learning advanced from the transmission approach to the active transactional approach, and eventually progressed to the transformational approach to teaching. This was planned to be an effective succession.

Some skills and concepts required teacher demonstration - the introduction of scientific problem solving in Lessons 1-3. Also, scientific terminology like "dissolve", "hypothesis" and "procedure" dictated that the initial learning be transmission-oriented, or teacher-directed, through a Socratic discussion. However, the next three lessons allowed the students to become more active participants in the learning process.

Active problem-solving was the underlying goal of the transaction approach utilized in the programme. It was expected to be an effective way of developing the children's cognitive skills. The students were progressively allowed more independence as the experimental activities continued. Since people learn best by being actively engaged, the proposed "hands-on" transactional activities were expected to be productive.

It is important to note that the "hands-on" approach executed in the programme involved real problem solving. This is different from the "cook-book" exercises in which the students follow a step-by-step procedure without formulating their own hypothesis or devising their own procedure. In this particular situation, the children lose sight of the basic levels involved in problem-solving. If asked, "What step are you doing?" the answer is more likely to be "Step 4", than "The procedure". There is an advantage in teaching the basic concepts at the elementary level - the educator is more apt to concentrate on problem solving **per se**, since at this level there is less emphasis on the content of the programme, than at higher academic levels.

Finally, in trying to teach so many different individuals with unique attitudes, the transformational approach to education was incorporated into the final lessons. These lessons were designed primarily to accommodate the varied interests and needs of each student. Thus, the emotional involvement of the child was considered. Programme individualization occurred when the children were allowed to choose their personal topic of study. This was the greatest student autonomy permitted.

The gradual progression from teacher-directed to student-directed learning was designed to be a practical tool for maximizing participation in science exploration. The students were given time to become familiar with science and the skills of problem solving , before they were expected to perform independently. This promoted self-confidence, which in turn encouraged student initiated learning.

TEACHER'S BELIEFS AND ROLE

When assessing educational change, the teacher's beliefs are an integral aspect of implementation. Reasons to change must be very convincing. In implementing the programme, the teachers' beliefs in this case were an asset rather than a liability. Since the change was personally initiated, it did not provoke any defense mechanisms. The hands-on transaction approach had been personally chosen for the programme.

Also, the characteristic isolation of the teacher became an advantage. The author could practically close the door on the rest of the school and put the proposed programme in effect. The social organization of the school did not hinder implementation, since the curriculum primarily affected one classroom.

What was the teacher's role? It was as critical in this hands-on approach as in any other teaching mode. To a certain extent, the teacher identified the task and explained the nature of the activities without robbing the children of the possibilities of discovery. The instructor provided activities that accommodated the students' existing frame of reference. It was the job of the teacher to apportion the skills, processes and content of the activities, and to decide how much student interpretation and individualization was to be acceptable.

Once the children were attending to the task, the teacher circulated freely among the groups, looking for the distracted or frustrated pupil in order to clarify instructions, arouse interest and encourage the learners to explore their environment. The instructor probed, guided, observed and acted as a resource in order to facilitate science exploration.

There is one more consideration for the teacher's role. When a question arose that the teacher was unable to answer promptly, the instructor admitted to uncertainty about the correct answer. Honesty was considered to be the best policy. In fact, recognizing that one does not know the answer to a question is the starting point for all investigations. Ultimately, this is exactly what occurs in real-life scientific exploratIon. addition, junior students are intelligent and like most people take offense at being duped. They do not hold the teacher in contempt for admitting to not knowing the answer. Through contact with resource personnel or textbooks, the instructor was able to supply the proper response at a later date. Consequently, through such honesty, the puzzling question became an instance of problem-solving modelled by the teacher, rather than an embarrassing moment.

Clearly, the teacher guided the learner to master the problem-solving sequence and encouraged them to practise productive group skills. The teacher's genuine interest in the subject promoted student exploration. As in any programme, the role of the teacher was crucial. The instructor was the key to promoting learning.

ORGANIZATION

As well as considering the particular objectives and the appropriate method of teaching, the overall classroom organization and structure of the programme had to be considered. This was determined primarily by the author's knowledge of children and the practical teaching experience. The ultimate aim of the project was to provide opportunities for the children to define their own science questions, and utilize the appropriate inquiry skills, as they progressed through the problem-solving format. The unit of study in Appendix C, provides the specific objectives, lesson content, and student activity worksheets.

The focus was on the active participation of the pupils in the recommended "hands-on" method of teaching junior science. This approach denotes children working, doing and learning with the flexibility that allows for progress at individual rates. Brennan, McKenzie and Di Ianni (1985) affirm that an inquiry-based programme provides the appropriate framework for the discipline of science, in that the scientific method inspires the children to arrive at an answer through a systematic process. They collect information, interpret, organize, evaluate and share it with others.

Due to the complexity of this objective, much repetition and practice is built into the project. For each activity a cognitive-process skill is identified, followed by a description of the stages a teacher might follow in conducting the activity. A number of discussion questions are proposed which should clarify the particular skills involved in problem solving.

The learning methodology was structured in the following sequence:

a) whole class instruction to clarify the goals and the procedure to solve them. Through leading questions, the students were encouraged to plan their own procedure.

b) active student learning in groups of two, as the students executed the experiments and completed the worksheets. The teacher circulated freely among the groups, providing assistance whenever required.

c) whole class instruction to consolidate the conclusions.

To assist the teacher in student supervision, all the students performed the activities simultaneously. However, should teaching resources be limited, different groups could execute an assortment of tasks.

It was estimated that the programme would take about five to six weeks to complete. Some timetable changes were also anticipated; library time was scheduled in order to support the programme, the teacher-librarian would be kept informed of the project, several art periods would be allocated to preparing the students' exhibits, and a visit to the public library would supplement the school's resources.

Certainly not all children will do equally well in science exploration. It is important to allow for the special educational needs of some children. However, all students can participate and contribute to some extent, be it through oral reports or written work, or through artistic endeavors such as sketching the change that took place in their explorations. Carefully prepared activity sheets completed co-operatively by students, allowed the teacher to work with small groups of under achievers who needed more guidance. Thus, all children were actively encouraged to participate in one way or other.

CLASSROOM ORGANIZATION

Items such as rulers, pencils, paper and crayons were allocated to each child, and thus the possibility of sharing such resources was circumvented. In order to free the teacher and abet student responsibility and independence, several behavioral routines had already been established in September. The children were allowed to compare answers or to discuss learning problems with the person sitting closest to them. This eliminated unnecessary pupil movement. When the assigned tasks were fulfilled, the students could then move to the activity centres located at the front and back corners of the classroom. Here, they could choose an activity and complete it independently at their own desk or co-operatively with their friend at one of the work spaces provided.

Having already satisfied the required lesson on their own or with limited assistance from the child sitting nearby, the children could then share the outcomes of their basic learning task with a friend. Emphasis was placed on the children using a soft "group voice" when talking to each other, in consideration of the pupils who were still working out the original assignment, and to permit the execution of the regular teaching-learning activities. For instance, the teacher was often instructing one group of students, while the other groups were working independently on designated tasks.

Another important pattern of behaviour that was established prior to the programme allowed the student limited independent movement. This routine enabled the students, with the teacher's permission, to leave the classroom, without disrupting class activities by verbally attracting the teacher's attention. Three library pockets and cards were attached to the wall nearest the door. The cards protruded from the pockets. Each card could then be taken out and replaced in the pocket. The appropriate display of the green or red symbol communicated to other students whether permission of movement was available. A detailed explanation of the routine is located in Appendix D.

Once in effect, this permission system eliminated the pupils' need to attract the teacher's attention in order to leave the classroom. More importantly, this routine freed the teacher for teaching duties. The sight of a raised hand could only indicate that a child was having learning difficulties that required the instructor's assistance.

Such routines were particularly useful in the active hands-on group activities proposed in the programme. At the sight of a raised hand, the teacher moved toward that group, knowing that further clarification of the task was required.

PROGRAMME ORGANIZATION

Having expanded on the background classroom organization for the benefit of the reader, the next phase entails the organization of the programme itself. Due to the students' minimal scientific background, it was deemed best to choose physical science as the basic area of study. It offered a multitude of opportunities for manual manipulation of materials and direct student observation of the visible outcomes of the experiments. The involvement of the senses gave the children ample first-hand experiences in science exploration. First-hand investigations were chosen to facilitate student understanding of the more abstract scientific concepts expressed in their conclusions.

The initial lessons in the programme were teacher-directed to the entire class. It was planned that this controlled entrance into the programme would ensure that all the children received the same instruction and background to the scientific problem-solving method. The aim was to build confidence in the inquiry approach, since only a few children had used the principle of scientific problem-solving in the primary grades.

Due to the learners' limited knowledge and experience with the subject of science, the author built into the programme several strategies to promote learning. Some of these included motivation, participation, repetition and reinforcement. Thus, once the scientific problem-solving model was introduced in Lesson 3, the next three activities in Lessons 4-6 reinforced the problem-solving sequence.

The amount of teacher direction was assumed to diminish as the programme progressed. The students were considered partners in learning. Once the problem of discovering what substances transmitted light was established as the starting point of their investigations in Lesson 6, it was expected that the pupils would be working independently from the teacher. Since different approaches to teaching were utilized (from the traditional, teacher-directed transmission approach, to the current pupil-centred transaction approach), the students' role was also expected to change.

Each individual lesson had a fixed format typical of elementary school lessons. Each lesson began with a "warm-up" in which there was a review of some of the important or difficult components of the previous lesson, followed by an introduction to the new concept. The "warm-up" was teacher-directed through a series of prepared questions. The body of the lesson was an application of the objectives stated. Some guidance was offered through a Socratic dialogue before the students actively engaged in the activity.

The problem-solving sequence and scientific concepts were developed in numerous ways: the students comparing discoveries, and orally presenting them to the rest of the class, and the teacher culminating the learning through a Socratic dialogue. Various reporting techniques such as demonstrations, charts, pictures and oral reports were recommended. It was expected that the act of ordering the learning in a sequential manner through the preparation of an oral or written report would further the students' thinking abilities, as well as strengthen their communication skills.

Each lesson was structured with behavioral and problem-solving objectives. The students were to acquire the desired behaviour and skills, through the completion of the assigned tasks, the sequential structure of the lessons, and the teacher's constant reassurance.

To some extent, all the lessons were open-ended. Based on their investigations, the students had to form their own conclusions. The fact that the activities only introduced basic concepts about the topics of "Matter", "Light" and "Magnets" was important, in that the observable outcomes of the experiments inspired problem-solving. A certain leeway was allowed in recording the outcomes of the experiments. Student-generated strategies were accepted if the teacher considered that they would facilitate learning. For example, the worksheet for Lesson 4 suggested a chart for recording the students' observations; if a pupil proposed an alternate method of record keeping, it was accepted so long as the teacher considered it to be viable.

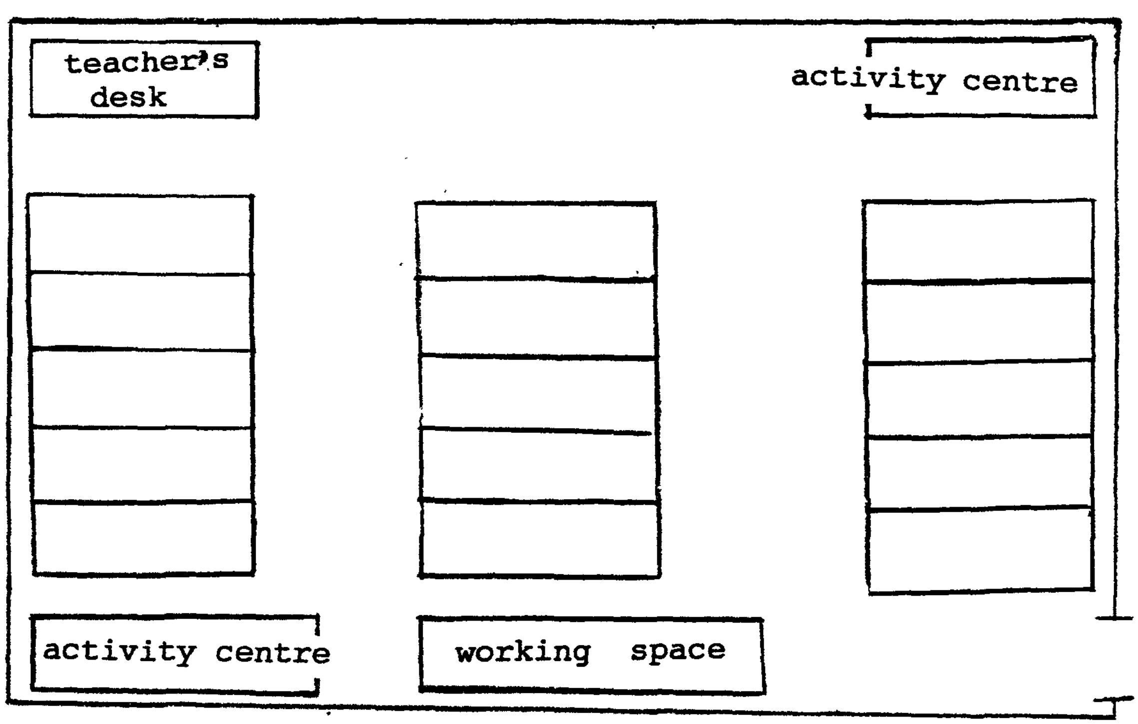
LEARNING ENVIRONMENT

Science education in the junior classes generally focusses on stimulating an interest in science exploration. Since the children's abilities and intellectual development in one class usually encompass a broad range, a variety of concrete materials was incorporated in the programme. Such objects as magnets, flashlights, water straws, foil and coins were used to establish a supportive environment which were to enhance the students' interest in science exploration.

To ward off possible student apathy, the author developed a collection of activities which covered various topics in order to provoke the pupil's interest. The child's emotional well-being was considered, and the accomplishment of the various assigned tasks raised the child's feelings of self-worth. Finally, skill-development was ensued to buttress the learners' productivity in the new programme. Consequently, a combination of the appropriate environmental factors was used to nurture first-hand investigation.

PHYSICAL CLASSROOM ENVIRONMENT

The teacher was in direct control of the physical environment in the classroom. Initially, the location for implementing the programme was not ideal. It was the regular homeroom classroom. With movement and activity involved in the programme, the desirability of a larger work place was manifest. The arrangement of the desks was altered by pushing pairs of desks together. The desks were also arranged against the two opposing walls in order to maximize the working space. The following illustration depicts the seating arrangement:



Adapting the surroundings for extra storage space was another factor. During the on-going experimentation, each task and the accompanying materials were stored in bags, which were in turn kept in shoe boxes. A box containing the equipment of the experiment in progress was kept at the activity centre. More bags supplying the necessary materials were added as additional experiments were introduced. Children who needed to complete any lessons approached the activity centre, selected the appropriate equipment and completed the work.

Storing the materials for the final task was another challenge. Initially, the large display boards for the science experiments were folded and compactly stored on the back cupboard. After experiencing some difficulty locating specific displays, each group was asked to retain the same storage space for the remainder of the unit, rather than changing the location at will. Furthermore, distinct areas were designated for storage. This allocation facilitated retrieving the necessary materials in record time.

It is important to note that curiosity, exploration and discovery were integral factors in designing the programme. Consequently, besides changing the physical working space of the classroom, a science resource area was added. This mini-library housed a conglomeration of different resources like science textbooks, histories of scientists, former students' exhibits, scientific problems, filmstrips and pictures. The various resources were expected to increase student interest in science by provoking questions about the world around them.

Also, an attention-grabbing visual display was prepared by the teacher. Baking soda, water, popcorn, vinegar and raisins were placed in a large "Big Boss" plastic pop bottle. The chemical interaction between the vinegar and the baking soda created carbon dioxide gas bubbles which floated the popcorn and raisins to the surface of the water. Here, the particles rested a few seconds only to drop to the bottom of the bottle again. As more gas escaped to the surface, the food particles once again floated to the surface, repeating the cycle. The students were challenged to predict: "What has been added to the water to cause the food bits to float up to the surface?" Such a visual display was expected to add a little "magic" to the programme, and to spark the scientific spirit.

Finally, it must be noted that the activity and movement in the first-hand investigative approach was more than the teacher had anticipated. Strangely enough, the noise level irritated the instructor more than the students. To ease the congestion of the constant movement, some groups were allowed to work in the hallways near the homeroom . When the working noise was deemed unacceptable, the teacher made a "peace sign". This action was the symbol for complete silence in the classroom. All movement stopped. After several seconds, the teacher quietly reminded the pupils to use their soft "group voices" as they proceeded with their work.

CLASSROOM LEARNING ENVIRONMENT

Since it is now believed that the way children view themselves influence their learning, the author concentrated on an "open", supportive classroom atmosphere. An open environment to education was a priority, if the children were to diversify their thinking by asking, "What if ...? questions. Positive attitudes towards science were strengthened by demonstrating care, empathy and interest towards the children. From the first day of school, the students' fears and learning difficulties were handled with patience and perseverance. All student questions were carefully considered. Thus a supportive, nurturing atmosphere was communicated to the pupils.

By exemplifying toleration, the general tone of the classroom was set. Assistance was offered without ridicule. Learning is most effective when students are able to freely reveal what they know or think. This supportive interaction was particularly essential in science exploration. The children were dealing with a relatively unfamiliar method of learning, that of first-hand investigation as well as new concepts. A caring helpful attitude encouraged them to discover and appreciate their world.

In designing the project, it was important that the children be motivated to participate productively in the tasks outlined for each lesson. The teacher's consistent enthusiasm was to be an overt motivational factor. The instructor was constantly involved in discussions that challenged the children to solve problems through first-hand experience. Involvement was furthered when the students viewed their peers enjoying the learning. Also, the children received rewards and reinforcement both from the instructor and from each other as they discussed their observations.

Since the attitude of the student determines what child learns from the programme, a myriad of topics were included to attract the pupils' interest. For example. activities were centred on the topics of "Matter", "Magnets", and "Light". These three areas have traditionally intrigued young minds. Also, the "brainstorming" session before the final experiment, furnished additional topics of interest, such as "Electricity", "Worms", "Ants", and "Plants". Thus the programme individualized the learning to accommodate the children's own interests.

MOTIVATION

Motivation also played an integral part in developing and maintaining the students' confidence. Both extrinsic and intrinsic types of motivation were employed to affect the pupils' learning. Extrinsic motivation included external rewards such as praise from both teachers and peers, a good evaluation and perhaps extra privileges from the teacher, such as extra computer time. More importantly, the students that successfully completed the programme participated in the school's "Junior Science Fair". Here they presented their experiments to the staff, groups of students and any parental visitors.

Where extrinsic motivation dealt with outside influences, intrinsic motivation addressed the learners' inner development. This involved internal rewards such as an increased sense of self-worth and satisfaction. The accomplishment of the various assigned tasks, included in the programme were planned to arouse the child's feelings of self-worth. Moreover, progress in skill-development was supposed to further productivity. In conclusion, all these different techniques were expected to promote learning.

From the instructor's point of view, the teaching task is difficult, since there is no facile, universal recipe for motivating people. However, a general guide for arousing the children's desire to learn was employed. The following sequence, reminiscent of the scientific problem-solving model produced successful results:

a) Identify the lack of interest

b) Discover possible reasons for the apathy

c) Propose a probable solution.

Getting to know the learner on a one-to-one level, through observation and teacher-student interviews, as well as applying various principles of learning, successfully motivated the learner.

EXAMPLE:

> Al is a grade 5 student who refuses to work productively with his partner. He prefers to tease and distract others from their work. During a private one-to-one meeting, you discover that Peter wants to record the outcome of their experiment on electricity by drawing a diagram. His partner has told Peter he has to record the procedure in writing because he himself will sketch the diagram. As their teacher, you talk with the boys and suggest that they share both tasks more equally. Both boys could work together to record their procedure in writing, and then sketch the various outcomes. That is, Peter could draw one effective way for joining two wires, a battery, and a bulb to form a current, while his partner drew another arrangement. By convincing the boys to share the writing and the drawing, you have motivated the latter to complete his task.

The "open" learning environment necessitated by the programme was fraught with similar incidents. In these difficulties, the teacher was the facilitator. Only through knowing the students' needs and through persistent encouragement, did the instructor succeed in keeping some children focussed on their task.

In summary, the combination of the appropriate environmental factors, combined with the teacher's obvious enthusiasm, peer appreciation, and social group interaction spurred the students in fulfilling the behavioral and problem-solving objectives. They were productive in carrying out the tasks identified in the programme.

Having developed a sound implementation plan by attending to the finer details, it is time to observe the plan in action. Since the students' responses had expressed some social stereo-typing, gender discrimination was discouraged by challenging all the students to perform at their highest personal level of performance. In regard to this last point, the Ministry's (1983) policy states that children should have the opportunity to develop abilities and aspirations without the limitations imposed by role stereotyping. An assessment of the programme "Junior Science For General Education" follows in the next chapter.

CHAPTER IV

PROGRAMME ASSESSMENT

Several assessment techniques were used to validate evidence supporting the basic hypothesis that science is an effective vehicle for fulfilling general educational goals. As outlined in Chapter Two, these included: formative evaluation or daily record keeping, students' perspectives, observers' viewpoints, and a final or summative report. These different lenses reviewed the learning processes involved in the programme "Junior Science For General Education", from distinct outlooks.

The development of cognitive-skills and interpersonal communication skills was accentuated. Through the hands-on transactional approach to teaching, problem solving was performed in small groups. This method of instruction inspired the learner to be an enthusiastic and unique participant in the learning process.

The general strategy for instruction was sound. As suggested in the Ministry (1983) document, the numerous learning experiences furnished the children with opportunities to develop their intellectual power. They learned as they began to recognize and seek answers to questions and problems.

FORMATIVE EVALUATION

The formative evaluation or daily reports kept by the author were used to assess the more or less successful points of each lesson. From the instructor's perspective, the following observations and revisions were recorded:

LESSON	OBSERVATIONS	REVISIONS
1	- concrete sample of art was a fine motivation - interest in various topics evident	- emphasize outlining the shape of the object first before adjusting the lettering
2	- needed more time	- allot more time for collecting data
3	- teacher felt foolish playing the role of scientist - students were highly motivated	- wear white lab coat without carrying dialogue with self - allow more time for the students to explore one of their suggested hypotheses
4	- took longer time - worksheet complicated - CONCLUSION involved many	- provide more time - simplify worksheet - eliminate the questions

	questions; APPLICATION seemed redundant	written in the CONCLUSION; eliminate APPLICATION; use questions to guide the discussion
	- overly concerned with specific material composition	- generalize information provided on envelope: brass fastener becomes metal fastener
5&6	- extra guidance required to arrive at hypothesis	- more teacher direction, especially with slow learners
6	- collected data inefficiently	- remind class to use a systematic approach like a chart
	- more time needed	- adjust timeline
7	- difficult to monitor all student's progress	- devise BUDGETING MY TIME criterion to assist the students in self-evaluation
	- difficult to keep some students on task	- teacher's supervision of the student's progress
	- too much copying from printed material	- insist children answer prepared questions

	provided	in their own words
8	- difficulty in arriving at appropriate problems and hypotheses	- provide more problems to choose from - increase teacher's familiarity with the subjects chosen by the students
9	- difficulty storing equipment and exhibits - conflict over work space	- establish storing - allot permanent work space

The above formative evaluation was helpful in several ways; it created awareness of the less successful aspects of each lesson, and also identified the effective activities which could be duplicated when the programme was repeated in the future. The children concentrated on the objectives set for each lesson. It was clear that "learning by doing" was very much in evidence. The results from each lesson furnished evidence that the students were actively engaged in the problem-solving sequence, in an enjoyable way. They were developing thinking patterns through science exploration.

PROBLEM SOLVING

After a few lessons, it was manifested that the initial "warm-up" was one of the most effective ways to promote the sequence of stages involved in problem solving. By coincidence, it turned out that the students were scheduled for Environmental Studies after just returning from their luncheon break. Because of this, they were eager to begin their afternoon session. Consequently, the teacher took advantage of the students' energy by concentrating the new learning in the "warm-up" or review section of the lesson. However, even if the programme time had been slotted for a different hour, there is sufficient evidence to suggest that the programme would still have been a success.

During this quiet time, the students were very receptive to the teacher's suggestions. Thus, a deeper understanding of the concepts was achieved. Any problems and questions relating to earlier lessons were addressed. The extra repetition involved in the review helped the students to consolidate the new learning experiences.

Moreover, placing the newly mastered concepts in novel contexts made the schooling process both exciting and comprehensive. For example, in Lesson 6 the students discovered that different materials transmitted light in varying degrees. In the consolidation period, the realization that people who desired a bright, sunny room used sheer curtain material because the cloth easily transmitted light rays, fascinated the children. Conversely, people who preferred privacy used heavy, lined drapes in order to prohibit the sun's rays. Prior to this discussion, the children had blithely accepted such aspects of the world around them, without much thought or understanding.

All the lessons were structured in a consistent, effective format. Instruction began with a whole-class discussion in which the teacher reviewed and introduced new experiences, proceeded to group engagement of the assigned task, and then concluded with a whole-class consolidation. Groups that finished the task early compared their findings with others.

The groups that had not completed their task benefitted both from listening to the oral reports of their peers, and from identifying the difference in their peers' presentation. If necessary, the written assignment could then be finalized at home or during the children's spare time at school. The use of the senses of sight, hearing and touch were incorporated into each lesson, making instruction a memorable experience.

Problem solving comprised the foundation of each lesson. Each activity clearly stated its objectives so that success was readily evaluated. The objective evaluation of the children's final activity by a qualified person underscored the effectiveness of the transactional orientation to science education. It measured the students' achievement in the cognitive-process mode.

The selected concepts served as a vehicle for mastering the appropriate thinking skills. The stages involved - formulating a hypothesis, devising a testing procedure, collecting data and arriving at a conclusion, were usually reviewed in all the lessons. Therefore, a greater awareness of the scientific method was engendered.

Once the sequence of stages was introduced in Lesson 3, a chart outlining this scientific model was displayed in a prominent place in the classroom. For the students' convenience, the identical inquiry format was reproduced on paper. The new learning was thus made easily accessible.

When the children understood the problem under investigation, the author asked the children to consider the testing procedure which could solve the problem. The materials required for the procedure were always displayed in a central location. These acted as visual stimulants in leading the students to devise a testing procedure. In this creative endeavour the more ingenious students motivated their less inventive peers. Furthermore, to assist the students in remembering the basic steps suggested for the testing procedure, the key words were recorded on the board. Forming a hypothesis became an amusing practice. Having completed the discussion on testing, the students were then asked to close their eyes and imagine performing the test. To aid in the recall, the teacher orally outlined the steps of the testing procedure. In this way, the pupils were primed for predicting the answer to their question. A show of hands indicated the children's choice. This prediction became their hypothesis, which the students immediately recorded on their papers.

After the PROBLEM, HYPOTHESIS and PROCEDURE had been discussed, the children chose their partner, executed the testing procedure, recorded their OBSERVATIONS and arrived at the CONCLUSION or answer. The teacher circulated among the students, acting as a facilitator whenever needed. Distracted pupils were encouraged to concentrate on the task at hand. Also, the accomplishment of performing the various tasks raised the children's feelings of self-worth, while skill-development unfettered the learners' productivity in the programme.

Certainly, asking probing questions such as "Why do you think that?" or "What information do you have to support your answer?" were productively employed throughout the unit. In fact, the posing of such questions was of prime importance in developing the students' thinking patterns.
They allowed the children to hear their expanding knowledge and reinforced desirable attitudes. The new learning was

further consolidated by sharing their observations and findings with the rest of the class. In an area designated for the activity, the children displayed their experiments and presented their work to others. Thus, the learning experiences became an interaction between the pupils, the teacher and the new experiences.

The Ministry's (1983) goal to develop independent self-motivated thinkers was realized in the programme's last activity, where the children were allowed personal autonomy in choosing a topic of their choice. Generally, the students' responses indicated a high level of enthusiasm and interest in the transaction approach to science instruction. This hands-on method to learning initially guided the children's conceptual understanding by providing information at the concrete manipulation level, and by extending the activity to the more abstract level of formulating a conclusion for each experiment. The use of the senses better prepared the students to master the more abstract concepts.

It is important to note that the active, hands-on approach executed throughout the programme involved real problem solving. This is different from the "cook-book" exercises in which the students follow directions. As M. Tinnesand and A. Chan (1987) advocate "detailed lists of material and equipment needed, procedures to follow, data to collect ... don't train students to think. Only to follow directions - and that's not science" (p. 43). Thus, instead of giving detailed procedures, the teacher should pose a science challenge, such as a problem, and allow the students to devise a way to solve it. This routine was successfully manifested in the programme.

Learning experiences such as the main skills of cognitive-process and social interaction were incorporated into the programme. Ultimately, they should be incorporated into solving real-life problems. Despite Piaget's reservations concerning the mastery of abstract concepts for junior pupils, this progression proved to be a successful technique for introducing new learning. Perhaps, the concepts themselves were sufficiently basic for the students to grasp. On the other hand, the abundance of concrete materials certainly assisted the pupils in surmounting the obstacle of abstract concepts. More empirical research is required to clarify this point.

However, the students did experience some difficulty in postulating a clear precise "question problem" for their final activity. This obstacle had been anticipated. After each experiment, the teacher invariably asked the students if there were any further questions they would like to pose. The queries were carefully formulated and recorded for future reference. Some of these questions are included near the end of Appendix C. Four groups did choose one of the questions listed above for their final experiment.

Most children took advantage of the opportunity provided to choose a topic of their choice. This unexpected freedom probably contributed to the difficulty in formulating an appropriate, specific problem from a wide, general field of interest. The students were not familiar with thinking in such specific terms. The practice time allowed in class was clearly insufficient. Further practice may have alleviated this difficulty. To diminish frustrations for the teacher and the learner, the students were provided with a list of precisely phrased questions which made problem selection less daunting for some students. Robert D'Alessandro (1980) research, Science Fairs and Science Fair Projects offers numerous suggestions for this purpose. These could be used as a resource for expanding the teacher's knowledge on a collection of topics. A page of some sample questions employed in the grade five classroom have been included in the programme.

The key question in evaluating the programme was, "To what extent was the unit successful in developing the students' cognitive-process skills?" Several observations surfaced from assessing the programme. The students were required to arrive at the appropriate observations and conclusions in order to attain the behavioral objectives. The responses recorded in the conclusions of their experiments also indicated growing competence in the mastery of scientific concepts. Finally, group products in terms of the completed results of the experiments were simple to evaluate.

Further evidence of the success of the programme is supported by the following statistics. Twelve out of fourteen groups demonstrated mastery of the inquiry process by providing first-hand investigation on their topic of interest. This final task enabled the pupils to discover an answer to their problem through the actual processes of thinking, doing, observing, recording and concluding.

It was illuminating to consider the two groups which were incapable of tackling the final problem. In one case a student-teacher conference seemed to identify the children's problem, but the final outcome demonstrated minimal improvement on their initial venture. The pupils in the other group were prodded whenever their attention wandered, yet a successful consummation of their experiment proved to be elusive. For the former, more teacher-guidance eased the situation but brought no visible results, while for the latter, a less distracting working atmosphere might have been beneficial.

The last observation could support Neville Bennett's (1976) research, in which he states that informal methods of teaching could result with the pupils feeling unsure of what to do. However, on closer inspection, the teacher realized that three out of the four students unable to complete their first-hand investigations were also the same students who usually had difficulty fulfilling their assignments. Thus, at times, the teaching methodology is inconsequential.

It was helpful to have extra personnel during this time slot. Since half the class had been identified as students needing a modified course of study, a special education instructor was designated to assist some students in coping with the Environmental Studies programme. The extra instructor effectively supervised the four specified students, who were withdrawn from the classroom during the first twenty minutes of instruction.

The classroom management in the homeroom was more complicated. During the personal choice of topics, it was impossible to competently assist all the children who needed help in identifying an appropriate problem or devising a possible testing procedure. Some students were always waiting for the teacher's support. Chapter Five offers a suggestion in circumventing this impediment.

Despite such shortcomings, the programme seemed enjoyable for both the teacher and the learners. Several innovative and interesting science exhibits attested to the success of the programme. When the class competed with other grade five students in the school's "Junior Science Fair", the work was compensated. The exhibits of three groups were respectively awarded first, second and third place ribbons, by objective, qualified teachers who judged all the junior exhibits. Surprisingly enough, the third place ribbon was earned by a group that followed a modified programme of studies. Such promising results attested to the success of the science programme.

Furthermore, the science teacher invited to assess the children's learning was quite satisfied. Since he had organized the school science fair, he ensured that the junior group awarded first place, participated in the Board's "Intermediate Science Fair". This further attested to the successful development and mastery of the cognitive-processes in the junior class.

GROUP SKILLS

The programme provided for whole-class, individual and group instruction, in order to accommodate the students' various learning styles. Although attention to cognitive-processes was a priority, the social skills were considered to be of secondary importance. Basically, social interaction was an important stage in implementing the transaction orientation. The children very much enjoyed working in small groups and tended to take the tasks seriously, concentrating for long stretches of time (45 minutes) in order to complete the activities. Some even pleaded for more time when asked to prepare for the next subject.

Since learning involved peer interaction, the three social skills of "C. C. C." (Communication. Co-operation. Compromise.) were often practised. Before initiating each task, the children were reminded to "C. C. C.". This catchy abbreviation of the major interaction skills was popular with the children. They were also prompted to share their observations, arrive at a final group solution and defend their answers to the rest of the class. Given that "C. C. C." are basic social skills that apply to many situations, their enhancement supported the main hypothesis that science exploration satisfies the general educational objectives.

The actual group interaction was quite interesting. When a group consensus had to be reached in recording their conclusions, the students' oral skills were accentuated. The bolder, more persuasive partner usually manipulated the other companion. When the more submissive partner proved to be correct however, it was gratifying to see the look of satisfaction on that child's face. Thus, the children's attitudes, as well as their thinking skills, were affected.

The criteria for group choice was established. For most of the lessons, the pupils were allowed to choose their own working partner on the basis of friendship. Although they were encouraged to establish new relationships, the students retained the final decision. This privilege of choice was allowed so long as the group worked productively.

For the final first-hand investigations, group formation had a different criterion. The students were asked to choose a partner who shared the same interest in the topic to be explored. This new criterion encouraged compromise and co-operation. Friends with different interests who wanted to remain working partners had to arrive at a common interest. The different criteria therefore, provided opportunities for further positive group interaction.

The choice of partners is noteworthy; the remedial students basically chose to partner other under achievers, while the above average pupils preferred other high achievers. In a class of twenty-nine students, only four pupils violated their mainstream grouping. The social interaction of these two groups was illuminating. In one case, the enthusiastic high achiever did the bulk of the work, even though his friends' chatter was a constant distraction to him and to the rest of the class. Despite some verbal complaints about the friend's lack of co-operation, the high achiever did succeed in teaching his friend a procedure for setting up an electrical circuit.

The other group was a different story. Numerous proddings were administered by the teacher, without visible results. Finally, the group was disbanded in order to increase student productivity. One of the partners attempted to work independently, while the other stubbornly refused to participate. It was only when he realized that the oral presentations were starting that he finally settled down to work.

Positive social interaction was affected by factors such as the pupils' temperament, state of health, weather conditions, timetable disruptions and even emotional upsets resulting from athletic competition. The teacher had to be aware of all these influences. In promoting positive group dynamics, the teacher prompted the students to review their conduct in order to realize how their behaviour was in harmony or discord with others. Perhaps this should have occurred on a daily basis prior to the programme itself, rather than when it was demanded by inappropriate behaviour. As postulated by Tyler (1949), it is desirable for students to review their conduct in a particular area, in that this scrutiny is important for behaviour modification.

Productive social skills were continually reinforced by the teacher during the group activities. Further affirmation took place in the whole-class consolidation period at the end of each activity. The teacher complimented the students who had practised positive social skills. When group break-down persisted despite teacher intervention and a student "cooling-off" period, an ultimatum was delivered:

students who could not work together with their partner were expected to complete the designed task independently. The objective of the ultimatum was to encourage the children to honour their group commitment. Since almost all the students remained working with their partner, the threat of the ultimatum served its purpose.

There was evidence that group dynamics were more instrumental in the learning than expected. Compromising to solve a disagreement, tolerating each others' weaknesses and persevering to complete their activity with their original partner were all part of the total instruction. In fact, the "better" student often guided his or her friend along the road to discovery.

It must be noted that the activity and movement in the first-hand investigative approach was more than the teacher had anticipated. Strangely enough, the noise level irritated the instructor more than the students. To ease the congestion of the constant movement, some groups were allowed to work in the hallways near the homeroom . When the working noise was deemed unacceptable, the teacher made a "peace sign". This action was the symbol for complete silence in the classroom. All movement stopped. After several seconds, the teacher quietly reminded the pupils to use their soft "group voices" as they proceeded with their work.

STUDENTS' PERSPECTIVES

Another form of assessment was provided by the children themselves. Different students chosen at random, were informally interviewed in small groups or individually at the end of each lesson. The children were asked several questions; "What did you enjoy most?" "What did you not enjoy? and "Have you gained a greater understanding of science through active participation in the programme?".
The students' comments indicated their varying interests. Clearly, different students enjoyed different aspects of the programme: some liked the drawing of diagrams, while others enjoyed recording their findings. Many enjoyed the actual execution of the testing procedures, whereas a few were happy to watch or assist their partner in the activity. The majority thought the amount of work was just right, while a few did extra first-hand investigations, and two others found the work load heavy. However, a general consensus was expressed on two points: everyone enjoyed the movement and activity, and no one expressed any displeasure with the programme.

Theoretically, the wide range of responses expressed by the children could confirm the notion that children do think independently, and that there exists potential differences among the learners with respect to knowledge and performance.

OBSERVERS' VIEWPOINTS

The students' productivity was noticed by several people. Of their own volition, various teachers commented on the movement and activity of the grade five students. The librarian noticed that the children generally knew the science topic they wanted to research. Older siblings commented on their younger brother or sister's enthusiasm in solving science problems at home. Finally, an objective qualified teacher who evaluated the final activity was quite satisfied with the calibre of the problem solving, the oral reports and the written records of the junior students. Due to this teacher's position in the school, as the only intermediate science teacher, he was considered the subject specialist. Thus his praise was highly esteemed.

Regarding gender discrimination, four of the top five exhibits were completed by girls. This supports the general belief that social stereotyping does not apply at the elementary, but it occurs at the secondary level. The Canadian Science Council's (1984) research also concluded that girls lose interest in science in the high schools. It is possible that more effective science teaching at the elementary level could change this negative situation.

SUMMATIVE EVALUATION

A final report was written after the last session. From this report, the author ascertained the overall programme strengths and weaknesses. Several positive aspects of the junior science programme were reaffirmed. The display set by the teacher was well received by the children. Robert Cichowski (1983) provides three more "attention-getting" displays suitable for sparking the scientific spirit. Keeping in mind that the ultimate programme aim was to develop the students' awareness of their surroundings, a beneficial outcome of this visual tactic was the reinforcement of the fact that every happening has a cause. It was not "magic", as some students initially thought.

The specific ordering of the lessons, progressing from simple to complex concepts, effectively assisted in the achievement of the objectives set for the programme. The later lessons, more challenging than the first few, aided in promoting student interest in science exploration.

The inquiry approach to education permitted the children to continue first-hand investigations at the concrete operations level. But, as specified by Jacobson and Bergman (1980), could go several steps beyond manual manipulation: they could classify objects according to different schemes, observe changes, question what they saw, and reinforce learning through further experimentation. Thus, the curriculum was especially structured to develop the cognitive-processes by applying Piaget's of concrete operations.

Should one be concerned with knowledge? Clearly scientific knowledge takes place during the inquiry process. By communicating their knowledge to others, the children further accommodated their own learning. B. J. Gustafson (1986) warns educators that since what children actually learn is often different from what teachers hope that they will learn, it is essential to determine what has been learned. In the programme, mastery of knowledge was demonstrated through the completion of the assorted learning tasks. It was not assumed that knowledge was of value as an end in itself. Instead, the information was obtained as part of the total problem-solving process.

Through the expressive visual activities, the children achieved a better understanding of science exploration and the world around them. The students' predominant use of verbal interchange during the execution of the problem-solving sequence promoted the development of communication skills. This progression was further abetted by asking the students to complete the required worksheets, which in turn encouraged the growth of both written and oral skills. Since the students had to consistently explain, defend, and share their observations in a small group situation, their observational, intellectual and communicative skills, skills which are vital for necessary survival, were enhanced.

One of the general aims of the programme was to encourage the pupils' interest in the physical world. This was achieved by allowing the pupils to choose their own topic of study. This task also provided practice in decision making. However, in order to diminish student procrastination, a more stringent time limit for problem selection could have been enforced. To this end, a "Budgeting My Time" guide has been added to the programme, as suggested in the formative evaluation. This is located in Appendix E.

Because everyone learns by repeated exposure to an experience, the students were encouraged to continue to develop their curiosity about the surrounding world. A later opportunity could have been provided in order to reinforce the critical thinking skills. Exploration centres set up in the classroom could provide this later opportunity.

In summary, the evaluation techniques provided evidence to support the view that several learning factors like thinking style, self-expression and communication skills were promoted through the programme. The assessment provided evidence that the students were both using practical reasoning, and interacting at a social level. These two major skills were the ultimate objectives of the proposed programme, and remain important factors of living and learning.

Student self-discipline was exercised in varying degrees. Most of the children needed gentle reminders to attend to their task, while a few required constant supervision. This pattern generally corresponded to the usual daily disciplinary problems. The informal teaching method could have increased the frequency of discipline problems, but this was not generally the case. However, the increased pupil autonomy in movement and their freedom in choosing their own topic of study, did cause some difficult moments. This was understandable. In addition, the students' previous exposure to group work had been limited: they were basically unfamiliar with working independently of the teacher, and thus, experienced moments of uncertainty.

The major accomplishment noted in the grade five students was in the ability of the children to work independently, both individually or in small groups. Their demand for teacher direction diminished as the programme progressed. This was due to various reasons - the similar lesson format of each activity, familiarity with the problem-solving sequence, and an increased growth of their self-confidence as they met with success in the programme.

Finally, there was sufficient evidence to indicate that the programme was successful. Since junior students like problem solving, the scientific method provided an effective vehicle for satisfying the general educational goal of a self-motivated thinker." Structuring the learning through group work drew out the necessary social skills, which in turn highlighted the general language skills, and boosted tolerance of others' differences. Improvement in oral communication was fostered by the identification and defence of their personal views. Written proficiency was advanced through completion of the assignments, and through culminating activities such as oral and written reports. Certainly, group interaction placed the learning of new concepts in a "fun" context - that of learning with friends.

Expressed succinctly, the assorted techniques for programme evaluation supplied evidence that science instruction contributed to the achievement of the general educational goals. Science was an appropriate subject for fulfilling the basic learning objectives.

CHAPTER V

CONCLUDING COMMENTS

Generally, it is expected that both novice and seasoned teachers will find the programme a worthwhile educational tool, and successfully test it in their own classroom setting. Lack of training or limited professional development in the subject is quite negligible. The author has not undertaken a science course over the last ten years. Despite this obstacle, the programme assessment of "Junior Science For General Education" attests to the success of the hands-on scientific approach.

Teaching the basic concepts at the elementary level offers an educational bonus. The teacher is more apt to concentrate on problem solving, since there is less emphasis on the content of the programme at this level than at higher academic levels. Also, the fact that the majority of the teachers teach science to their homeroom classes underlines the idea that science is for everybody.

The project was a useful curriculum aid for stimulating the pupils' interests in science exploration. The positive outcomes of the programme were evidenced by the high calibre of the pupils' personal investigations. Success was further evidenced in the children's choice of literature since they continued to read junior science texts after the programme ended. The students increased their understanding of the world around them in an entertaining way that will remain a memorable experience. In addition, the rapport between the teacher and the students was strengthened. They became better acquainted with each other, creating a more pleasant working atmosphere. Furthermore, the group activities provided the opportunity for developing positive social skills and extending their friendships.

RECOMMENDATIONS

Having assessed the programme, the author has several recommendations. When the children were working on their personal topic of interest, it was impossible to maximize the students' productivity. Due to the differentiation demanded by the final task, the groups were at dissimilar levels of attainment. As a result, the teacher was required to be all things to all pupils at the same time. The consequences of this pupil-centred task included "constant interruptions, divided teacher attention, lack of class supervision, and often teacher frustrations" (Bennett, 1976, p. 219). To diminish these factors, the benefit of additional assistance in the classroom, such as parent volunteers or secondary students should be considered. They could support the teacher's efforts in responding to the students more promptly. In future implementation, interaction skills will receive more attention. The teacher should take advantage of the fact that the programme can provide the opportunity to explore new friendships in an interesting learning environment. As a result, the choice of partners will be more teacher directed: students will be required to experience several working partners. From these diverse partnerships, the children will have a better criteria for selecting their final helpmate. These various combinations might even lead to a new friendship.

In promoting group dynamics, one should remember Tyler's (1949) recommendation regarding the manner in which behaviour can be modified. Therefore, a daily review of the observable student behaviour could be established as a routine. Having provided the basic requirement of learning - enabling students to learn in a "fun" group situation - the teacher should capitalize on this opportunity to discern insights into the students' behaviour through teacher observation.

More importantly, K. J. Dueck (1984) believes that "simply providing the opportunity for group involvement is not enough" (p. 70). Since instruction often proceeds as if students were proficient in the skills of group dynamics, she offers eight systematic steps to teach effective group skills. A social skill is identified for each activity, and it is followed by a description of the steps the teacher can pursue in conducting the activity. She also proposes a number of discussion questions which clarify the intended skills involved for both the teacher and the students.

Perhaps this plan could be implemented near the beginning of a school year to establish the ground rules for group interaction. This would eliminate teaching which views the children as readily proficient in group dynamics. At the least, it should decrease emotional working conflicts and the noise level inherent in an activity-based programme.

In addition to the criteria for the evaluation of the children's thinking-processes programme, written criteria for encouraging satisfying social interactions was stipulated. A criterion for "Group Observation" is provided near the beginning of Appendix C. This model should promote an objective, consistent assessment of attitudes. A teacher-student conference could also provide the learner with knowledge and insights into his behaviour.

If student apathy lingers, then G. R. Girod and G. R. Harmon (1987) provide possible strategies for influencing children towards more positive attitudes in social studies classes. Among the many selling tactics that a teacher can use, they list persuasion, developing inconsistencies, personalized contact, a show of competence, and simulations, as strategies to overcome the students' passiveness. The employment of these schemes helps alleviate stress in the classroom.

INTEGRATION OF SCIENCE

Should one integrate science with other subjects? If so desired by the teacher, science instruction could incorporate several other disciplines. About four decades ago, Tyler (1949) recommended integration. This is still a popular concept supported by the Ministry's (1987) current directives. As determined in the Science Council 's (1984) report Science Education In Canadian Schools, the inclusion of environmental studies at the elementary level provides an excellent opportunity for this integration to take place. In the implementation of the project, some integration such as library time for collecting resources, and art time for sketching observations and preparing exhibits, was immediately achieved. However, a broader plan is possible.

When the students are ready to present their personal investigations to the rest of the class, further language practice could be integrated. Invitations could be created and extended to other classes. Personal invitations could also be advanced to parents and relatives. This enrichment activity would accentuate the writing skills. Moreover, the programme assessment affirmed McBride's (1988) suggestion that such show-and-tell activities spur the students to complete their work more promptly. Such acknowledgement would also provide further reward for a job well done.

It is an accepted fact that people learn by repeated exposure to the learning experiences. Students need the same reinforcement. The skills of hypothesizing, designing a test procedure, gathering information and drawing conclusions are complex. Jacobson and Bergman (1980) suggest setting up activity centres to furnish reinforcement for the students at a later date. They outline the requirements for effective activity centres, and even provide examples of scientific tasks initiated either by the student or the teacher. In this manner, the pupils are offered a subsequent opportunity to develop the awareness of the world around them.

Since the artist and scientist share a habit - constant close observation of the world - incorporating drawing and painting in the science curriculum could strengthen intellectual process. In fact, according to G. D. Hamilton (1981), art appreciation involves such diverse skills as hypothesizing, analyzing, inquiring, verifying, comparing and evaluating. Thus, teaching science through art "sharpens our perception and expands our horizons. It can also open our eyes to our environment" (p. 25).

To further the students' appreciation of the manner in which subjects intertwine, the teacher could integrate creative writing with science. Apart from permitting the students to see the interconnectedness of their learning and allowing students to develop their writing skills, Doreen Housel's (1987) article makes a strong case for this integration. She posits that "the process of writing focuses attention on concept understandings" (p. 50). It offers an explanation of most types of poems, precise guidelines for poetry writing, and a "scientific" sample for each type of poem. Teachers can employ such creative ideas to monitor the children's scientific comprehension and language skills in engaging ways. This type of concept attainment lesson has the potential to enhance the students' thinking skills as they manipulate their understanding in novel ways. Once the content is mastered, the teacher may use poetry to extend the learning. Poetry forms such as haiku, acrostic, ballads, concrete poetry, picture poems and diamantes all can be part of an integrated approach to reinforcing the children's scientific concepts.

Amy Scharf (1987) reaffirms the indisputable fact that writing strengthens the basic scientific skills. Writing techniques learned in another subject can be used to broaden the learner's conception of nature. For example, she emphasizes pure observation by suggesting that her elementary pupils write an "I See" poem and an "I Hear" poem. She declares that the student responses were "phenomenal." Concluding that "observation is, after all, both a scientific and an artistic endeavour" (p. 8).

Clearly, the type of poetry that the teacher requests from the students will complement the type of information that the students are to acquire. Particular types of poetry work better with different conceptual understanding. For example, a haiku poem is effective in extending the students' observational skills, while an acrostic poem or ballad is effective for sharing information. Teacher discretion is required in applying such enrichment.

Do songs and singing belong in a science programme? George R. Hague (1987) reminds us that nobel prize winner J. J. Thomson wrote a song called "Ions Mine" sung to the tune of "Oh My Darling, Clementine." Here's a verse and chorus:

> In the weird magnetic circuit
> See how lovingly they twine,
> As each ion describes a spiral
> Round its own magnetic line.
>
> Oh my darlings, Oh my darlings!
> Oh my darlings ions mine.
> You are lost and gone forever
> When just once you recombine.

Another example from the same article includes science cheers.

> TNT!
> Dynamite!

The chemistry students
Are hot tonight!
Cis - Boom - Pow!
(p. 56).

Cheers in the science class can be a fun activity for both teachers and learners. A less dramatic teacher could forego the costume or prerecord the cheers. Allowing the children to write their own cheers in small groups is another alternative. Prior to this project, the author achieved success with such student activity as writing cheers, but never considered applying such an approach to science. In future implementation, scientific cheers could also be attempted.

Children have always enjoyed the excitement of "dressing up". Their excitement at the sight of a teacher wearing a costume at Halloween speaks for itself. Why, then, should dressing up be left only for Halloween? G. R. Hague (1987) suggests such appropriate scientific costumes as Albert Einstein, Santa Molecule, Chemi the Chemistry cheerleader and Ethyl the Ether Bunny. These characters are bound to bring entertainment to the subject of science, even if junior students may require an explanation of the terms.

In summary, the above variety of activities integrate science into core curriculum subjects. By incorporating art, poetry, writing and singing into the hands-on science approach, the curriculum would:

a) arouse the students' interests by using activities not ordinarily considered part of science studies.

b) demonstrate the interconnectedness of disciplines

c) reinforce conceptual science learning and

d) more importantly, establish science as part of their life.

All these extended activities can be accommodated in the project "Junior Science For General Education".

CONCLUSIONS

In the final conclusion, several important questions should be considered in light of the results obtained from the implementation of this project. The most important question deals with the subject itself. What is science? The response is not as simple as it may appear. Gradually, the students should come to know what this subject entailed. F. J. Rutherford (1983) emphasizes that the pupils should realize that the "boundaries of science are not defined by subject matter but by the kinds of questions asked, the kinds of procedures used, and the kind of answers sought" (p. 9). Thus, by virtue of what is done in the classroom, children should recognize when they are in scientific territory. This was a beneficial outcome that resulted from the programme, the modification of the children's image of "science". If seen as difficult concepts that require internalization and recall, science can be a bore. But as an adventure guided by a knowledgeable teacher, it can sweep children up to the excitement of discovery.

Moreover, the distorted stereotype of the scientist as a "mad scientist, whose experiments often go wrong" was slowly modified. A more accurate version of "scientist" emerged. This entailed someone who **does things** in a certain way, such as asking questions and seeking solutions through the scientific method, rather than a person "who wears a white lab coat". (Actually, most laboratory coats worn by scientists are far from white).

Through scientific experiences children build a more comprehensive view of themselves and the world in which they live. They have a chance to consider some of the broad generalizations of science, and to learn how to use abstract ideas. They also experience another approach to learning about their surroundings. Ultimately, they gain some of the scientific base that will assist them in appreciating future explorations which will take place during their lifetime. Since children live in a world of science technology, their present scientific experiences should help equip them in dealing with future adaptations.

Should knowledge be emphasized? Certainly incorrect concepts must be corrected. However, knowledge is not to be acquired merely for its own sake. Marcel Risi, in the Canadian Science Council's (1984) report entitled Science For Every Student, offers a critical analysis of the goals and methods of contemporary education. In the following account, he predicts that the innovative school system of the future:

> Education, like industry, will become holistic. In corporations, for example, it is not enough to combine disciplines and find the "recipe"; rather the task is to learn to combine, integrate and prioritize information flowing from the real world (p. 20).

In this vision of education, there is a shift from the acquisition of knowledge to its application. More and more information is now being stored in accessible form in computers. Thus, the difference between the skilled and unskilled will not be based upon what is known, but rather upon how well the knowledge is utilized. The Canadian Science Council's (1984) research suggests that "education for the world of work must therefore increasingly stress the information-processing skills that the citizen of the future will require" (p. 16). An active, activity-based science programme encompasses both the processes and knowledge that nurture a child's intellectual growth.

Was the teaching methodology successful? For each activity in programme, the pupils discovered more information concerning the manner in which to state their problems carefully, collect appropriate materials to solve problems, and to test and record their findings more effectively, than through any other strategy. According to Glenn Blough and J. Schartz (1969), learning how to use the process of discovery is one of the important goals of teaching. Our success in living with one another is increased if we are skillful in solving daily problems. The solutions involve knowing what is pertinent information, learning how to apply it and checking the validity of results. These talents parallel the scientific method.

Will the transaction approach always motivate students? If this is the dominant methodology practised for science exploration the children should gain expertise in first-hand investigations. This method can be modified for use in whole-class, small-group and individualized instruction. It should be stressed that this hands-on transactional approach is not the one and only method of teaching. The instructor should have a repertoire of various teaching models, ranging from a transmission to a transaction and transformational approach. The appropriate model of instruction could then be applied to the curriculum. Perhaps a progression of all three teaching modes may be required, as was evidenced in the project.

Why insist on a cognitive-process approach? The influence of an activity-based science programme goes beyond the acquisition of process skills and positive social attitudes. B. J. Gustafson (1986) concludes that "a hands-on program is also an internal process where children can begin to experience what it is to be at home in the world, learn about life and science, and encounter a vision of what can be" (p. 27). Other researchers have made similar observations. It is time to implement such conclusions if today's children are to be prepared for the future demands placed on the environment.

Is group interaction a necessity? That the problem-solving skills could just as easily be taught using learning centres where the students progressed at their own pace by completing task cards, is inarguable. The children could even perform their experiments independent of others. However, as Jacobson and Bergman (1980), point out:

> Many of our problems and those our children will face can be resolved only through the cooperation of many people and this makes it critically important that all children receive an education that equips them to analyze and work with others in the resolution of these problems - the solutions to most of our environmental problems such as the desecration of our parks or the pollution of our hydrosphere and atmosphere cannot be dictated from above but require informed cooperation (p. 21).

Thus, communication, co-operation and compromise are essential skills for today's growing population.

In addition, curiosity and a sense of wonder are precious qualities. Robert E. Yager (1987) emphasizes that "real advances in science begin with curiosity, which is refined and expressed in questions" (p. 22). Many young children come to school rich with these attributes, but the desire to discover is stunted by the time they leave elementary school. Perhaps, this is an outcome of maturation or the result of the kinds of educational experiences the children have had. If the lack of curiosity is caused by the latter reason, appropriate teaching methods may appeal to the children's inherent sense of wonder.

Finally, there is still another reason for an empirical approach. It is found on the faces of children as they discover the scientific cause for some aspects of our environment, hereto unquestioned.

Trite but nonetheless true, our children's future depends mainly on their educational opportunities. It is the author's hope that by introducing young children to problem solving in science education in a way which is consistent with modern educational thinking and practice, they will develop a lifelong appreciation and understanding of the subject. Jacobson and Bergman (1980) appropriately quote H. G. Wells, "Human history becomes more and more a race between education and catastrophe" (p. 21).

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APPENDICES

The source of the "Group Observation Sheet" in Appendix C is unknown: it was collected throughout the years of practical experience and professional development. However, the specific lesson objectives on "Matter" and "Magnets" are modified from curricula aids from the Hamilton-Wentworth Roman Catholic Separate School Board, while the concepts on "Light" are adapted from the Hamilton Board of Education.

Some of the illustrations are reprinted from Robert D'Alessandro (1980). The page number of each illustration is indicated in the booklet.

APPENDIX A

APPENDIX A STUDENT QUESTIONNAIRE

1. When you hear the word science, what thoughts come to your mind? ______________________________

   ____

2. Did you study science in the primary grades? What topics?

   ____

   ____

3. Have you ever set up and done an experiment by yourself, or with a classmate? Which one?

   ____

   ____

4. Have you written up an experiment using the scientific method, for example, using such terms as PROBLEM, PROCEDURE etc.? ______________________________

   ____

5. Would you like to study science using the scientific method of first-hand investigations? ______________

   ____

6. Do you like this subject? Why or why not?______________

   ____

7. When you hear the word scientist, what comes into your mind?

   ____

STUDENT QUESTIONNAIRE

1. When you hear the word <u>science</u>, what thoughts come to your mind? ______________________________

2. Did you study science in the primary grades? What topics? ______________________________

   ____

3. Have you ever set up and done an experiment by yourself, or with a classmate? Which one?

   ____

   ____

4. Have you written up an experiment using the scientific method, for example, using such terms as PROBLEM, PROCEDURE etc.? ______________________________

   ____

5. Would you like to study science using the scientific method of first-hand investigations? ______________

   ____

6. Do you like this subject? Why or why not? ______________

   ____

7. When you hear the word <u>scientist</u>, what comes into your mind? ______________________________

   ____

8. What sort of persons should become scientists? ________

   ____

9. Should girls become scientists? Why or why not? ______

   ____

APPENDIX B

APPENDIX B LEARNING EXPERIENCES

Two different types of learning experiences were anticipated in the programme; problem-solving and group interaction skills.

PROBLEM-SOLVING MODEL

One of the difficulties in teaching problem solving is that people can become confused about the labels associated with the various steps. The Ministry lists an eight-step sequence for problem solving, while Ross and Maynes (Miller and Seller, 1985) extend this outline to a more complex eleven-step model.

The following illustrates the sequence of stages involved in problem-solving at the junior level. For the sake of clarity, the author has expanded some of the main skills:

1) Exploring: The students concentrate on materials using the five senses. In the process, they identify their interests of study and formulate questions.
2) Identifying: The pupils generate some questions on a basic topic in order to narrow their focus to one problem.
3) Hypothesizing: The students, with the teacher's encouragement, imagine the problem and predict a possible solution. Ross and Maynes (Miller and Seller,

1985) claim that "this is the most important skill in problem-solving" (p. 100). They refer to this step as "establishing a framework".

4) Planning and collecting: The children obtain information about the problem by conducting an experiment. They identify resources such as books and equipment that will help them discover the solution to their problem. They carry out the experiment and record their findings.
5) Interpreting: The students select the relevant information, analyze the data and determine the best answer to the question. They may also draw comparisons or require further data.
6) Evaluating: The children check the effectiveness of their problem-solving techniques. By evaluating the original hypothesis, they realize whether or not their predictions are sound.
7) Communicating: the students decide on the best way to present their findings: oral reports, written reports, murals, charts, etc., and record their investigations using the four principle headings of PROBLEM, PROCEDURE, OBSERVATIONS and CONCLUSION.
8) Applying: The children seek examples from their own experiences to illustrate what they have learned.

GROUP SKILLS

Group work is extremely important at the junior level. These reflect some of the important group skills suggested by the Ministry (1987) project, Science Is Happening Here:

a) Co-operation: The students develop sensitivity in dealing with the feelings and concerns of others.

b) Communication: The students express their ideas, feelings and achievements to their peers. (This is further reinforcement of one of the problem-solving skills).

c) Compromise: The students share the supplies and consolidate their learning into one conclusion.

APPENDIX C

APPENDIX C GENERAL OVERVIEW

LESSON	TIME	OBJECTIVE
1.	45 minutes	To elicit students' interest in science To identify various different topics for scientific study.
2.	45 minutes	To review and understand the basic process.
3.	45 minutes	To introduce the proper method for recording an experiment.
4.	45 minutes	To reinforce the problem-solving sequence by discovering what substances magnets attract.
5.	1 hour	To reinforce the problem-solving sequence by discovering the path of light.
6.	1 1/2 hrs.	To reinforce the thinking skills by devising and executing a test to discover what substances transmit light.
7.	1 1/2 hrs.	To focus attention on one scientific topic of study interest.
8.	4 hours	To demonstrate the cognitive-process skills by formulating a clear problem and hypothesis on a particular topic.
9.	1 1/2 hrs.	To communicate the scientific discoveries to others.
	Total time 12 3/4 hrs.	

GROUP OBSERVATION SHEET

NAMES

ROLES														
Initiating activity														
Seeking clarification														
Giving clarification														
Summarizing content														
Evaluating														
Testing for agreement														
Encouraging														
Maintaining standards														
Mediating														
Reliving tensions														
Summarizing feeling														
Drawing new members in														
Being antagonistic														
Seeking attention														
Withdrawn														

RESOURCES

The following lists the necessary resources. The numbers will vary to accommodate the class size and the number of working. It is assumed that the students already have access to a pencil, ruler, eraser, and pencil crayons. The timetable of the remedial teacher was consulted, in to ensure that the remedial students would be assisted during this science programme.

Lesson 1: coloured construction paper, wax crayons, scissors, variety of junior science library books, transparency labelled SCIENCE

Lesson 2: graph paper for each group

Lesson 3: 2 plastic glasses, warm water, a whole sugar cube, a crushed sugar cube (plastic bag and mallet for crushing the cube), worksheets

Lesson 4: envelopes labelled with the objects and the material-composition of the objects contained, e.g. brass fastener, nickel-covered tacks

Lesson 5: flashlights, drinking straws, worksheets, additional personnel such as the librarian

Lesson 6: flashlights, foil, cardboard, paper styrofoam, wax paper, plastic cups, and worksheets for each group

Lesson 7: science textbooks (same as used in Lesson 2), newsprint, SCIENCE topics art displayed (Lesson 1), list of student questions (compiled throughout the unit), list of resource problems reprinted from Robert D'Allesandro's booklet

Lesson 8: research from previous lesson, project sheets

Lesson 9: resource personnel to evaluate exhibits

SCIENTIFIC TOPICS

LESSON 1

TIMELINE: 45 minutes

AIMS: To elicit students' interest in science.
To identify the different topics of scientific study.

MATERIALS: scissors
crayons
coloured construction paper
selection of library science textbooks
transparency sheet

METHOD:

1. Transform the classroom into a tiny science library by randomly placing a selection of science books around the room.

2. Encourage the children to browse through several different books in order to become familiar with the variety of scientific topics.

3. Brainstorm the diverse topics and record them on the transparency sheet.

STUDENT ACTIVITY:

1. Observe and predict how the art sample was constructed, The teacher guides the students to imagine the sequence of steps.

2. The pupils choose a topic of interest and illustrate the word in a pictorial manner. These will decorate a Science bulletin board display.

THE SCIENTIFIC PROCESS

LESSON 2

TIMELINE: 45 minutes

AIM: To understand and review the basic principle of the scientific process.

METHOD:

1. The teacher will say: Rest your head on your desk and close your eyes. I am going to take you on an imaginary journey,through time. We'll go back to when everyone was in primary. Think of activities where you looked and touched different materials in order to learn.

2. Do you remember your teacher taking you for a walk in the fall to collect the fallen leaves? Then in class, you examined the leaves and answered the questions: How would you organize these leaves into groups? Do you remember what sense you used? You used your eyes to place them into groups having similar shapes. That was science.

3. Do you remember "Show-and-Tell" time when you brought your pet to class and explained how you had tried different food to discover which was the favorite. That was science.

4. Do you remember experimenting with paint, mixing different colours to discover which ones mixed together would make another colour? That was science.

* Through such accounts the children are indirectly taught that scientists have a problem, try out their solution to the problem, observe the results, and state a conclusion or answer.

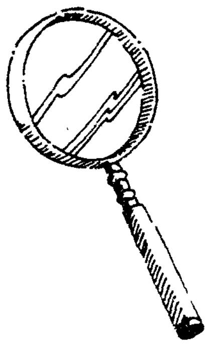
STUDENT ACTIVITY:

1. The class discusses the criteria used in the primary grades to classify and organize the leaves during their primary science experiences, e.g. classifying leaves by shape or colour.

2. They establish the senses used: sight, touch, hearing, smell and taste.

3. In groups of two, the students share their past experiences where the senses had been used to learn about their environment. They identify the sense used in each situation.

4. The students graph the experiences indicating the senses involved in each situation. A chart may also be used.



SCIENCE

Name:____________________

The subject SCIENCE spans a broad range of topics. Some examples are:

SCIENTIFIC PROBLEM SOLVING

LESSON 3

TIMELINE: 45 minutes

AIM: To introduce the proper method for recording a scientific experiment.

MATERIALS: two glasses, warm water, worksheets, a whole sugar cube, a crushed sugar cube

METHOD:

1. Provide the students with the problem-solving worksheet.

2. Through a Socratic discussion with the children, the teacher wearing a "white lab coat" will focus the students' attention on the scientific terms used on the worksheet. (According to the preliminary student survey, a white laboratory coat was the identifiable sign of a scientist.)

3. The teacher asks: What's the PROBLEM we have to solve? The students read it orally from the worksheet.

4. The children are encouraged to predict the answer and to share their prediction with the class, beginning their answer with, "My hypothesis is ...". Thus, the scientific term HYPOTHESIS is applied. The students record their choice on their papers.

5. The teacher evokes suggestions for solving the problem. The responses are recorded on the board encouraging a step by step procedure. The major steps are highlighted. On their paper the students record the principle steps.

6. The teacher demonstrates the procedure, aided by students who volunteer suggestions and participate in the experimentation.

7. Through a discussion, the students are guided in their observations and express the changes viewed in their own words.

8. The teacher elicits the results of the procedure, by asking, "What did we discover?" The children record their discovery, which is identified as the CONCLUSION.

9. The students are encouraged to use their new vocabulary within the proper context.

* This is a good time to introduce the idea of controlling variables. For the grade 5 students, this concept was successfully taught as "ways to keep the experiment fair". For example, by keeping the temperature constant, as well as the amount of water the experiment was judged fair. These conditions were all elicited from the children themselves by teacher directed questions.

STUDENT ACTIVITY:

1. The children draw a diagram of the experiment labelling it appropriately in print, on the accompanying worksheet.

2. The teacher asks: Are there any questions you would like to ask about the experiment?

* Any questions formulated from the investigation are recorded and displayed in a central location. Other questions will be added to the list as the programme is executed.

STUDENT WORKSHEET

Name:__________

TOPIC: MATTER

PROBLEM: Which dissolves faster in warm water, a whole sugar cube or a crushed sugar cube?

HYPOTHESIS:

I think that if I________________________________
_____________than the (crushed or whole cube)_______will dissolve faster.

MATERIALS: two _______ whole sugar ____
warm w____ crushed _____ cube

PROCEDURE:

(What steps will I follow in my testing procedure in order to discover the answer?)

1.____

____

2.____

____

3.____

____

4.____

____

____

____

____

DIAGRAM:

OBSERVATIONS:

(What changes did I see?)

I saw ____

____

CONCLUSION:

(What have I discovered?)

I learned that ___________________________________

____

MAGNETS

LESSON 4

TIMELINE: 45 minutes

AIM: To reinforce the problem-solving sequence by discovering what substances magnets attract.

MATERIALS: worksheets
an envelope for every group of two pupils labelled with the names and the material composition of the objects contained inside

For example:
- nickel-covered tack
- copper penny
- metal staples
- brass fastener
- rubber eraser
- your own choice of substances

METHOD:

1. Provide students with papers and ask them to read the papers over silently.

2. Guide the students to orally read over their assignments by asking leading questions.

a) What is our PROBLEM?

b) What do you predict the magnet will stick to? Write down your prediction. This is your HYPOTHESIS. What test will you devise to discover the answer? This is also part of your HYPOTHESIS.

c) Consider the steps involved in carrying out your test. Organize and record them in the appropriate sequence. This is your PROCEDURE.

d) How will you record the results? After eliciting some suggestions, the teacher will direct the pupils' attention to the accompanying chart. The pupils are lead to realize the efficiency of using a chart in collecting such data.

STUDENT ACTIVITY:

1. The students are now prepared to execute the experiment by following the instructions on their worksheets. The teacher circulates to keep the children motivated.

2. The groups that have completed their experiment and worksheets, join another group in order to compare discoveries.

3. The teacher consolidates and reinforces the learning by engaging the children in an oral discussion of their tasks. By asking leading questions, special attention is given to formulating a proper CONCLUSION.

4. The group demonstrates their testing procedure and discoveries to the class.

* The teacher elicits and records any further questions that arise about MAGNETS. As the study proceeds, other questions will be added to the list. These will be used in the final project.

STUDENT WORKSHEET

Name:_________

TOPIC: MAGNETS 

PROBLEM: What kinds of materials will stick to a magnet?

HYPOTHESIS:

(What kinds of materials do you think will stick to a magnet and how will you discover the answer?)

I think that if I____

____

then____

____

PROCEDURE:

(Consider your proposed test. Write down the steps to follow.)

1. ____

____

2. ____

____

3. ____

____

4. ____

____

____

OBSERVATIONS:

(What did you see happen? Record your information in an organized manner. You may use the chart.)

NAME OF OBJECT	METAL OR NON-METAL OBJECT	MAGNET STICKS	MAGNET DOESN'T STICK

The materials which stick to a magnet are called <u>magnetic materials;</u> all other materials are called <u>non-magnetic</u> materials.

CONCLUSIONS:

(What did you learn?)

1. a) List the objects that you tested that stuck to the magnet. ______________________

   ____

   b) Were the objects that stuck to the magnet made of metal?

   ____

2. a) List the objects that you tested that did not stick to the magnet.

   ____

   b) Were the objects that did not stick to the magnet made of metal material?

   ____

   ____

LIGHT

LESSON: 5

TIMELINE: 60 minutes

AIM: Reinforce the scientific format for recording experiments by investigating the path of light.

MATERIALS: transparency proving the new vocabulary with its definitions
a flashlight and a drinking straw for each group

METHOD:

1. Provide students with worksheets and invite them to read the assignment.

2. Guide the students to delineate the necessary sequence of steps for problem solving , by asking leading questions. The students are assisted in completing the PROBLEM, HYPOTHESIS and PROCEDURE by using a Socratic method.

STUDENT ACTIVITY:

1. In groups of two, the students execute the experiment and complete the papers independently. The teacher assists only those in need.

2. They prepare to share their learning with the class.

3. The students demonstrate their procedure and discoveries to the class.

* The teacher asks: Are there any further questions that arise about "Light"? Any problems raised are carefully stated and recorded for future reference.

PROBLEM-SOLVING TERMS

Name:__________

TOPIC:	- Title of your personal area of study
PROBLEM:	- State it in the form of a question.
HYPOTHESIS:	- Offers solution to your problem, after reading background information. - Write it in form of a statement.
MATERIALS:	- List materials needed. - Let teacher know if you require school supplies.
PROCEDURE:	- Explain the steps of your experiment clearly. - List in proper order so that others can follow your testing method.
OBSERVATIONS:	- Record what changes you see using charts, graphs, diagrams, sentences, etc.
CONCLUSION:	- Write in a sentence what you learned due to the results of your experiment. - Relate your findings back to your hypothesis. Was it accurate? - Accept or reject your hypothesis.
APPLICATION:	- Explain how your findings could apply to other situations, if possible.

SCIENCE PROJECT WORKSHEET

Name:__________

TOPIC: Light

PROBLEM: Along what type of path does light travel?

HYPOTHESIS:

I think that if I____

____

then ____

____

MATERIALS:

____

____

PROCEDURE:

(Write down the steps of your testing procedure.)

1. ____

____

____

____

____

____

____

____

DIAGRAM:

OBSERVATIONS:

1. I saw that ______________________________

____

2. ______________________________

____

____

____

CONCLUSIONS:

I learned that light travels ______________________________

____

____

LIGHT

LESSON 6

TIMELINE: 1 1\2 hours

AIM: Reinforce the inquiry format by devising and carrying out a test to discover what substances transmit light.

MATERIALS:

a flashlight	paper
foil	styrofoam cups
waxed paper	cardboard
plastic cups	other substances

METHOD:

1. Push the desk together to facilitate group work.

2. Distribute the assignment.

STUDENT ACTIVITY:

1. The students choose a partner, devise, set up and carry out their procedure. The teacher circulates the classroom, anticipating any problems.

2. The students prepare to share their learning with the rest of the class.

3. Each group performs their testing procedure and shares their discoveries with the rest of the class.

* Any further questions raised on the subject of "Light" are recorded in a central location, along with prior questions on "Matter" and "Magnets".

STUDENT WORKSHEET

Name -----------

TOPIC: <u>LIGHT</u>

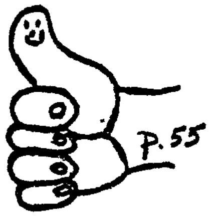
PROBLEM:

1. With your partner, determine "Through what types of substances can light travel?"
2. Devise an experiment, using the scientific method to discover the answer.
3. Carry out the experiment, make your observations and drawing your conclusions.
4. Complete the worksheet.
5. Be prepared to communicate your discoveries with your classmates.

* After the presentation, the teacher asks, "Are there any further questions about LIGHT that arise from your investigation?" The teacher records any problems voiced, to the list of questions from the previous activities.

SCIENCE PROJECT WORKSHEET

Name:__________



TOPIC: Light

PROBLEM: ____

HYPOTHESIS:

I think that if I____

____

then ____

____

MATERIALS:

____

____

PROCEDURE:

(Write down the steps of your testing procedure.)

1. ____

____

____

____

____

____

____

____

DIAGRAM:

OBSERVATIONS:

1. I saw that ____

____

2. ____

____

3. ____

____

CONCLUSIONS:

I learned that light is transmitted _______________________

____

____

____

BACKGROUND RESEARCH

LESSON 7

TIMELINE: 1 1\2 hours

AIM: Focus attention on one scientific topic of interest, to establish background information for personal investigations.

MATERIALS: junior science books
newspaper paper
SCIENCE bulletin board display
list of questions compiled from previous investigations

METHOD:

1. Through discussion, all the topics displayed on the bulletin board are reviewed.

2. Review all the questions generated from the previous lessons on MATTER, LIGHT and MAGNETS. Brainstorm any further questions on these topics and on any other topics raised.

3. In a plenary discussion involving the whole class, the teacher leads the students to formulate questions on their chosen topic.

STUDENT ACTIVITY:

1. In groups of two, the students choose their topic of study and list six or seven questions they would like to research on the accompanying worksheet. The "learning by doing" methodology is highlighted.

2. In a teacher-student conference, the questions are reviewed. Students requiring assistance in formulating appropriate questions are assisted.

3. The students locate their resources (books, films, posters, people) research and answer their questions in detail.

4. The students revise their notes. The teacher may be consulted at this point.

5. The students, under the direction of the teacher organize their findings in a pleasing manner i.e. booklet, poster, interview, notes.

DEVISING A SCIENCE EXPERIMENT

LESSON 8

TIMELINE: 4 HOURS

AIM: Demonstrate the cognitive-process skills by formulating a clear problem and hypothesis on a topic of interest.

MATERIALS: personal research information from the previous lesson worksheets
list of questions compiled from previous activities.

METHOD:

1. The teacher guides the children to review their research from the previous activity, in preparation for choosing their own problem and hypothesis.

STUDENT ACTIVITY:

1. In groups of two, the pupils choose either a question that is of particular interest, or a fact that especially surprising.

2. They devise a test procedure to discover the answer to their question or to discover the "surprising fact" for themselves.

3. Verify their test in two ways:
   a) experimentation
   b) student-teacher conference.

4. Complete the worksheet, stating their TOPIC, PROBLEM HYPOTHESIS, PROCEDURE etc.

5. Students revise their procedure as needed. The teacher suggests possibilities only when necessary or when the children's experiences are limited.

6. They repeat their experiment to clarify the observations.

7. Each group prepares to present their problem and procedure in an effective manner.

* The teacher should review effective ways of reporting and speaking to a large group. For example, the speaker should talk clearly, loudly, and with expression, as he or she makes eye contact with the listeners.

The concept of <u>controlled variables</u>, better known in grade five as, "ways to keep the experiment <u>fair</u>," is also reviewed.

POSSIBLE PROBLEMS

With the teacher's support, the students formulated the following question after completing the appropriate investigations.

MATTER:

1. Which sugar cube will dissolve faster in cold water the whole sugar or the crushed sugar cube?
2. Which cube would dissolve faster if the solutions were stirred, the whole sugar cube or the crushed sugar cube?
3. What if tea, coffee, or milk was used for the solution, which sugar cube would dissolve faster?

MAGNETS:

1. How could you make a magnet?
2. What coins will stick to a magnet?
3. What happens when you touch two magnets, tip to tip?
4. How strong is a magnet?

LIGHT:

1. Can light rays be bent?
2. Is light needed for growing plants?
3. What colours are there in light rays?
4. Does light pass through light-coloured materials?
5. Does light pass through dark-coloured materials?

SCIENCE PROBLEMS

1. Do mealworms have a sense of smell?

2. What brand of paper towel absorbs the most water?

3. What type of detergent removes the most dirt?

4. How does the depth a seed is planted affect its growth?

5. Design and build bridges out of straws and straight pins. Determine which design is the strongest and why.

6. How does the shape of an ice cube affect the rate at which it melts?

7. What characteristics of a paper airplane affect the distance it can be made to fly?

8. How does the time it takes an ice cube to melt in air at room temperature, compare with how long it takes an ice cube to melt in water at room temperature?

9. What type of cup will maintain the temperature of a hot drink?

10. What native birds and animals can be found in your neighbourhood?

11. Can insects be located during the winter? What happens if these insects are brought indoors?

12. What plants can be grown without soil?

13. What conditions promote the growth of algae in an aquarium?

14. How is the pulse rate affected by:

    (a) sitting
    (b) standing
    (c) eating
    (d) 5 pushups
    (e) 1 minute of skipping

15. How fast do your fingernails grow?

16. How much food does a hamster eat in a day (gerbil, dog, cat)?

17. What determines whether an object will float?

18. From which direction does the wind blow most frequently where you live?

19. How accurate are old-time weather signs and savings? Choose one and test it out.

20. Are students more restless during cloudy weather?

21. What brand of chewing gum will hold its flavour the longest?

22. What brand of food does your pet prefer to eat?

FINAL ACTIVITY

Name:________

Your project will consist of: BACKGROUND RESEARCH, an EXPERIMENT, an EXHIBIT and an ORAL PRESENTATION in order to share your discovery with others.

RESEARCH:

1. Topic: Choose your topic and list 6-7 questions you will research.
2. Background: Brief notes should be made when you are reading pertinent information about your topic.

   Decide on a method for sharing your findings with the class.

EXPERIMENT:

1. Problem: This should be stated in the form of a question.
2. Hypothesis: This should be in the form of a statement that offers a possible solution to the problem. Your hypothesis should be based on your background information, not guess work.
3. Materials: Decide on the equipment needed. Consult with the teacher if necessary.
4. Procedure: Write the steps for testing your hypothesis.
5. Observations: Record the changes you see after performing your experiment, in charts, graphs or notes.
6. Conclusion: State what you learned from the results of your experiment, in a sentence.

SCIENTIFIC EXHIBITS

a) Prepare your display board by choosing the background colour and the contrasting border.

b) Organize your research, experiment and diagrams in a visually pleasing arrangement. Glue these to your board. Others should easily share in your findings.

ORAL PRESENTATION:

a) Decide on how you will present your discovery.

b) Prepare and practice your delivery and scientific procedure in front of another group, in preparation for the final class presentation.

STUDENT WORKSHEET

Name----------------

TOPIC: ____

POSSIBLE PROBLEMS:

Remember to choose questions that begin with WHAT, WHEN, WHY, WHERE and HOW. They should be precise problems that lend themselves to first-hand investigations.

1. ____
____
2. ____
____
3. ____
____
4. ____
____
5. ____
____
6. ____
____
7. ____
____

RESOURCES:

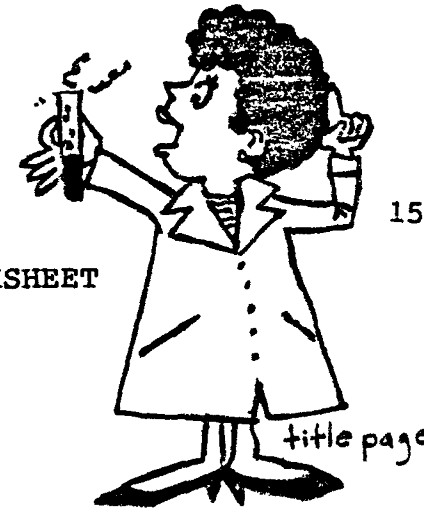
(Check which resource materials you could use.)
I may need to use

__ books
__ filmstrips
__ nature
__ people
__ posters
____

For performing my experiment I will need the following supplies: ____
____

COMMUNICATING MY DISCOVERIES:

I will share my information with others by ______________
(booklet, poster, interview, oral report, chart, graph)



SCIENCE PROJECT WORKSHEET

Name:__________

TOPIC: __________

PROBLEM: ____

____

HYPOTHESIS:

I think that if I ____

____

then ____

____

MATERIALS:

____

____

PROCEDURE:

(Write down the steps of your testing procedure.)

1. ____

____

____

____

____

____

____

____

DIAGRAM:

OBSERVATIONS:

I saw that ____

____

____

____

____

CONCLUSIONS:

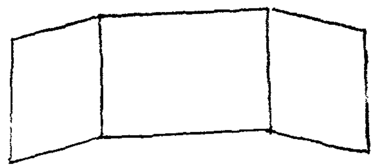
I learned that ____

____

____

ORGANIZING AN EXHIBIT

LESSON: 9



TIMELINE: 45 minutes

AIM: Communicating the scientific discoveries to others.

MATERIALS: large box and
scissors for each group
3 or 4 science displays from the intermediate students
coloured construction paper
glue

METHOD:

Through a Socratic dialogue with the children, and observation of the displays provided, the preparation of a display model is demonstrated. The teacher ask leading questions like:

1. How is the topic indicated? (in large, coloured letters)

2. How do scientific terms stand out from the background? (contrasting colours have been used).

3. How has the pleasing appearance been achieved? (only 3 to 4 colours are used, neatly written, well-spaced, organized appearance with a centre of focus).

4. How is the work presented? (various ways, such as charts, notes, pictures, magazine articles).

5. How has the display been framed? (with a paper border).

STUDENT ACTIVITY:

1. The students plan their displays on newsprint, and decide the colours they would like to use.

2. They choose their construction paper.

3. They cut out or colour the scientific terms in a

contrasting colour.

4. They organize their research, experiment and diagram in an effective arrangement.

5. They prepare an interesting report for their presentation.

6. When presenting their work, the students encourage others' ability to predict outcomes by posing their problem to the class, in order to draw out possible hypotheses and conclusions.

7. They share their problem, procedure and discoveries by executing their experiment.

8. They are prepared to answer any questions from the class since they have done the background reading.

* The teacher reminds the students of the prior evaluation criteria which was stated on the paper entitled FINAL ACTIVITY.

APPENDIX D

APPENDIX D PERMISSION ROUTINE

The permission cards granted leave to go to the girls' washroom, the boys' washroom and the school's library. Through past trial and error, the author discovered that three library pockets accompanied with the appropriate cards is the most effective method for allowing limited movement. There is allowance for only one girl to use the girls' washroom, one boy to be in the boys' washroom, and another pupil to visit the library. Thus, three is the maximum number of pupils permitted out of the classroom at any given time.

Below is a probable scenario for a girl who needs to use the toilet.

EXAMPLE:

> Mary needs to use the toilet. She checks the girls' washroom card. If the card protruding from the pocket shows a green circle, this symbol indicates she has the "green light" to leave her desk, go to the permission card and turn it over to the red circle. This indicates to the remaining girls that they have the "red light". They cannot leave their desks since the card is already being used. Meanwhile, Mary walks out to the washroom. When she returns to the classroom, Mary turns the girls' washroom card so that it displays the green circle- the symbol that the girls' washroom may now be used.

A similar routine would be followed by a boy wanting to use the boys' washroom, or any student desiring to visit pupil be permitted at each locality, the children were discouraged from congregating at one particular place.

APPENDIX E

APPENDIX E BUDGETING MY TIME

DATE	SIGNATURES		JOBS TO DO
	TEACHER'S	STUDENT'S	
			identify a precise problem
			start background reading and record pertinent notes
			decide on testing procedure
			repeat experiment to check results and keeping the test a fair one
			evaluate results as they relate to the original problem and hypothesis, to decide on the relevance of your hypothesis
			write up experiment using the scientific method
			prepare written research including pictures and charts
			organize display board to enable others to share your results
			prepare and practise oral presentation of experiment and any other relevant information

* Please see the teacher after you complete each level.