

ISSUE-CENTERED STS (SCIENCE-TECHNOLOGY-SOCIETY) IN THE ELEMENTARY CLASSROOM:

A CASE STUDY

by Larry Verstraete

A thesis  
submitted in partial fulfillment of the  
requirements for the degree of Master of Education  
in the Department of Mathematics and Natural Sciences  
University of Manitoba



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LARRY VERSTRAETE

A thesis submitted to the Faculty of Graduate Studies of  
the University of Manitoba in partial fulfillment of the requirements  
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MASTER OF EDUCATION

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## ABSTRACT

In 1984, the Science Council of Canada published a major report which reviewed the state of science education across the nation. Included in its recommendations were proposals calling for the inclusion of a science-technology-society (STS) emphasis in science programs at all grade levels.

One approach to STS has been labelled the issue-centered approach in this thesis. Such an approach explores a selected socio-scientific issue, problem or application. Scientific concepts and skills are developed en route in the exploration process and are viewed as tools to understanding.

The intent of this study was to examine the issue-centered approach to STS. Using a five-stage organizational framework derived from current literature, an STS unit revolving around the issue of snow removal and snow dumping in Winnipeg was planned, developed and implemented in a grade 4 classroom.

Ethnographic methods were employed to gather and analyze classroom data. Journal writings, interviews and classroom observations traced the events, interactions and perceptions of the participants and provided an indepth picture of the issue-centered unit in action.

This study suggested that, given consideration to resources, time limitations, the nature of the selected issue, and the skills and degree of preparedness of the teacher and students, issue-centered STS, as organized around the five-stage framework, is a viable approach to STS at

the elementary level. Furthermore, the issue centered approach satisfies many of the aims of STS and the recommendations proposed by the Science Council of Canada.

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## Chapter 1 - INTRODUCTION

During the past decade there have been major science curriculum reviews both in the United States and in Canada. The main thrust of these studies was to investigate the past and present state of science education, to determine the needs of science education for the future, and to propose recommendations for change.

A gap between what science education was supposed to achieve and what science education actually achieved was obvious to the researchers involved in the studies. In part, science education practices failed to prepare students for the challenges of the future, for the scientific, societal and technical decisions and issues ahead. Consequently, a major refocusing of science education was recommended in order to bridge the gap between science, technology and society. Efforts to link the science, technology and society facets of science education have been called science-technology-society or STS.

Kliebard (1975) stresses the importance of maintaining a historical perspective when engaging in curriculum evaluation and revision.

This involvement with the past need not be construed as formal historical writing, but rather as a kind of dialogue across generations about the basic concerns of the field. By engaging in such a dialogue, present-day practitioners are at least aware of the ideas and the forces that have helped shape their field and their thinking....such an approach does serve to provide some sense of continuity and direction, and, for me at least, offers a broad perspective on the state of the curriculum field generally and on certain curriculum issues in particular. (p.39)

To better understand the STS focus, then, and its implications for the teaching of elementary science - the major theme of this thesis - a review of the historical influences promoting change is required. An examination of where science education has come from, as well as where science education is going, is needed.

## HISTORICAL PERSPECTIVES

### Background to Change: Antecedents to STS

Many historians mark the year 1957 as a major turning point in science education. On Oct. 4 of that year the Soviets launched Sputnik I. The western world realized the disparity between existing science education and the rapid changes in science and technology. It became clear that the educational system was lacking. An upper edge in the space and military race could be achieved only through a revamped curriculum, one that stressed achievement in science above everything else (McCormack, 1985).

Bruner (1960), following John Dewey's earlier progressive-experiential lead, proposed a discipline-centered curriculum that emphasized the development of scientific skills or processes through discovery and inquiry methods. Teams of scientists, educators and psychologists decided the content and structure of each science subject and based instructional changes on the latest research on learning styles. Students, emulating the techniques and approaches of the scientist,

searched for new knowledge and solved problems. The emphasis was on pure science, academic excellence and careful preparation for a future generation of scientists (Kyle, 1984; Yager, 1981).

Course development and teacher preparation received vast support during the years between 1955 and 1974, an era which has come to be called The Golden Age of Science Education. An estimated five billion dollars was funnelled into K-12 science curriculum developments in the U.S. (Yager, 1981). Dozens of new curricula were developed and hundreds of inservice hours were devoted to training teachers. The stress was on departmentalization, team teaching, process skills, conceptual schemes, objectives, taxonomies and content (Marcuccio, 1987). The impact of new U.S. programs spread beyond its borders as many other nations, including Canada, followed its example.

In the 1970s support for the movement waned. The Americans had conquered space and the gap in Soviet and U.S. technology had narrowed. The immediate goals that had set the wheels of change into motion had been seemingly accomplished.

With the flood of materials and programs now available, however, there was diversity instead of uniformity. A wide range of goals, philosophies, methods and materials seemed to be in use (Pratt, 1981). A 'back to basics' movement was adrift which shifted emphasis away from science (Marcuccio, 1987). At the same time other concerns had surfaced, among them environmental degradation, depletion of natural resources, urban strife, and the threat of nuclear warfare. Japanese superiority in

industry and technology threatened the American technological advantage. These factors again forced questions to be asked of the scientific community, educational institutions and governments (Yager, 1981). It was apparent in Canada, the U.S., and around the world that the goals and outcomes of science education needed to be re-evaluated.

In the United States, the National Science Foundation (NSF) commissioned studies to assemble information on the status of K-12 education. In addition, a nation-wide assessment of science for nine, thirteen and seventeen year olds was undertaken. The results of the NSF studies and the national assessment were assembled and interpreted under a research effort called Project Synthesis. Basic to its design, Project Synthesis identified discrepancies between the desired state of science and its actual state (Kahl and Harms, 1981).

The Science Council of Canada similarly initiated a review of the state of Canadian science education in 1980. Discussion papers were commissioned from leading science educators and four major research projects were conducted from 1980-1983. The projects involved an analysis of science curriculum guidelines and textbooks, surveys of nearly 7000 science teachers and case studies of actual science teaching practices. A series of nationwide conferences was conducted to discuss questions raised by the study and to determine future directions for science education. A three volume report, under the heading Background Study 52: Science Education in Canadian Schools, was made available to the public. Recommended policy initiatives and conclusions of the study were issued

in a separate report entitled Report 36: Science for Every Student: Educating Canadians for Tomorrow's World.

### The State of Science Education

From Project Synthesis, the Science Council studies, and other research efforts over the past decade, a clearer picture of the state of science education in Canada and the U.S. emerged. While there were positive aspects to existing science programs, these studies unearthed and focused on gaps in programming. These included the following:

a) Teachers themselves were confused about the goals of science (Kyle, 1984; Science Council, 1984; Yager, Bybee, Gallagher & Renner, 1982).

b) Large numbers of elementary teachers felt uncomfortable with science (Bethel, Ellis & Barufaldi, 1982), relied on textbooks for guidance (Kyle, 1984; Science Council, 1984), and deemed the 'basics' as more fundamental than science (Stake & Easley, 1978). In Canada only 10% of school time was allotted to science at the elementary level (Science Council, 1984).

c) Students were not prepared for their role as participating citizens in a scientific-technical society (Science Council, 1984; National Assessment of Educational Progress, 1978). Skills needed for responsible decision-making such as critical problem-solving, reasoning etc. were largely missing from science programs (Goodlad, 1984).

d) Students rapidly lost interest in science as they moved through

school (Hueftle, Rakow & Welch, 1983). Ninety percent of students being taught paid no attention to science as adults (Voelker, 1982). As well, students tended to pass off ownership for science-society issues to a group they considered to be more technically elite, the scientists and engineers (Fleming, 1987).

Such evidence suggested that science education was not responding to the needs and influences of society. Yager, Bybee, Gallagher and Renner (1982) summed up the situation in this way:

Science education exists within society. Science education must be responsive to science and education. When science education fails to adapt to changes from the related institutions and from society, it soon reaches a point of crisis...We are at such a point. (p.394)

#### **The Desired State of Science Education: Where Science is Going**

Both Project Synthesis and the Science Council's Report 36 outlined recommendations for future science education programs. Working separately, each group compiled a list of four parallel and similar sets of goals, broadly linking changes in science education to a) the personal needs of students b) societal and political issues c) career awareness and development and d) more advanced science education for those with special interests and abilities.

As its overriding theme, the Science Council endorsed 'Science for All', a goal of science literacy for all Canadian students. Its four major goals were identified as:

1. Science for Personal Development

- to stimulate intellectual and moral growth to help students develop into rational, autonomous individuals

2. Science for the Informed Citizen

- to develop citizens able to participate fully in the political and social choices facing a technological society

3. Science for the World of Work

- to provide an appropriate preparation for the modern work world

4. Science for Future Education

- to train those with a special interest in science and technology fields for further study

As part of its report, the Science Council identified eight ways in which changes in science education could be initiated. Also included were 47 recommendations, or strategies, designed to foster a national renewal in science education.

Through its goals and recommendations, the Science Council set the tone for change. In particular, it stressed the need for connecting science, technology and society elements of science education, there-laying the cornerstone for the STS movement.

If we as a society fail to understand the interaction of science, technology and society, we surrender control of the most potent forces shaping our world to a technocratic elite. (Report 36, p.13)

While the specifics of such STS links at the classroom level were not included in the Science Council report, it was clear that existing

programs and practices, although adequate for the teaching of content and processes, did not meet the all of the requirements for renewal.

In general, the Science Council's survey showed that at the early and middle years, teachers stress the development of scientific skills and attitudes, and at the senior years, the learning of science content. Technology, the social context of science, or the history of science in Canada are not systematically covered in science courses, usually because of a lack of time, or because teachers feel that they do not have the academic training needed to teach with these emphases. (Summary to Report 36, p.5)

In speaking of emphasis, we do not mean something to be taught instead of a science topic, nor something to be added on after the "real" science topic is finished like the applications sections of some textbook chapters (which are often ignored). Emphasis implies a particular way of teaching the whole of a given science topic. (Report 36, page 39)

According to the Science Council report, to achieve the broad goals of science literacy, of which the science-technology-society emphasis was a part, changes in actual programs and approaches were necessary.

## TWO APPROACHES TO SCIENCE-TECHNOLOGY-SOCIETY

The Science Council and Project Synthesis directives have spawned new science programs that have science-technology-society elements. Two approaches to STS have emerged. For the sake of discussion in this study, one will be called a concepts/process-centered approach, the other an issue-centered approach. Each approach suggests a different orientation to STS.

Traditionally, science teaching begins from a knowledge base. The

elementary science teacher selects a portion of the laws, principles or theories already known to science and attempts to have students grasp these through carefully chosen activities centered around discovering, exploring or expanding the concepts selected (Hickman, 1984).

In the concepts/process approach to STS, the teacher identifies a core of concepts and processes that are to be developed and understood by students. Issues, problems or applications are commonly structured around this framework of concepts and processes. Students thus approach STS through their understanding of scientific facts.

There are proponents of another view of STS, however. Other sources suggest that societal issues, problems and applications should be the organizing framework. Concepts and scientific skills should be developed and enhanced as they link up to an intensive examination of the issues, problems or applications (Rubba, 1987; Yager, 1986b, 1988; Hickman, 1984). Such an approach is called the issue-centered approach to STS in this study.

The pilot version (1989-90) of the Manitoba Department of Education Science Curriculum Guide (K-4) suggests that STS can be approached in several ways, but supports a concept-process organizing framework:

The methods for incorporating STS are varied. One approach is to develop a science concept first, followed by applications... Another approach is to introduce the application first, and conclude with the basic science concept. (p.15)

### A DEFINITION FOR STS

While the Science Council report stressed the need for a science-technology-society link, and through its recommendations and goals broadly described the focus and intent of such a link, it did not suggest a definition for STS itself.

In keeping with its concepts-process vision of STS, the Manitoba Science Curriculum Guide (K-4, pilot version) offers this interpretation of the STS emphasis:

A science, technology and society (STS) emphasis attempts to help student understand the applications of science and how this relates to the world around them, making science much more relevant. (p.12)

Such an interpretation focuses upon the applications of science without mention of the socio-scientific issues and problems which form the basis of the issue-centered approach. Given that there are two common approaches to STS, and in order to prepare for the discussion to follow, another definition of STS is offered.

The definition given below incorporates the concept/process terms suggested by the K-4 Curriculum Guide, but extends them further to include societal issues and problems and the interpretations given them by the issue-centered approach. Such an extended vision of STS, it would seem, also satisfies the greater goals of the Science Council, namely the development of a skilled, informed, and aware citizenry, willing and able to meet the societal, scientific and technological challenges that lie ahead. For the purposes of this thesis, STS is defined in the following

terms:

STS is an approach to teaching science that attempts to connect science taught in the classroom with the issues, problems and applications of science in the child's world, making science more real and relevant.

#### PURPOSE OF THE STUDY

Curriculum change is a lengthy, slow-moving process. In the words of W.W. Charters (1924):

It may be said that a change in the curriculum runs on the average ten years behind the advocating of a change in the aim of education. And for the curriculum to change to become large enough to be noticed, a much longer period of incubation is necessary...But even though a change comes slowly and sometimes seems infinitesimal, it is always preceded by a new statement of the aim of education.

- W.W.Charters, Curriculum Construction

If Charters is correct, it would appear that we are at a midpoint in this educational shift. We have had a decade of 'incubation', a period of reflection and analysis about the state of science education, a period where new directions and aims for science education have been proposed. Now we are embarking on a second era of 'incubation', a period where these new directions are reaching the classroom level, a period of implementation into actual science programs.

Given the two approaches to STS, the concepts/process centered version is the more common practice. This is, in part, because elementary science teaching normally begins with the identification and selection of knowledge and skills. This is the approach which is most familiar to teachers. Furthermore, the Manitoba Curriculum Guide supports

such an approach and provides structure and resources for its implementation.

The issue-centered approach to STS, however, is less frequently used. The aim of this thesis is to examine the issue-centered approach, exploring its rationale, intent and approaches, to determine its demands and expectations of students and teachers, and to assess its implications, applications and ramifications for the teaching of elementary STS.

Four goal areas for this thesis have been identified:

I. Based upon current literature, to examine the nature of issue-centered STS, with particular attention to its rationale and methods, and its expectations of students and teachers.

II. Based upon current literature, to develop an organizational framework to assist with planning and implementing an issue-centered STS unit.

III. Using the proposed organizational framework, to plan, develop and implement an issue-centered STS unit in an elementary classroom. Ethnographic research methods will be used to trace and interpret events, interactions and perceptions of the participants in the classroom.

This research aims to examine three aspects of the issue-centered unit:

1) Student Responses:

In what ways do student perceptions, attitudes and opinions evolve and change during the unit? How do students "make sense" of

the issue?

## 2) Roles and Responsibilities:

What roles and responsibilities are assumed by the teacher and student throughout the unit? How do these roles and responsibilities change with each stage of the proposed framework?

## 3) Reflections and Recommendations of the Teacher

What are the teacher's assessments and recommendations concerning the organizational framework, the selected issue, and the issue-centered approach and its implications for teaching and elementary science programming.

IV. Based upon the literature review and the research study, to assess the issue-centered STS approach and its implications, applications and ramifications for teachers and elementary science programs.

### DEFINITION OF TERMS

In order to promote clarity and understanding, these terms have been interpreted as follows:

concept - an idea generalized from particular and relevant experiences  
processes - the skills, methods and techniques of scientists e.g. classifying, measuring, inferring, hypothesizing, identifying and controlling variables, experimenting etc.

traditional science - science as a distinct discipline, with a historical lineage, that has an established body of knowledge, procedures and ways of thinking.

concept-process centered STS - an approach to the teaching of STS where concepts and processes provide the organizing framework, and socio-scientific applications, issues and problems are extensions of this knowledge/skill base.

issue-centered STS - an approach to the teaching of STS where socio-scientific issues, problems, and applications provide the organizing structure. In this approach, concepts and scientific skills are developed in the process of examining and exploring the issue, problem or application.

#### LIMITATIONS OF THE RESEARCH

In this study, the issue-centered unit was planned, implemented and monitored in a grade 4 classroom. Perceptions and impressions, collected through journal writings, classroom observations and interviews, form the basis for subsequent discussions about the issue-centered approach.

Because ethnographic research is an in-depth look at a particular set of interactions in a particular setting, extensions and generalizations to other situations are not always possible or appropriate. While the findings of this study are relevant to the narrow context of this particular classroom situation, in the final analysis, generalizations of applications, implications and ramifications in the broader sense - as

they extend to other grade levels, other classes, other schools, other issues etc. - must be approached with caution.

#### ORGANIZATION OF THE THESIS

Chapter One has presented the purpose, possible research questions, definitions and limitations of the study. Chapter Two contains a review of relevant literature that explores the nature and methods of issue-centered STS, organizational frameworks, related developmental theories, and pertinent research methodology. Chapter Three presents the design of the study including a description of the subjects and setting, entry methods, unit design, and data collection, data analysis, and data interpretation techniques. Chapter Four contains the data and its corresponding analysis and interpretation. Chapter Five presents a summary of the research, with discussion about the implications, applications, limitations and extensions of the issue-centered approach and the research study itself.

## Chapter 2 - REVIEW OF THE LITERATURE

In this chapter, current literature will be examined in order to explore the nature of issue-centered programming in an attempt to delineate its aims, methods and approaches. Organizational models for STS will then be examined and a composite model, the basis for subsequent in-school research, will be proposed. To prepare a background for understanding and interpreting student responses in the classroom study, cognitive and moral development theories will also be considered. Lastly, the nature and methods of qualitative research will be examined and its features will be compared and contrasted with those of quantitative research.

To facilitate these ends, this chapter has been divided into four parts:

- I - The Nature of Issue-Centered Programming
- II - An Organizational Model for Issue-Centered STS
- III - Cognitive and Moral Development
- IV - The Nature and Methods of Qualitative Research

## I - THE NATURE OF ISSUE-CENTERED PROGRAMMING

### The Context of Issue-Centered STS

Since an overriding goal of education in the 1980s is science literacy, it is useful to examine the concept more closely. Shen (1975) views science literacy as three separate, but interrelated forms: practical, civic and cultural. Practical literacy is the possession of scientific and technical knowledge that has direct applications for personal development. As one example, nutrition education might be taught with direct applications by the student as one of the goals. Civic literacy is the awareness of science and technology as they relate to social problems, enabling citizens to act upon civic issues. Cultural literacy is the understanding of science and technology as major human achievements. It acts as the thread which bridges the gap between practical and civic literacy.

Seen from this perspective, science education in the traditional sense aims, at best, to satisfy some of the needs of practical literacy, but largely ignores the other two aspects. Science education of the 1960s era has operated from a view that it is an isolated discipline, distinct from other disciplines and from society as a whole. Science seen in this way is restrictionistic i.e. science neither affects nor is affected by social and cultural values. (McInerney, 1985)

Civic and cultural literacy are two goals of STS programs. An involved and informed citizenry is the aim and traditional approaches fall

short of the goal.

Aikenhead (1985) notes:

Science and technology, like all fields, are social creations, characterized by both objectivity and subjectivity, logical thought and leaps of imagination, and many other human attributes and shortcomings known to our society. Science has a human, political, ethical and economic context; school science becomes sterile, separated from society, laden with misconceptions. The social sterility of the science curriculum can be seen as unwittingly hampering social responsibility by interfering with thoughtful decision making. (p.133)

This view is shared by others, including the Science Council.

(Hickman, 1984; Bybee, 1985; McInerney, 1985; Yager, 1986a) While recognizing the international flavor of science, the Council proposed that science and technology are products of culture. As such, "while scientific knowledge is international in nature, it is supported economically, produced, applied and taught in a specific national context". (Science for Every Student, p.40) In order for students to learn of the interplay between science and technology, how social/political climates shape and determine science activity and vice versa, the Council recommended that science be taught in its social, historical, and cultural context.

### Starting Points

While traditional science teaching begins from a knowledge base, there is evidence to suggest that attempts to approach STS through a knowledge base may be futile. In a study by Fleming (1984), students

were asked to discuss two STS issues. Information packets were provided to ensure a knowledge base for discussion. Students, however, did not use them. Neither did they view previous knowledge covered in school as being useful. Fleming argues that social cognition, rather than scientific analysis, dominated the students' thinking. Issues were viewed from a different domain. Understanding science concepts is not necessarily related to a student's understanding of social organization.

According to Fleming (1985):

Teachers who believe that all students require more background science information before they are able to tackle social issues are naive. (p.207)

If students approach issues using primarily social cognition, then instructors would benefit from allowing students to start in this domain...issues - the risks, the effects, and the nature of science and technology - trigger responses from students. Contemporary science instruction must accept this as a starting point and build on the students' initial responses. (p.211)

Yager (1986b) proposes that the Ss in the STS acronym are in the wrong order. Properly placed, it would be better viewed as society-technology-science. He maintains that society, not science, is the common denominator for all people and the STS movement would be better approached through societal issues. Technology - the applications of science for the benefit of humankind - is more concrete, more meaningful and more interesting than science. It is the connecting link between society and science. In the Yager model, STS begins with societal issues and is linked to science through technology.

Rubba (1987), when commenting on exemplary STS programs identified

by NSTA, notes that a common element of such programs is that they use issues as a starting point. The emphasis is not upon resolution of the issue, but upon the development of investigations and action skills that the student can incorporate as a decision-making strategy they can apply later in life. The common characteristic of such programs is the hands-on attempt to resolve the issue while developing skills in the process.

Yager, Blunck, Binadja, McComas and Penick (1988) maintain that knowledge and information do not appear to suffer through such an approach. Referring to studies of STS programs in Iowa, they comment:

Information concerning student retention over time has not been collected. Some of the STS efforts have been too new to permit follow-up studies over the span of several years. However, since STS students are so much better at making applications and connecting experiences to others, there is every indication that the information students possess is indeed knowledge, i.e. information that is useful. If information which is mastered can be used and if it has meaning for the learner, there is every reason to believe that STS instruction is providing a much better experience in the information domain. (p.11)

While not specifying methods or approaches, the Science Council recommendations would, at the very least, seem to defend the use of issue-centered STS. Since a primary goal of science education, according to the Science Council, is the development of a responsible, informed and aware citizenry, one given to active rather than passive involvement, beginning with social issues and problems would seem appropriate.

### Discovery/Inquiry in STS

While this view of STS is society-based, issue oriented, problem-solving and decision-making; discovery/inquiry techniques have a redefined position in the program. The focus, emphasis and function of such methods differ from those received in traditional science programs.

Studies by Kyle, Bonnstetter, Gadsen and Shymansky (1988); Shymansky, Kyle and Alport (1983); and Bredderman (1982) have compared the "hands-on" activity-based approach of the 1960s with textbook oriented science programs. They report that the average student in classes using the new science curricula outperformed students in traditional courses on achievement measures. As well, student attitudes, cognitive skills, problem-solving abilities, process skills, creativity and performance in related subject areas were also positively enhanced.

Rather than sacrificing content goals for process goals, as many predicted, the opposite is true. Furthermore, the hands-on, discovery/inquiry approach is a more stimulating and productive view of science, one that fosters a challenge similar to the one facing the scientist.

In elementary science classrooms, discovery/inquiry methods are seen as a means of developing content through the use of scientific processes. In issue-centered STS, discovery/inquiry techniques serve another purpose. Once an issue or problem has been identified, such methods are employed as a means of unearthing evidence and information that will help to clarify the issue or seek solutions.

In his description of exemplary elementary science programs, Kotar (1988) emphasizes the connection between "hands-on"/inquiry methods and the link to STS:

The exemplary elementary school science program - one that uses hands-on science projects - stresses the students' inquiry and decision-making processes. These programs aim for an excellence that reflects the investigative nature of science and its direct applications to the students' lives.

The goals of learning should mesh with personal goals. Children should learn through science how to make rational decisions and how to evaluate personal consequences. They should learn how science and technology help to resolve society's problems. Science should teach our children how to collect, organize and interpret information. (p. 4)

#### Holistic and Interdisciplinary Links

Traditionally science has incorporated a mental process that Bohm (1983) has called fragmentation or reductionism. In order to make reality more comprehensible, manageable and easy, science has been compartmentalized into separate disciplines. Each discipline in turn utilizes the scientific method, the systematized means of separating thoughts and examining one component while holding others fast. It is a way of reducing factors to a simple equation so that solutions can be considered.

Reductionist techniques have merits. The rapid progress in science and technology over the past century is a witness to its effectiveness. But Bohm, Bybee (1979) and Nachtigall (1987) propose that reductionist techniques have limitations, too. Bohm argues that by concentrating on fragments we lose sight of the whole. Solutions produced will be

correspondingly fragmentary. He suggests that more than one view is needed to add up to a total reality.

Nachtigall argues that in nature there is really only one science. If one aspect is changed, it affects another aspect because everything is interrelated and interdependent. Fragmentation of the sciences removes responsibility for change. It becomes the responsibility of someone else, or some other discipline or some other 'expert' to promote change. Fragmentation leads to remoteness, a distancing from reality.

Garmulewicz (1986) supports this view:

Reductionism leads to a belief that investigating the parts will produce an understanding of the whole. This approach may be very effective in solving some problems, but when it is applied to systems incorporated in the biosphere the inter-relatedness of the problems is ignored. Problems are defined too narrowly in time and space, simple solutions are sought for complex problems, and negative trade-offs of solutions are not considered. (p. 3)

Garmulewicz proposes that the key is not necessarily to do away with reductionistic techniques, but to balance them in a holistic-humanistic-environmental-natural view of science. Solutions and problems have to be recognized from the perspective of an integrated whole. Within this context, the strengths of reductionism can be used to advantage.

In order that science be taught on the interface of science, technology and society in relation to the environment, the structure of the entire curriculum must be integrated as much as possible...By integrating science with other subjects, and vice-versa, not only is a holistic perspective of science-related social issues encouraged, but it will enable teachers to increase the amount of classroom time devoted to science. (p.12)

The case for subject integration is supported by research studies.

Koballa and Bethel (1984) compiled research findings linking science to other subject areas. They report that processes and methods found in science are used in other disciplines as well. Furthermore, the integration of science with other school subjects improves not only the quantity and quality of science instruction and learning, but also benefits other subject areas, too, such as reading, oral and written language, study skills, mathematics, logical thinking and problem solving.

Marker (1987), Rubba (1987) and Charles (1985) propose that STS instruction is a synthesis of science and social studies and could be included in either subject or both. Kobella and Bethel support this view. Surveys of science and social studies teachers indicate that both groups identified common goals in the broad areas of knowledge, values, beliefs and decision-making skills. Both groups were also critical of movements to isolate the study of science from the study of society.

Kobella and Bethel report that the science-technology-society theme is relatively easy to incorporate in the elementary school since there is a thread of common skills and concepts in the disciplines and often the same teacher teaches both subjects.

### Values and Realities

Traditionally, science has espoused a value-free atmosphere. Science was empirical, divorced from other disciplines and the society in which it functioned.

Science which is society-based and deals with social issues is by

necessity value laden. Problems are complex and solutions are multi-sided, with shades of grey instead of the black and white of traditional science. Decisions must be based on current information, but with an eye to future consequences. Science is not always right, nor are answers always possible. Often there are many sides to every issue and many points to consider. (Koballa, 1984; Zeidler, 1984; Bybee, 1985; Fleming, 1985)

Science presented in this way models real life science. According to Mahoney (1979), the majority of scientists are engaged in questioning, debate and controversy. Such controversy is the life of science, but in our traditional teaching fashion we have eliminated the critical nature of science and have presented science as a series of one-issue simplistic investigations with one-sided solutions. (Fleming, 1985)

By posing value-laden problems and issues, science also takes a step towards achieving civic and cultural literacy for future citizens. Bybee (1985) states it this way:

Class discussion of STS issues helps students develop insight into their current values and assumptions and recognizes the importance of being receptive to ideas. It motivates them to develop sound values and to be responsive to change when necessary. Learning to apply their skills to solve problems and resolve issues gives students encouragement to act, to participate as citizens. (p.92)

Such an approach is consistent with the goals proposed by the Science Council which considered the presentation of a realistic and accurate portrait of science, with all its benefits and limitations, as a priority for science educators. Such a move, the Council felt, would

help achieve its goal of developing citizens willing and able to deal with the political and social choices of the future while at the same time promoting another of its goals, the intellectual and moral growth of the individual.

### The Roles of Teacher and Students

Yager and Penick (1984) examined 50 different outstanding science programs in the United States and surveyed the more than 200 teachers involved. From this study, which focused on science programs that satisfied the goals of Project Synthesis, Yager and Penick extracted a set of twenty qualities that effective science teachers had in common. Since the goals of Project Synthesis closely parallel those of the Science Council, it is enlightening to examine the list in order to glean a picture of the activities of the STS teacher/STS student and some sense of issue-centered STS as it is applied in the classroom.

The list included, in part, that exemplary teachers made a difference by:

- being models of active inquiry
- using societal issues as a focus
- being concerned with developing effective communication skills
- requiring considerable student self-assessment
- expecting students to question facts, teachers, authority and knowledge
- encouraging pragmatism

- providing systematically for feelings, reflections and assessments
- asking questions that lead to a synthesis of ideas
- being flexible in their time, schedule, curriculum, expectations and view of themselves
- viewing learning as not being bounded by classroom walls

Along with the components of STS programming discussed earlier, this list of qualities gives us a glimpse of the teacher-student relationship and roles in issue-centered STS.

In the main, the issue-centered teacher initiates, probes, facilitates, guides, encourages and investigates. In partnership with the student, the teacher raises issues and actively explores them and possible solutions. The teacher asks provoking questions, sets the stage for investigation, encourages communication, welcomes opposing views, does not skirt around sensitive or moral issues, fosters a climate of openness and plans for synthesis, reflection and assessment. For such a teacher, science does not start or end in the classroom, in a textbook, or in a simple experiment. The teacher draws from the total environment and experiences of the student. For this teacher, science incorporates, utilizes, and depends upon other disciplines.

The student in the issue-centered classroom plays an active, integral role. Rather than being the recipient of knowledge, "discovering" only what is already predetermined and known, the STS student gives shaped and direction to the program by raising issues, asking questions,

seeking understanding, exploring solutions and evaluating them. The student's knowledge and scientific skill base - the concept and processes of science - are developed in the context of issues and problems drawn from the his/her own environment.

The teacher in this STS approach is not the center of knowledge. It is not necessary to have all the answers. Indeed, having the answers may actually detract from the goals of issue-centered STS. Yager (1983, 1987a) points out that elementary teachers often feel inadequate because they do not possess a strong science background and do not have information at their fingertips. Yet, as indicated earlier, interest in science is strongest in elementary grades. As children move to higher levels where they encounter specialized subject areas and science-only oriented teachers, interest and attitudes towards science drop off dramatically.

Yager attributes the positive attitudes at the elementary level in part to the teacher's lack of knowledge. By admitting to not knowing the answers, these teachers focussed attention on questions, encouraged investigation and research, and stimulated further thinking. This active, solution-seeking process, Yager feels, is closer to the real nature and purpose of science and may be one of the most essential parts of issue-centered STS programs.

Table 1:

A Comparison of the Aims, Methods and Roles of  
Traditional Science and Issue-Centered STS

| Traditional Science                                                               | Issue-Centered STS                                                                                                                                           |
|-----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| - isolated from society: neither affects or is affected by social/cultural values | - immersed in society: derived from its social, cultural, historical context                                                                                 |
| - treats science as a distinct discipline, separate from other disciplines        | - links science to other disciplines                                                                                                                         |
| - aims to develop concepts and scientific skills                                  | - aims to connect science in the classroom with science outside the classroom: concepts and skills are developed while developing decision-making strategies |
| - starts with a knowledge base                                                    | - starts with socio-scientific issues and problems                                                                                                           |
| - uses discovery/inquiry techniques to develop predetermined concepts and skills  | - uses discovery/inquiry techniques as a tool to explore issues and problems                                                                                 |
| - uses reductionist techniques                                                    | - reductionist techniques are balanced with a holistic view                                                                                                  |
| - value free                                                                      | - value-laden                                                                                                                                                |
| - teacher determines the shape and direction of the unit                          | - teacher acts as a facilitator in the problem-solving, decision-making process; teacher & student partnership provides direction and shape for the unit     |
| - student seeks to master content and skills selected by the teacher              | - student actively seeks understanding of issues and masters content and skills as it relates to, and evolves from, issues                                   |

### Summary: The Nature of Issue-Centered STS

Although STS is a relatively new focus in science, there is general agreement in current literature about many of its essential features. STS involves social cognition as well as knowledge, requires a more holistic and interdisciplinary view, deals with values and opinions, attempts to present an authentic view of science and its relation to society and deals with problems, issues and applications appropriate to the developmental levels of students.

Although there is more than one view of STS, the issue-centered orientation is consistent with the recommendations of the Science Council. Such an approach starts with issues, problems and applications of a socio-scientific nature. In the process of examining and clarifying such issues, students and teacher work together to reach understanding and devise strategies to deal with the issue. Scientific concepts and skills are developed in the active process of seeking understanding.

Table 1 summarizes these essential points and compares the aims, methods and roles of participants in traditional science to those of issue-centered STS.

## II - AN ORGANIZATIONAL MODEL FOR STS

## Traditional Organizing Models

To derive an organizational framework from which to develop issue-centered STS programs, it is useful to first examine a traditional approach to curriculum design. Hickman (1984) argues that in the traditional model science starts with a body of laws, theories, facts and principles believed by the teacher to represent the current state of a scientific discipline. (Figure 1) Teachers use a set of criteria to select from the organized body of knowledge the elements that are considered important to the education of children. In doing so they carve out a segment of the whole body to present to students:

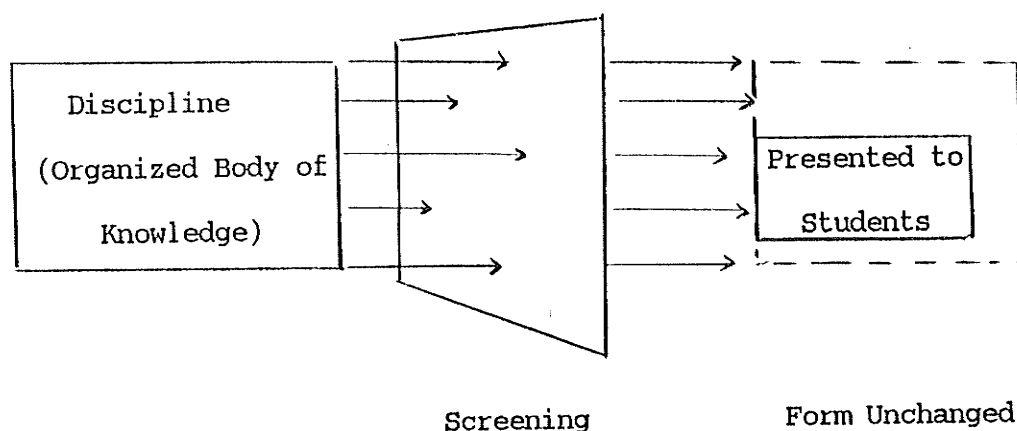


Figure 1: Traditional Organizing Model

Two assumptions are inherent to such a method of programming. Teachers assume that the integrity of the whole has been preserved in the selected portion. Secondly, teachers also presume to know what knowledge has relevance to the child now and in the future.

### The Hickman Organizing Model

Hickman proposes an alternative organizing model (Figure 2). Rather than starting with a body of knowledge, the curriculum begins with real life situations. Life is the starting point. The educational process proceeds as teacher and student conduct an active search for understanding, drawing from the body of knowledge provided by the disciplines. In this model there is interaction between learners and educators and between the disciplines. From this active learning approach, conceptual schemes will develop.

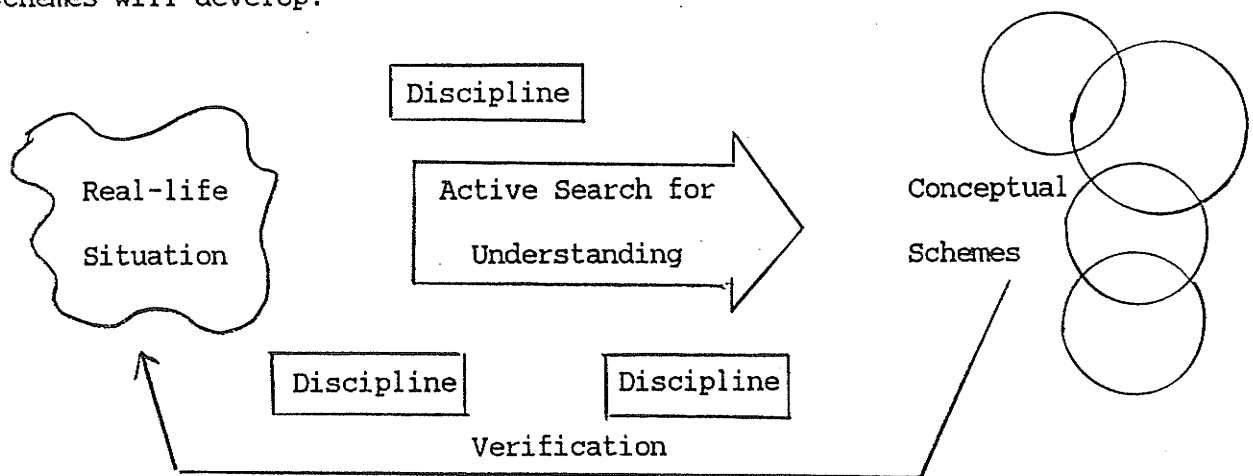


Figure 2: Hickman Organizing Model

Hickman defines conceptual schemes as "the big ideas that one can use to make sense of real-life situations". (p.107) Conceptual schemes are the "mental pegboards", the arrangement of hooks on which new ideas are hung so that the individual can make sense of them.

When faced with a new problem, the learner evaluates existing "hooks" on which to hang new ideas and principles. If an existing "hook" is not appropriate, the learner creates new ones or rearranges old ones to accomodate them.

Hickman argues that conceptual schemes vary from student to student and from situation to situation. Conceptual schemes are interrelated and overlap. They form the pattern from which new knowledge is produced, tested and reapplied. Conceptual schemes are the learner's way of making sense of the world.

Such a way of viewing learning models the work of the scientist, Hickman notes. Existing knowledge is used in the search for new understanding. Existing structures and patterns are tested against new evidence.

This approach to curriculum planning differs widely from the traditional organizational model. In this approach, teachers construct curriculum, not by viewing a single discipline and subjectively choosing a portion, but by asking what "big ideas" students should gain. "Big ideas" must be valid in themselves, but also must be applicable to real-life situations in the present and future. The curriculum planner must predict the most useful conceptual schemes and must draw from a bank of

sources in order to ensure that students benefit from their experiences.

### The Yager Organizing Model

Yager et al (1988) propose a similarly structured organizational scheme. Five domains for science education are identified: connections and applications, creativity, attitudes, processes and knowledge.

(Figure 3)

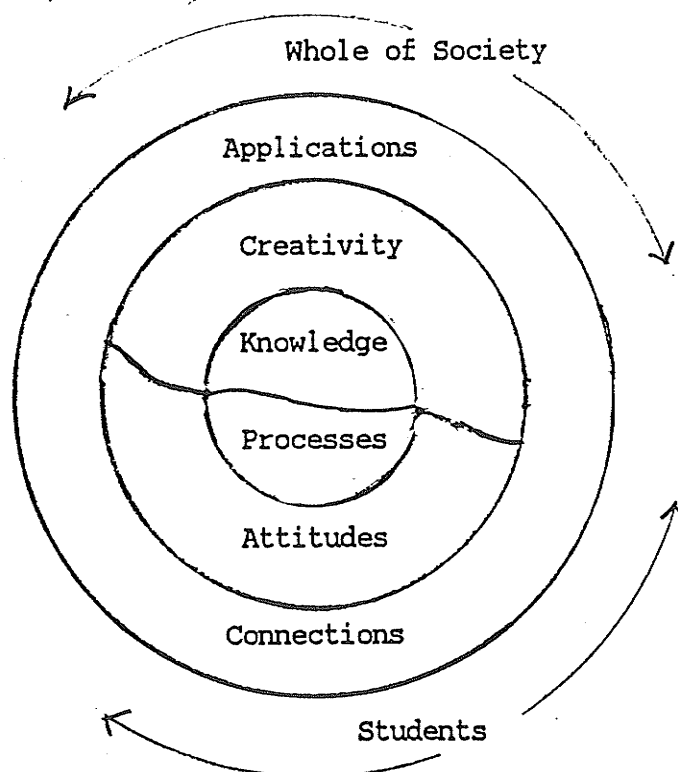


Figure 3: Yager Organizing Model

In this STS model, programming begins with problems and questions that are drawn from society as a whole. This is a cooperative venture requiring input from both teacher and student. Once the issues are

identified, they are analyzed and studied. Connections between social problems and science are made through technology - the applications of science.

Students actively seek understanding to clarify issues and to develop decision strategies. In the process, attitudes change and creative applications and solutions are examined. Information and processes are viewed as tools to be used and developed as students seek to resolve issues.

Studies of this approach to STS report positive results. Yager notes that STS ideas and approaches have been introduced in the classrooms of 300 teachers in grades 4-9 in Iowa. Assessment results have shown that compared to students in traditional science programs, students in STS programs were better able to apply information and perform basic science processes. Attitudes towards science and creativity measures improved. Acquisition of knowledge did not suffer in this approach.

#### **Problem-Solving Models**

Although there are various models of problem-solving, according to Jackson (1975) these usually encompass five stages:

- 1) Formulate the problem (detect, identify and define it)
- 2) Interpret the problem (develop an understanding of the problem).
- 3) Construct courses of action

- 4) Make decisions (evaluate proposed courses of action against relevant criteria; select preferred actions)
- 5) Implement the actions.

### The Proposed Organizational Framework

This thesis proposes an organizational framework for STS that is based upon the Hickman and Yager models and the discussion of STS which preceded them. Its design and sequence also has roots in typical problem-solving methodology as suggested by Jackson.

The proposed organizational model for STS, as shown in Figure 4, has five stages. Each stage of the model is outlined below:

#### 1. ISSUE IDENTIFICATION AND SELECTION:

The STS program begins with the identification and selection of a socio-scientific issue drawn from real life.

#### 2. ISSUE CLARIFICATION/ INITIAL RESEARCH

In the second stage, students critically examine the issue. Together with the teacher, they compile and study the available information, determine what further data might be needed and how it will be obtained, and collect relevant information through a variety of means including investigations, media sources, field trips, contacts with officials, interviews etc. At this stage the issue is examined and clarified against a backdrop of knowledge. Scientific concepts and skills are developed and strengthened in the research process.

### 3. STRATEGY/ACTION PROPOSALS

Once the facts are in and the issue is in clear focus, action plans or strategies are generated. In this phase, students seek answers to the question, "What can be done about the problem?". On a more personal level, this translates into, "What can we do about it?".

Proposed actions may have wide-ranging implications. At one end of the spectrum, solutions or resolutions might be forthcoming. At the other end, students may realize that there is little that can be done or that much more information or expertise is needed. Between these two extremes lie other possibilities of social action: publishing an information newsletter about the issue, organizing debates or interviews to increase public awareness, building models that illustrate the problem or possible solutions, writing letters to officials, organizing an assembly for the whole school, writing and performing in an issue-related play etc.

### 4. STRATEGY/ACTION EVALUATION AND SELECTION:

In the fourth phase, action plans are evaluated for feasibility, effectiveness, social appropriateness, relationship to the issues that initiated the process, and other criteria defined by the group. The most plausible strategies are selected and implementation procedures are identified.

### 5. STRATEGY/ACTION IMPLEMENTATION AND EVALUATION:

In the fifth stage, the selected action plans are implemented and monitored. Continual evaluation provides feedback for the students and teacher and may provide opportunities for related issues to be examined.

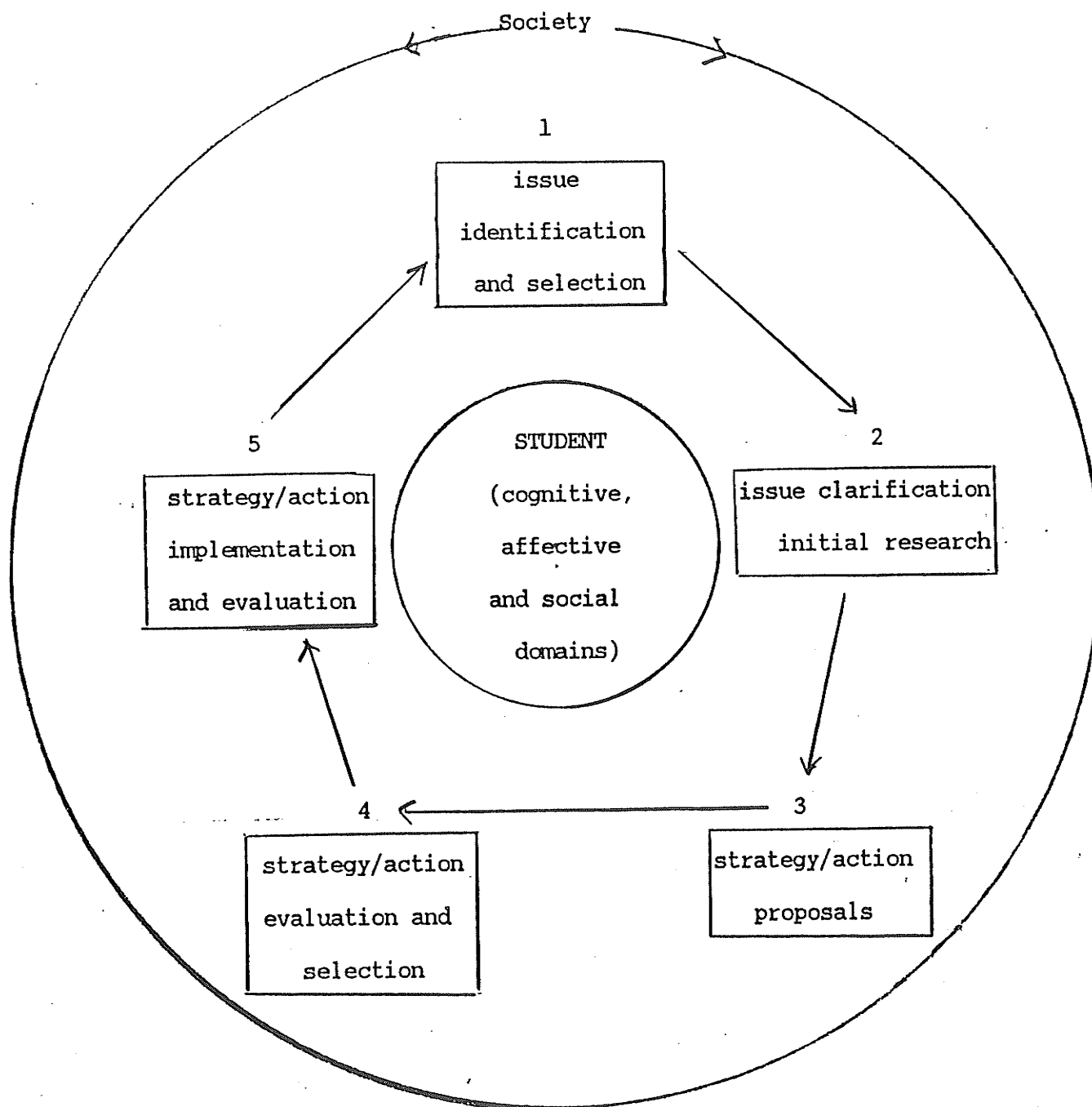


Figure 4: Proposed Organizational Model

### III - CONCEPTUAL AND MORAL DEVELOPMENT

Since the methods and tasks of the issue-centered approach involve the development of knowledge and concepts, the formation of values and opinions, and the evaluation of strategies and actions, a discussion of cognitive and moral theory is appropriate.

Two researchers dominate the developmental theory realm: Jean Piaget and Lawrence Kohlberg. Piaget is best known for his theory of cognitive development, although some of his earliest work clearly assumes a relationship between the cognitive, affective and moral domains. Piaget's theory of cognitive development influenced the later work of Lawrence Kohlberg who proposed that children's strategies for cognitive moral decision-making followed a stage sequence similar to that proposed by Piaget.

There are critics who challenge the work of Piaget and Kohlberg. However, it is not the intention of this discussion to evaluate the merit or usefulness of these developmental theories. Rather, it is the intention of this discussion to present the work of Piaget and Kohlberg as a means of establishing background information that will assist with the understanding and interpretation of subsequent research findings in this thesis. The common assumptions underlying the two theories will be explored first. This will be followed by a closer examination of each theory and, lastly, a discussion of the implications and relationship of the theories to this research study.

### Assumptions of the Theories

Not surprisingly, given the reliance of Kohlberg upon Piaget, there are some common assumptions between the two theories. Each theory envisions a sequence of stages involving a hierarchy of capabilities from simple to more complex. Each stage is characterized by a consistent pattern of thinking about, and organizing of, perceptions, actions and decisions. A person tends to be in one dominant stage at a time and must pass through each stage before advancing to the next. Furthermore, the sequence of stages is the same for each individual regardless of culture. Development thus involves a continuous evolution into more advanced patterns of reasoning, but any individual may stop at a particular stage.

Although children at a selected age level tend to be in similar stages, each child advances through the sequence at his own rate. This developmental pace is governed not by maturation within the child or by simple copying of the environment from outside the child, but rather by the interaction between the child and the environment, as regulated by the child.

Table 2 provides a comparison of age/grade relationships to Piaget's theory of cognitive development and Kohlberg's theory of moral development.

Table 2 Relationship of Age/Grade to Piaget &amp; Kohlberg

| Age/Grade Level                                                                                    | Piaget's<br>Cognitive Stages                | Kohlberg's<br>Cognitive-Moral<br>Stages |
|----------------------------------------------------------------------------------------------------|---------------------------------------------|-----------------------------------------|
| Young children,<br>ages 3 & up<br>(Primary grades to<br>upper elementary)                          | Preoperational -<br>Concrete Operational    | Preconventional<br>Stage 1 & 2          |
| Preadolescence into<br>adulthood<br>(Elementary grades and<br>into high school)                    | Concrete Operational<br>- Formal Operations | Conventional<br>Stage 3 & 4             |
| Adolescence or<br>early adulthood,<br>(if at all)<br>(Junior high to<br>high school and<br>beyond) | Formal Operations                           | Post-Conventional<br>Stage 5 & 6        |

### Piaget's Theory of Cognitive Development

Piaget divides cognitive development into four stages: sensorimotor (birth to two years); preoperational (2-7 years); concrete operations (7-11 years); and formal operations (11 years and older). It is the latter two stages that are of particular relevance to the elementary grade levels.

Children at the concrete operations stage are able to perform operations i.e. mental actions that are reversible, however, they are not yet able to perform abstract reasoning processes. These children mentally develop their operations through interactions with objects. Only after having physical experiences with objects are children able later to progress to using the operations in more abstract ways. In the area of science, hands-on activities are essential to the development of concepts.

Formal operations mark the ability to reason in terms of formal abstractions, to perform "operations on operations", to use an abstract criteria and manipulate it logically. Children in this stage are not limited to the facts before them. They can abstract, isolate factors, mentally and concretely hold variables constant, formulate hypotheses, generate possible solutions to problems, and test variables. A major characteristic of this stage is the ability to do reflective thinking i.e. to think about thinking.

### Kohlberg's Theory of Cognitive Moral Development

Inspired by Piaget, Kohlberg focused on moral reasoning, examining not the choices people make in moral dilemmas, but on the reasons why they make them. According to Fenton (1978) the phrase "cognitive moral development" accurately describes the work of Kohlberg and his colleagues.

Three words - cognitive moral development - capture the essence of their work. Cognitive stresses organized thought patterns. Moral involves decision making where unusual values, such as the sanctity of life and the need for authority, come in conflict. And development suggests that patterns of thinking about moral issues improve quantitatively over time. (p. 52)

Kohlberg identifies six stages, at three levels of moral development. The three levels are discussed below:

#### Level 1: Preconventional Level

This level includes Stage 1 (Heteronomous Morality) and Stage 2 (Concrete Exchange and Individualism). This first level most often characterizes children's moral reasoning, but many adolescents and adults also employ this outlook. A person operating from this level approaches a moral issue from the perspective of the concrete interests of the individual involved. There is interest on the concrete consequences the individual would face, not in what society defines as the right way. At Stage 2, "right" action consists of acting fairly, the goal being to serve one's own needs and interests while recognizing that other people have their own rights and interests, too.

### Level 2: Conventional Level

This level usually arises during preadolescence, comes into more prominent use during adolescence and often remains the dominant thinking of most adults. Attitudes at this level are typified by consideration of group or societal norms and expectations. Included in this level are Stage 3 (Mutual Interpersonal Expectations) and Stage 4 (Social System and Conscience). At Stage 3, "right" action involves good motives, maintaining long-term relationships, and living up to socially defined roles. At Stage 4, "right" action involves fulfilling one's defined duties and obligations and contributing to the good of the whole. Most adults use Stages 2,3 and/or 4 predominantly.

### Level 3: Postconventional or principled level.

At Stages 5 and 6, the individual can see beyond the given norms and laws of his own society and may ask questions about the principles upon which any good society is based. This level is the rarest - only a small percentage of adults operate at Stage 5 or 6 levels.

Essential to Kohlberg's theory is the connection between cognitive development and moral development. Although it may not be the only prerequisite condition, development of cognitive stages is a necessary condition for the development of parallel socio-moral stages.

People adopting a preconventional perspective are highly concrete in their approach. This suggests that their moral reasoning is based on either the preoperational or the concrete operational stage of cognitive development. People adopting a conventional perspective consider the more abstract issues of what their society would expect of them. They are using moral reasoning that is based at least on beginning

formal operations. People adopting the postconventional perspective think in the purely formal categories of what would be the best solution given these moral principles. They are using reasoning based on advanced or consolidated formal operations (Hersh, Paolitto & Reimer, 1979, p.65).

Of particular importance for this thesis is the shift beyond attitudes of egocentrism which is noticeable as children move from a Stage 1 posture to a Stage 2 posture. To make this move the child must first develop concrete-operational thinking:

The ability to take the role of another person is a social skill that develops gradually from about the age of six and proves to be a turning point in the development of moral judgement. If we accept Kohlberg's definition of moral judgement as the weighing of claims of others against one's own, it stands to reason that only when the child can take the role of the other, and perceive what the other's claim is, can he weigh his own claim against the other's. (Hersh, Paolitto & Reimer, 1979, p.49)

Several assumptions and conditions are at the core of Kohlberg's theory. One of these involves the distinction between functioning levels and understanding levels. While individuals may function or operate from a certain moral stage, they can understand beyond it. Individuals can understand moral arguments at their own stage, at all stages beneath their own, and usually at one stage higher than their own.

Underlying Kohlberg's theory, too, is an assumption that moral judgement is a necessary condition, though not the only one, for moral action. Before one can follow and apply moral principles, one must understand and believe them. Action, however, does not always follow understanding.

The idea that cognitive moral development can be facilitated through structured experiences is a key feature of Kohlberg's theory. Fenton (1978) stresses the importance of conflict to moral growth:

But if people develop naturally through the stage, why try to facilitate development in schools or community organizations? Because many people reason morally at stages well below those which they could reach under better conditions...They fail to develop mainly because they have not had experiences which set up the cognitive conflict leading to stage changes. (p. 55)

According to Kohlberg, stage transition takes place primarily because encountering real life or hypothetical moral dilemmas sets up cognitive conflict in a person's mind. Research lends support to this view. Studies by Rest (1969), Dubinsky (1976), Keasey (1973), Turiel (1966) and Turiel & Rothman (1972) have shown that students who participate in moral discussions show significant increases in the stage of moral thought that they commonly use.

### Implications of the Theory

While neither theory suggests that all children operate from a particular level of reasoning at all times, each does suggest that there are some age-typified patterns. According to Piaget, children at the elementary grade levels are commonly in the concrete-operational stage of cognitive development. According to Kohlberg, while some children at the mid-elementary grades may operate at a Stage 1 or Stage 3/4 level, most will maintain Stage 2 reasoning. Stage 2 begins to develop among seven and eight year olds and remains the dominant stage throughout the grade

school years.

Such views of child development have implications for the selection of issues, problems and applications, the methods and approaches used to explore them, and the values, judgements and decisions made about them.

#### 1) The Selection of Issues/Methods and Approaches

Issues, problems and applications selected for study in the issue-centered approach must, according to Piaget, have direct, concrete links to the child's world. They can be neither too abstract nor too far removed from practical experience. Furthermore, the methods used to examine, explore and clarify the issue must incorporate personal, physical experiences if children are to establish mental strategies and conceptual frameworks. "Hands-on", concrete experiences are essential.

The importance of such links are recognized by the Science Council:

Young children need to learn about science through experiences in their immediate environment. Junior high students can begin to appreciate that scientific activities give rise to choices; and making these choices involves value decisions on a personal and societal level. In the senior years, students can become more aware of public issues related to science and technology and of the political choices involved. (Summary of Report 36, page 8)

The Science Council proposed that special attention should be paid to the immediate environment of the student at this level, that issues be of a more local than national or international nature and that teaching should maximize the child's innate curiosity of the natural, physical and technological world about him.

## 2) Issue Perspectives

Cognitive moral decision making is at the core of strategy proposals, evaluation and implementation. Decisions have to be made, viewpoints evaluated, values/morals considered. The work of Kohlberg has direct implications for this process.

Typically, children at this age adopt a Stage 2 stance. Fairness is a key issue, with the main concern being one of serving one's own interests and needs while recognizing that others have rights and interests, too. Fairness involves everyone getting an equal share or chance. Children at this stage characteristically are aware that everyone has interests to pursue and that these can clash. Right is relative in the concrete individualistic sense.

According to Hersh, Paolitto & Reimer (1979) this aspect of fairness has positive and negative forms. In the positive form, children evaluate and expect equality in the distribution of goods and benefits. People of equal status deserve equal shares. The negative form, however, concerns the aspect of justice. Wrongdoing is defined as concretely harming someone without due cause. Justice is complete when the punishment matches the crime -when the wrongdoing is returned - when the act is reversed. Acts are considered good only if they have positive consequences for the individual.

In the issue-centered approach, it is likely, then, that most students will be able to understand issues in terms of their personal consequences to the individual. An issue will pose a moral dilemma if it

appears to be unfair or unequal to the individual and others. Justice will demand that the inequality be corrected and personal rights are preserved.

According to Kohlberg, children can understand moral reasoning beyond their functional level. For this reason, and because some children at the elementary grades may operate at the conventional level, a stage 3 perspective may be adopted to issues. Characteristically, children at this stage are aware of shared feelings, agreements, and expectations which override individual interests. They can step outside of the two-person perspective that is typical of Stage 2 and look at issues from a third-person perspective. In effect, they can put themselves in the shoes of someone else. While Stage 2 involves looking at fairness in terms of one's own interests, a child at Stage 3 compares actions to the expectations and standards of others which is an initial conception of a social system.

Individuals with this moral outlook will look to a type of group rule as a means of providing a fair resolution to an issue. Typically, the Stage 3 person will seek external approval from a legitimate source of authority in deciding what is morally right.

### 3) Moral Conflict

Aside from the perspective children use in dealing with moral dilemmas, the Kohlberg theory has further implications for the issue-centered approach. Since children can understand beyond their functional

level, and because moral understanding can be advanced through moral conflicts, discussions are a key feature. Edwards (1981) addresses the matter of moral conflict:

Moral discussions are an important way in which teachers can help children to develop an awareness of moral issues... Whether real or hypothetical, the problems presented to children should be genuine moral conflicts -ones in which the issues seem significant and in which there is no one right or wrong answer. A genuine moral conflict has "right" on both sides, and that is why it makes people sit up and think. (p. 170)

Besides selecting conflicts which have "right" on both sides, Edwards also feels that the way that a teacher deals with conflict in discussion is a key factor in the advancement of moral growth.

Where the conflict is genuine, the teacher's goal can honestly be to encourage each child to express a position and explain why he or she has taken it. Young children cannot express complex positions, but they can begin to feel they have ideas and that moral positions require thought and justification. During the discussion, children will get the chance to hear answers that vary in their level of maturity. Because children themselves naturally prefer more adequate reasons to less adequate ones, teachers actually promote development most effectively by not evaluating children's answers and by instead reinforcing the critical stance that is the beginning of moral autonomy. (p. 170)

During discussion in the issue-centered unit, particularly when strategies and actions are being raised and evaluated, the teacher plays an essential role in the advancement of moral thinking by maintaining an honest, open and accepting climate in which opinions can be expressed. In addition, by seeking explanations and validations for expressed views, the teacher enhances the critiquing process which is an essential part of moral development.

#### IV - THE NATURE OF QUALITATIVE RESEARCH

Two paradigms dominate the research field - the quantitative paradigm and the qualitative paradigm. The quantitative paradigm is the most commonly used, particularly in the field of science-related research. Despite its science-based content, however, this study utilizes qualitative means to collect and analyze data. To better understand the scope, approaches, strengths and limitations of the research methods used in this thesis, the qualitative paradigm is discussed below and its features are compared to more common quantitative methods.

The quantitative paradigm, also known as the ends-means, empirical/analytic, experimental, theoretical, and scientific/technical mode, has its roots in the scientific method and job/work analysis techniques that evolved at the turn of the century.

The qualitative paradigm has also been called the hermeneutic, situational, phenomenological, naturalistic, pragmatic, and ethnographic paradigm. The qualitative mode as it applies to educational research is derived from approaches used in anthropology. Its influence as a tool of educational research is associated with the philosophical views of John Dewey, Joseph Schwab and others in the progressive educational movement.

##### The Purposes of Research

Quantitative research relies upon reductionist methods. By isolating and limiting variables, the quantitative researcher attempts to

determine the influence of factors upon one another. The aim is to narrow down the field of study through selective and controlling means so that a relationship can be stated between variables.

In qualitative research, however, the intent and focus is different. The aim is to achieve in-depth understanding of a phenomena through a study of its events and interactions in the social context in which they occur. Rather than reducing the field of study by narrowly restricting its parameters, it attempts to achieve understanding of the situation in its entirety.

An overriding premise of qualitative research is that an understanding of the whole is not achieved through the sum of its separate parts i.e. an understanding of the phenomena cannot be had by merely totalling various isolated components. An understanding can be achieved only by examining the whole in the context of all the interrelated factors.

The researcher strives to understand the gestalt, the totality, and the unifying nature of particular settings. This holistic approach assumes that the whole is greater than the sum of its parts; it also assumes that a description and understanding of a program's context is (sic) essential for understanding the program. Thus, it is insufficient simply to study and measure the parts of a situation by gathering data about isolated variables, scales, or dimensions. (Patton, 1980, p.40)

### Problems and Hypotheses

In quantitative research, the investigator states a narrowly defined problem area and a predetermined hypothesis at the outset of the study. In qualitative research, an investigator may have a general set of

questions when entering the field situation, but these are not viewed as precise or restrictive. Commonly, research questions and hypotheses evolve inductively as investigators become immersed in the study.

Gallagher (1988?) contrasts the issue of questions and hypotheses between quantitative (experimental) and qualitative (ethnographic) research this way:

A major difference between experimental and ethnographic research, at this point, pertains to hypotheses. In the experimental approach, the conceptual context would lead to deduction of hypotheses that would be tested by the research. Thus, the conceptual context plays a central role in determining the focus of experimental research. It determines what is to be examined, and by implication, the procedures are tightly specified through a logical, deductive process. In ethnographic studies, the conceptual context is just that...a context. In the former case, the conceptual context defines and proscribes the hypotheses to be tested in a deductive fashion; whereas, in the case of ethnographic research, it establishes the domain of the research in a more inductive sense. (p.1)

Slavin (1984) further addresses the issue of objectivity in ethnographic research:

The critical task in ethnography is maintaining objectivity, not allowing preset ideas to cloud the interpretation of what is happening. As the ethnographer gains understanding of the dynamics of the social setting, he or she may form tentative hypotheses and then conduct additional observations to explore them. (p. 71)

### Methods

In quantitative research, methods are stated and planned before the start of an investigation. Once set in motion such methods cannot be changed midstream without tainting the data and its interpretation.

In qualitative research the case is quite different. The researcher enters with a rough framework or design, but this is considered flexible. As new perspectives surface in the context of the study, new directions may be taken. Methods evolve and take shape in the light of interpretations.

All methods associated with qualitative research are characterized by their flexibility. As a consequence researchers can turn this to their advantage as a rigid framework in which to operate is not required. Researchers can, therefore, formulate and reformulate their work, may be less committed to perspectives which may have been misconceptualized at the beginning of a project and may modify concepts as the collection and analysis of data proceeds. The advantage to this approach is that the researcher has little reason to terminate a study through lack of commitment to a set of standardized methods of data collection. (Burgess, 1985, p.8)

### Data Collection and Interpretations

In quantitative research, data are collected impersonally and anonymously. Data in the form of numbers and statistics are presented via tables, charts, formulas and equations. Interpretations are extracted from the data through deductive techniques. The emphasis is on results, on matching conclusions with predetermined purposes, on achieving credibility through numerical statements of reliability and validity.

In qualitative research, the collected information tends to be less concise and more voluminous. Descriptions, quotations, vignettes, and conversations form the bulk of the data.

In their search for understanding, qualitative researchers do not reduce the pages upon pages of narration and other data to numerical symbols. They try to analyze it with all its

richness as closely as possible to the form in which it was recorded or transcribed. (Bogdan & Biklen, 1982, p. 28)

Rather than being anonymous and impersonal, the investigator is an integral part of the study. In his struggle to derive meaning and understanding, the researcher questions, evaluates and adjusts his own perspectives and interpretations in the light of the evidence. The process of data collection and data analysis occur simultaneously. As data are collected, themes and categories evolve, interpretations and theories take shape, and all of these influence the direction further in-situ observations and interpretations will take.

Just as researchers are able to formulate and reformulate their studies on the basis of a flexible research design, so this element of flexibility occurs throughout the collection and analysis of data. These elements of the research project are not part of a linear process but occur alongside each other. Indeed, data are not usually collected to support or to refute hypotheses but categories and concepts are collected during the course of data collection. The theory is therefore not superimposed upon the data but emerges from the data that are collected. (Burgess, p.9)

In reporting and analyzing the data, the researcher's task is to present interpretations of meaning and understanding through the categories and themes that have evolved in the study and to present evidence to the reader via collected observations, conversations and writings that such interpretations are indeed legitimate ones. The data must be a fair representation, suitable enough to support the interpretations made. Since the interpretations are situation-specific, replication of the study and predictions beyond the setting may not be possible.

The completed research report represents a "frozen slide" in the film, as it were, of the researcher's process of coming to understand the situation. His own understanding continues to develop, whereas the report remains static and open to reinterpretation over time by its readers. (Werner & Rothe, p. 106)

### Measures of Trustworthiness

According to Guba and Lincoln (1981) quantitative and qualitative inquiry must satisfy four similar and parallel tests of rigor for establishing trust in their outcomes: truth value, applicability, consistency and neutrality. Each of these measures will be discussed in the context of a quantitative framework, then will be more closely examined from a qualitative viewpoint.

#### 1. Truth value

Truth value is concerned with establishing confidence in the truth of the findings. In quantitative research truth value is associated with internal validity while in qualitative research an analogous term is credibility. The qualitative inquirer is concerned with testing the credibility of his findings and interpretations with the various sources or groups from which his data was drawn.

Credibility is maintained in the field through member checks. This involves "taking data and interpretations to the sources from which they were drawn and asking directly whether they believe - find plausible - the results. This process of going to sources is the backbone of satisfying the truth-value criterion." (Lincoln & Guba, 1985, p.110)

Credibility is further enhanced if the researcher draws data from several sources and by several methods, then uses techniques of triangulation and cross-examination to analyze and interpret the varied bits of evidence. In triangulation, propositions are exposed to facts and assertions from the data sources or developed using different methodologies to check for consistencies or incongruities. In cross-examination, the researcher examines the underlying biases, values, assumptions, trade-offs or flaws which might influence assertions or propositions.

## 2. Applicability

Applicability refers to the extent to which the findings can be applied in other contexts or with other subjects. In quantitative research this is known as external validity or generalizability.

Since qualitative research aims for understanding of a selected situation as a whole, applications to other situations may be limited.

Whether or not information is generalizable is a function not only of the degree to which the locale of the study is in fact a "slice of life", but also of whether that particular "slice of life" is representative of other "slices of life". (Guba and Lincoln, 1981, p 116)

Guba and Lincoln propose that fittingness rather than generalization is a more suitable concept for the qualitative researcher.

Evaluators ought not to think in terms of generalizations that have some kind of enduring truth value. Rather they ought to think in terms of working hypotheses and of testing the degree of fit between the context in which the working hypotheses were generated and the context in which they are to be next applied. Fittingness, rather than generalization, is the naturalist's key concept. (p.119)

### 3. Consistency

Consistency relates to the issue of replicability i.e. can the inquiry be repeated to obtain the same or similar results? In quantitative research replicability is understood as reliability.

According to Lincoln and Guba, since the aim of qualitative research is situational understanding, replication is not an issue. More important is the matter of internal consistency as expressed in the concept of audibility. Audibility suggests that a second evaluator should be able to arrive at the same conclusions as a previous evaluator when presented with the same work or evidence. In practice, then, a researcher's data should be a representative sampling of the situation, open to audit and interpretations by others. After examining the work of a qualitative inquirer, others should be able to make the same conclusions, propositions and interpretations.

Schatzman and Strauss (1973) stress that such an audit must necessarily include the conceptual themes and categories of the researcher:

That another observer - with or without the same general framework or perspective - might develop a very different analytic scheme, conceptual model, or metaphor is to be expected....It is only when an independent analyst is given the original researcher's categories and propositions that he can possibly arrive at the same conclusions. Without these

categories and linages, another analyst - even if trained in the original researcher's own tradition - would create his own leads to follow or to develop. (p. 134)

#### 4. Neutrality

A requirement of research is objectivity or neutrality. The question asked is: How can the researcher confirm that the findings of the inquiry are a function solely of the subjects and conditions of the inquiry and not of the biases, interests and perspectives of the inquirer?

In quantitative research, two approaches are used to secure objectivity. First, researchers disassociate themselves from the study through the uses of tests, physical instruments and other impersonal data probes. Secondly, decisions about research design and data collection procedures are made before research begins under the assumption that such a priori decisions decrease the likelihood of personal biases.

Such approaches to neutrality are not transferable to qualitative designs. The issue becomes not one of intrinsic objectivity in the research design or objectivity on the part of the inquirer, but confirmability of the information once it has been obtained. To Lincoln and Guba this means transferring the burden of proof from the investigator or the methods to the data itself.

In the process of establishing truth-value (credibility) the inquirer also confirms the neutrality of his interpretations and propositions.

The issue is not the intrinsic objectivity (in the qualitative sense) of the methods used to generate information or the objectivity of the investigator, but the confirmability of the information once it is obtained. In that regard, the methods

for establishing truth value discussed earlier seem appropriate: triangulation, cross-examination, persistent observation, member checks, and testing of congruence with referential adequacy materials. (p. 125/126)

In summary, then, the quantitative concepts of trustworthiness - internal validity, external validity, reliability and objectivity - cannot be directly translated to the qualitative paradigm. Instead, in qualitative research the inquirer establishes trustworthiness through four parallel tests: credibility, fittingness, audibility and confirmability.

In practice, trustworthiness is enhanced in the field if the researcher collects a wide variety of data in several different ways. Then, as data is analyzed and interpreted, a process that is continuous and on-going, the researcher further establishes trustworthiness by conducting member checks with the principals, and by subjecting propositions to tests of triangulation, cross-examination and further observation. In the final stage, conceptual themes and interpretations along with representative evidence in the form of quotes, vignettes and observations are presented for audit by others.

## Chapter 3 - METHODOLOGY

As indicated by the goals raised previously, this research study has attempted to seek understanding of the events, interactions and decisions involved in the issue-centered STS approach as it applies to an elementary classroom situation. Of particular interest were the processes participants used to "make sense" of the issues, the thoughts and impressions of the individuals in the class, and the reasons behind decisions. As well, the study explored the reflections and assessments of the teacher and student teacher with regards to the issue-centered approach and the unit itself. Because of the in-depth nature of this situational study, an ethnographic study was deemed the most appropriate research method.

This chapter examines the following aspects of research methodology:

- I - The Subjects and Setting
- II - Entry
- III - The Issue-Centered Unit
- IV - Data Collection Techniques
- V - Data Analysis and Interpretation

#### I - THE SUBJECTS AND THE SETTING

The research was conducted in a grade 4 classroom in an open area school of 405 students in south Winnipeg. The participants included eighteen grade four students, their homeroom teacher and a fourth year student teacher.

The school was divided into grade level areas. The grade four area consisted of three separate classes arranged in a loose L-shaped pod that was separated by walls and dividers from other grade level areas in the school. While the three grade 4 teachers team-taught math and language arts, each individual teacher was responsible for teaching science to her own homeroom class.

The participating teacher had extensive teaching experience, having taught most subjects to grades 3 to 6 in her twelve year career. She had a strong science background with a B.Sc. degree (botany/geography) and a B.Ed. degree (science 4-9). Having an interest in science in general and in STS in particular, she had drawn students' attention to applications and issues in previous science units covered in the year, but had approached them through a concepts/process base. This was her first experience with an issue-centered approach to STS.

The student teacher was in her final term of a four year school-based program (B.Ed.) in the Faculty of Education at the University of Manitoba. Although she had been in the classroom on a once-weekly basis, she had just started her final student practicum - a nine week block in the grade 4 classroom. Her background in science was limited to high school courses, a university level earth-planetary science course, and a curriculum and instruction science methods course in her final year.

Of the eighteen students in this grade four class, 10 were girls and 8 were boys, ranging from 9 to 11 years of age. The class was grouped heterogeneously, with a cross range of abilities, interests and maturity levels.

## II - ENTRY

In late February and early March, several weeks prior to implementation of the unit in the classroom, meetings were held with the teacher and student teacher for the purpose of establishing rapport, clarifying the goals and methods of research, identifying an issue-centered topic, and delineating the roles and expectations of each of the participants.

In mid-March, a week before implementation, the researcher was introduced by the teacher to the students. The teacher explained that the researcher was interested in a forthcoming science unit students would soon be doing. Students were told that the researcher would be present during science classes to observe the lesson and, at times, might call students aside to talk to them or to interview them. As well, students were told that the researcher would be reading journal entries and might use these when reporting the results of the study.

The right to privacy and confidentiality was guaranteed to all participants. As well, participants maintained the right to withdraw from the data collecting activities of the researcher at any time without penalty. Journals entries were to remain anonymous, but for the sake of clarity and understanding the researcher retained the right to correct

spelling and grammar as deemed necessary so long as the content of the writing remained intact.

In order to familiarize students with the researcher's presence, he remained as an observer during a subsequent art lesson, and returned on a later date to observe a science project fair involving the whole school. A note was also sent to parents explaining the researcher's presence, intent and research methods (See Appendix A).

### III - THE ISSUE-CENTERED UNIT

Working in conjunction with the teacher and student teacher, the organizational framework was used to sequence an issue-centered STS unit. The topic of snow-removal and snow-dumping was selected by the teacher and researcher for several reasons. The issue bordered on the interface of science and society. It overlapped a curriculum unit entitled "Water and Land" which the class had previously studied. The topic of snow-removal was a seasonal one, too, and the issue of snow dumping been raised recently in the news media.

Two snow-dumping sites in the city were selected for study. One was the Waverley Street site which was a short distance away from the school. The Waverley site was stationed in a field and had a drainage-ditch system to the Red River. The second site was the Lyndale site, a dumping site directly on the banks of the Red River.

Consistent with the rationale behind issue-centered STS and the proposed framework, the unit was not planned in detail at the start.

Daily student responses determined much of the direction of the unit. Pre and post class meetings were arranged with the teacher and student teacher for the purpose of discussing the shape of the unit, clarifying and verifying pertinent observations and deciding upon the format and direction of the next lesson.

#### IV - DATA COLLECTION TECHNIQUES

A variety of data collecting techniques were utilized. The researcher attended each class and recorded observations, conversations and interactions in transcript form.

Each of the participants also kept a journal. The teacher and student teacher recorded perceptions, impressions and interpretations at the end of lessons or when they perceived a need for reflection and clarification or in response to specific questions or themes posed by the researcher.

The students also wrote in a notebook. Half of the notebook became a daily log where information and relevant content was recorded. The other half of the student notebook served as a journal where students recorded their perspectives and opinions, sometimes in free verse, at other times in response to a specific theme or question raised by the teacher.

To further supplement the data, informal interviews were conducted with the participants during the unit to clarify or verify observations, impressions or interpretations. At the close of the unit, more structured

interviews were conducted. The teacher and student teacher were asked to respond in writing to a series of questions presented by the researcher (Appendix B). Oral interviews were held with students. Their responses were taped and later transcribed (Appendix C).

## V - DATA ANALYSIS AND INTERPRETATION

Observations and impressions gathered during lessons, from journal entries or interviews, were processed after each session. Processing consisted of reviewing notes and entries in order to flesh out implications, associations, reflections and interpretations of the in-situ experiences. Such processing promoted the shaping of conceptual themes and paved the way for further observations and decisions.

To assist with processing, the organizational methods of Schatzman and Strauss (1973) were employed. Notes and entries were organized into three distinct "packages" of material according to whether they were "Observational Notes" (ON), "Theoretical Notes" (TN), or "Methodological Notes" (MN).

Observational notes are statements which represented the Who, What, When, Where, and How of an activity deemed important to record. An ON could be an actual conversation, event or interaction. ON's contain as little interpretation as possible. If the researcher wished to go beyond the evidence, a theoretical note (TN) was written.

Theoretical notes represent conscious attempts to derive meaning from the observational notes. Interpretations, inferences, hypotheses,

conjectures, conceptual links or themes are part of TN statements.

Methodological notes concerned actual techniques, methods or reminders to the researcher. MN's were viewed as notes to the researcher himself that provided direction and shape for further study.

Attempts were made to establish the trustworthiness of the data as it was processed. Conceptual threads and propositions were cross checked across the various data forms: classroom observations, journal entries and interviews. Pre and post class meetings with teacher and student teacher provided opportunities to share and member-check impressions and interpretations derived from theoretical notes, to address questions and concerns that might have arisen in methodological notes and to determine the direction and focus of subsequent lessons. Interviews, particularly those conducted at the close of the unit, provided further opportunities to validate impressions and interpretations.

## Chapter 4 - RESULTS

Initial meetings with the teacher and student teacher began in Feb. 1989. The unit itself was started with students the next month. A total of 24 scheduled science periods were used to complete the cycle of issue identification and clarification, strategy proposal, evaluation and implementation. As well students worked independently on research and projects in unscheduled periods. Appendix D, Schedule of Lessons and Activities, summarizes the classroom lessons giving their time distributions, activities, student journal topics and relationship to the organizing framework.

In order to develop an overall, but in-depth picture of the issue-centered unit, three broad categories of research were identified. Conceptual themes and threads identified during the process of analysis and interpretation were classified into these broad areas.

One area of research was concerned with changes and developments encountered by students themselves. Of importance there was the evolution of perceptions and attitudes as the unit progressed. The thoughts, understandings, interactions and opinions of the students as collected through journal writings, interviews and classroom observations provided the bulk of data in this first area of research.

A second area of research was concerned with the roles and responsibilities assumed by the participants. Classroom observations

provided the major portion of this data, but this was supplemented and supported by journal writings and interviews.

A third area of research involved teacher reflections and recommendations for the unit itself. Of interest here were teacher impressions regarding the applications, limitations and implications of the issue-centered unit and the issue-centered approach. Journal entries and interviews, both formal and informal, provided the information needed for this area of research. Although evaluative statements were sought throughout the unit, these became more significant once the framework cycle had been completed.

In keeping with these three areas of research, this chapter is organized as follows:

- I. Student Responses
- II. Roles and Responsibilities
- III. Teacher Reflections and Recommendations

### **I. STUDENT RESPONSES**

Early in the unit, it was recognized that there was a delicate relationship between teacher decisions and student responses. While decisions about the direction, pace and focus of the unit were ultimately made by the teacher, they depended largely upon student interests, understandings and initiatives. Such student responses, in turn, were shaped and influenced by teacher decisions.

Three aspects of student response were of interest to the teacher,

student teacher and researcher alike: issue perceptions, issue ownership, and unit ownership.

The student's concepts, attitudes and opinions of the issue were regarded as issue perceptions. Since such perceptions were likely to evolve and change as information and strategies were brought to light, and would in turn evolve and change the unit itself, monitoring them was of major importance. Student journal writings and interviews plotted changes in attitudes, opinions and conceptualizations, while teacher and student teacher journals and interviews reflected the corresponding perceptions of the instructors and their day by day decisions. Observations made during class sessions were compared to journal entries and interview data to verify positions and interpretations.

Since a prime focus of issue-centered STS is the fostering of student involvement and action, the development of student ownership was another target of observation by both researcher and teachers. Ownership was interpreted in two ways: unit ownership and issue ownership.

Events or interactions where students directed the unit, thereby determined its shape and content, were considered to be signs of unit ownership. Development of social awareness and a sense of personal responsibility and commitment to the issue were viewed as evidence of issue ownership. Observations of class interactions and journal entries were considered to be the major sources of ownership evidence.

In order to trace the growth of student perceptions and student ownership, and corresponding teacher decisions, the following discussion

attempts to recreate the pattern of change and evolution witnessed in the unit, aiming for a holistic picture of student development. For this reason, in the first part of this discussion, the responses of nine students (identified by letters A to G) are traced and analyzed in the context of the unit events themselves.

The unit started with a general discussion of the reasons for snow removal and the necessity for having sites to collect the snow. Snow samples taken from the street were compared to those taken from the playground and the discussion turned to the topic of snow contaminants. At the close of the lesson, students were asked to respond in writing to the question: "What is the problem with snow dumping?".

The class was divided in two distinct sets of views. One group indicated either that they did not see any problems with snow dumping or saw the issue as a personal one with consequences that were of a concrete, practical nature. The following responses were typical of this group:

Student A:  
There is no problem.

Student B:  
I think that there will be a problem cause the snow dumped might be very dirty and the kids like sliding down hills and if a kid slides down all the dirt will stay on him and he might get sick.

Student C:  
The problem with snow dumping is it could blow against your house or a wall and if it was an old house it would maybe cave in.

Student D:  
I think that there is a problem because if the men who put the snow on the side of the road pile it too high a kid might come

along and push it on to the street where cars are driving. What if a car ran over a pile of snow and it went on the other cars window and it caused an accident?

A second group, the remaining eight students, saw the issue in more abstract terms, with consequences that were more global and social in nature.

Student E:

I think there is a problem because if the city dumps dirty snow on farmer's land, in the summer when the farmer is planting his crops and he also waters it, all the salt, gas and fumes will absorb into the crops and the crops would die.

Student F:

I think there is a problem because you shouldn't dump snow by the side or by the river bank. It will get polluted and that is dangerous.

Student G:

I think there is a problem with snow dumping!! The problem with snow dumping is that when they dump near creeks and streams the snow will eventually melt into them and dirty and pollute the water. Also I wouldn't like dirty snow dumps near my farm!! Lakes can be flooded.

The teacher attributed this span of views to the student's lack of prerequisite knowledge:

The class was asked to return to their desks and write out what they felt the problem was. Many were unsure as they had not yet perceived what it might be.

At this point, the students don't seem to have enough knowledge of the issue prerequisite - what's in the snow? What does it do? Is it harmful? and to what? How is it going to affect me? How is it going to affect the environment? Some are developing an awareness of social responsibility - others see only what directly affects them. (Teacher Journal)

To provide basic prerequisite knowledge the teacher decided to introduce several hands-on experiences with snow samples taken from the

street and playground (Lessons 2,3). As well, a field trip to the snow dump sites was arranged (Lesson 4).

Upon returning to the classroom after the field trip, the students shared their observations and experiences about the dump sites and then again journalled a response to the question "What is the problem with snow dumping?"

At this point the class was much closer in their views. There was a growing awareness that the snow dumping issue involved more than just simple, individual consequences. Except for one student who still indicated that he did not see any problems with snow dumping, the others who had originally stated personal, concrete concerns, now grasped more abstract, complex aspects of the issue:

Student A:

That when the snow melts the mud and sand and all the things that are in the snow will pollute the river and lakes. And we can have a flood.

Student B:

I think that the problem is if the dump is near a river the snow might cause the river to flood. If the dump is like the one on Waverley Street there is lots of snow and dirt in the dump that might affect the farm near it.

Student C:

When it melts it might flow into the river and pollute the water.

Student D:

I think that a problem arising from snow dumping could be that when all the snow melts there might be a flood. Another problem might be that the things in the snow might pollute the rivers and lakes. It might even make our drinking water dirty.

The students who had initially stated more abstract, socially complex concerns reiterated their concerns or expanded their views, sometimes stating opinions or plans of action as well.

Student E:

There might be floods and the farm land wouldn't be fit for planting with all the salt and gas and oil.

Student F:

I think the problem might be that when the snow melts it might cause a flood. And mud might pollute the ground. It might get too high and might fall down. And it might pollute the water as well as the land. The one by the Norwood bridge might pollute the water. And there will be a big flood by Lyndale and Waverley. Snow might cause erosion.

Student G:

There could be a lot of flooding because there is so much snow. The snow dumping could be contaminating our water and causing wild life to be slowly poisoned. I think they shouldn't dump so much snow at one site. If there is another way they should use that alternative.

While student perceptions of the issue had shifted towards consideration of more complex social aspects, the student teacher noted that students were a long way from developing ownership for the issue or unit:

I was pleasantly surprised to see that the level of "excitement" in snow dumping had increased significantly. The students seemed more eager to participate in the group discussion. As stated, the students are moving away from this being a small problem. They are starting to see that it is big and affects many things such as wildlife, environment etc. Although the students see that this is a problem, they have no clue as to how to solve it. This aspect may require assistance from the teacher. (Student Teacher Journal)

In the teacher's view, the problem of ownership was tied directly to understanding of the issue which, in turn, was linked to the child's

developmental growth i.e. the need of the concrete-operational child to have physical experiences prior to being able to conceptualize ideas.

The usual concrete aspects have been easy for the children to relate to. However, the "chemistry" end has needed clarification. This end perhaps might be considered the most critical due to the long term effects on the environment. This particular aspect of the issue might be better understood at an older grade level.

At this point I feel the class as a group has quite adequately identified the issue. Many appear concerned about the dumping, but perhaps many students are yet unable to "see" the effects. The idea of consequences and to visualize them does seem a bit abstract for those learners who are still tied to the concrete i.e. they know they should be concerned, but don't have a real perception of what this exactly means at this point. (Teacher Journal)

Satisfied that given the limitations of the age group, students had identified the issue sufficiently for further study, the teacher moved into the second stage - clarification and research. Under her guidance, students generated a list of research questions, questions they felt needed answers if the issue was to be understood fully (Lesson 5). The class classified the questions into four categories (Lesson 6): questions about erosion, questions about the snow dump locations and monitoring systems, questions about contaminants in the snow, questions about the drainage system and water flow. (Appendix E)

Each student selected a category of questions to investigate (Lesson 7). Based upon this selection, students were arranged into research teams and spent the next few weeks (Lessons 8-14) finding answers to the questions. As well, a second field trip to the dump sites was arranged.

It was during this phase that unit ownership became more pronounced.

According to the teacher:

Ownership became more apparent when the students began to organize questions they wanted answers for - then began to look for persons to get answers. (Teacher Journal)

The student teacher agreed:

As for my group, this (ownership) happened on April 11 when they decided who they would talk to and what they would say. (Student Teacher Journal)

Following this research phase, each group of students presented their findings to the other groups (Lessons 18-20). In Lesson 21, the information made available through the presentations was reviewed and students questioned each other to clarify pertinent points. The teacher had planned to move the discussion into the next stage of the unit, strategy proposal, but this shift in focus was prompted quite suddenly by the students themselves. Interlaced with research information, and directed by themselves rather than the teacher, students offered strategies for dealing with the problem.

This shift in views is best illustrated through a sample of dialogue taken from this lesson as students debated strategies:

Student 1: I think they should put the snow dump site in the country where it won't go into the river.

Student 2: I heard on T.V. that the river is polluted. This will just make it worse.

Student 3: I agree with N. (Student 1). In the city there are too many people. They could put it out into the country where it could be spread out.

Student 4: How do you know someone else doesn't own the land? Maybe they don't want it there.

Student 5: In the country trucks would have to go far - the distance would be too much.

Student 1: (agreeing with Student 3) One thing about the country - it might affect the animals. The meltwater and garbage will pollute the land.

Student 2: To put it in the country, it would cost a lot of money. There's the price of land. Gas.

In the discussion students showed an increasing awareness of the widespread social effects of the snow removal issue, and of the complex and multi-sided faces it had. It was obvious to them that the issue was not simply black and white and that strategies for dealing with the problem would not simple ones either. More than ever before, students were able to step out of their own shoes to try on someone else's, displaying an ability to see the problem from another person's viewpoint. There was a sense of involvement, too, as if the issue had become, for some students at least, their own cause.

At the close of the lesson, the teacher directed students to journal their positions again by responding to the question: "What are your concerns about snow dumping?"

Students responded more eagerly than in previous writings. Their responses indicated a continuation in the shift from concrete, and visible effects to more abstract, socially pronounced ones. As well, the responses became more personalized, with students noting particular concerns and at times even recommending plans of action. Students began

to suggest that steps had to be taken to ensure that property, wildlife and people were protected from harmful side effects of snow dumping.

Although these concerns were frequently expressed in terms of what others (often the city) could do, to the researcher, teacher and student teacher the developments apparent in the classroom discussion and journal writings were interpreted as a strengthening of unit ownership and the beginnings of issue ownership. Students were becoming actively involved and concerned about the issue and were now providing direct input into the flow and direction of the unit itself.

Student A:

My concerns about the snow dump is that the people are sneaking in and dumping garbage and another concern is that I don't think the snow dump should be open to the public and I think they should make a device that no one can dump garbage there.

Student B:

My concerns about the Lyndale site is: Why did they put the dump there if all the garbage is going to pollute the river? My concerns about the Waverley site is: Has the farmer's land been damaged by the garbage?

Student C:

No response available.

Student D:

My concerns on Waverley are: Is the Red River ever going to flood? Has the farmer's land ever been damaged? My concerns on Lyndale: I don't think they should put the dump there. Will the garbage hurt the fish?

Student E:

At the Lyndale site my concerns are for the bridge and for the garbage, snow, sand and salt that collects there.

Student F:

Lyndale: My concerns about the Lyndale site is if the snow dump was really high and the melted snow went into the river

it might overflow. The bad thing about the Lyndale site is that sand and salt, mud and garbage is getting into the water.

Waverley: I think that it is a good thing that this site is not on the farmer's property and I think it is fine.

Student G:

My concern about the Lyndale site is that the garbage in the snow will get into the river. Also it is pretty dumb that they would put a dump site beside a bridge! When that water melts it just rushes into the river. That could cause a flood.

I have no concerns about the Waverley site except that if the melt water drains wrong the farmer's field could be harmed. I think they did a good planning job when they put the Waverley site where it is!

In the next lesson (22), the teacher and students compared and listed these concerns. Then the teacher directed students to respond in writing to the question: "What can we do about the problem?"

The responses confirmed that not only had students grasped the nature and expanse of the issue, but were also able to identify ways that they could personally deal with it, a further indication of the extent of student ownership and the growth of social responsibility.

Student A:

I think we should go and tell district manager of District 6 all the information and our ideas we have to stop all the problems. Then we should contact the city newspaper, place an ad and tell them to put it in the paper and people would read about it and then everyone would find out about all the problems and they would become concerned and maybe do something about it.

Student B:

I suggest we have a play about the snow dump issue.

Student C:

I think we should give this information to the people that check the snowdumping.

Student D:

I think Lyndale Drive should not be used as a snowdump site because the river bank will probably be eroded. I think we should call Mr. L. (independent researcher contracted by the city to investigate the Lyndale site) and tell him what we found out and tell him what they should do. Maybe we could contact the operations manager of District 6 and tell him what we know about Waverley. We should tell him all our concerns. Maybe ask him more questions. Maybe tell him our ideas!

We could make banners or newsletters and hand them out in front of stores or on cars in parking lots. We could even write a letter to the editor of the newspaper.

Student E:

No response available.

Student F:

I think we should pick up the garbage so that the water won't get dirty.

Student G:

I think we should write a newspaper and put our information into cartoons. We could get people to draw and think up cartoons then we could photocopy them and give them away to families, friends and Districts 5 and 6.

The suggested actions were listed on the board and discussed. Based upon the appropriateness and time requirements of the strategies, students selected two actions to close the unit (Lesson 23). The class decided to write letters to the various people they had consulted during their research in order to inform them of the class findings and opinions. As well, a newsletter would be compiled with students volunteering information or points of view about the snow dumping issue.

The teacher and students composed the first part of the letter, while each student completed it with his/her personal views. The first part, common to all letters, read as follows:

Dear Sir,

We are a Grade 4 class. We have been looking into the subject of snow dumping. We have been looking into the problems that occur at the snow dump sites. The two sites we have studied were at Lyndale Drive and Waverley St. Our first field trip to the snow dump site was on April 10. We visited a second time to see what the changes were....

The letters reflect the growth in student knowledge and understanding. Although some students were still tied to the visible and concrete, most students also incorporated the less visible aspects (heavy metals, long term effects to wildlife and environment etc.) The letters also include opinions and recommendations. Although the issue was a complex, multi-sided one, by and large students were able to synthesize the information, evaluate it, develop opinions and formulate suggestions for dealing with the issue. The following letters represent a sample of the views expressed by the class:

We interviewed and phoned people and had them to our class. We have concerns. One of our concerns was how the heavy metals from the snow would affect the food chain and we wanted to share some ideas. Some of the heavy metals are from the garbage that's being dumped there so you should protect the snow dumps.

Some of our concerns were what the erosion would do and where about it would go. Some more concerns were: Would the meltwater affect the powerlines at the Waverley site? Does it matter where the dumpsites are? Which way will the water flow? Will the sites be harmful to animals and will it harm the drinkwater. We found out that the water wouldn't affect the powerlines, it does matter where the dump is, the water will flow north, and no the dumpsite will not harm the drinkwater.

We had a vote and more people said that they liked Waverley more than the Lyndale site. Those are the two sites we visited. I thought that the city thought of everything at Waverley. All the water from the snow dump will go into the little ditches and that water will go into the big ditches, but just in case you put burms around it to keep all the water in, but just in case it flooded they put ditches around and on and on. I think all sites should be like Waverley and none like Churchill and Lyndale.

I am concerned about the Lyndale snowdumping because they are not taking the garbage out and the garbage and sand and salt is getting into the river.

I think that there should be more security for the Waverley snowdump because people are using it for a garbage dump. I think that the Waverely site is constructed well.

We saw a pile of dirt and mud on the snowdumps and I also have one concern. My concern is the salt getting in the water.

Our concerns for the Lyndale site was that it was placed too close to the river. All the melt water would run into the river. The garbage in the snow would affect the fish because it would get into the food chain. The Lyndale site was not planned as carefully as the Waverley site. We barely had any concerns for the Waverley site because it was so well planned. We only had one, in fact. It was that there might still be some microscopic contaminants getting into the river.

We wanted to tell you some of our information and the problems there were at the Waverley site and the Lyndale site. We have some suggestions of what we could do to stop some of the problems. We wanted to put an ad in the paper so that other people will be aware of them, too.

We think that the Waverley site is better and more carefully planned out than the Lyndale site because the Lyndale site is only a test. The Waverley site is very well planned out as we have said before. The way they planned it was: they have a ditch then a burm (a pile of dirt) then another ditch which

goes all the way around the snow dump. The ditch is for catching the melt water. The garbage left after the snow is melted is collected by the city to the garbage dump. We think the city has done a good job here.

A newsletter, entitled Science and Social Newsletter - Snow Dump Alert, was also compiled with student's volunteering information or points of view about the snow dumping issue. An editorial perhaps best summarizes the controversial nature of the issue and the position taken by the students:

There are concerns about the dumpsite. Will it harm the animals? Well, we're not sure. We don't think so. According to where the dumpsites are, there can be major or minor problems. Most people think the Waverley dumpsite is better than the Lyndale dumpsite because as the Waverley dumpsite flows into the Red River it loses most of the contaminants, whereas the Lyndale site pretty well flows straight down into the Red River. Some people said the Lyndale site could erode the bridge. As you should notice both sites have a place to flow. The Lyndale site is located by a bridge near the Assiniboine River. Which site do you think is better?

## II. ROLES AND RESPONSIBILITIES

Just as there was a relationship between student responses and teacher decisions, so to there was a relationship between student and teacher roles and the responsibilities entailed in such roles. In the initial stages of the unit (Lessons 1-4), when students were grappling with identifying and clarifying the issue, the teacher played an active, dominant role in structuring the shape of each lesson, its content and the activities to be included. With predetermined goals and objectives in mind, the teacher decided upon the investigations, questions and field trips used to bring the issue to the forefront. Students generally played

a less active role, receptive to information, but not as yet owning the issue or unit. The focus was on developing knowledge through the use of scientific skills, the concept/process structure commonly used in elementary science classes.

Dialogue, taken from the second lesson, illustrates this teacher dominant/leading - student receptive/following relationship:

Teacher: Here are two samples of snow. Take a moment and speculate where you think each came from.

Student 1: The dark sample came from the roadside because cars pushed it up on the road side.

Teacher: Where did the white snow come from?

Student 2: From a place far from a road, out in the open.

Teacher: What's the same about the two samples?

Student 3: Both have snow.

Student 4: Both are moist and damp.

Student 1: Both aren't completely dirty or completely clean.

Student 5: Both have salt in it.

Teacher: I have some people who disagree.

Student 3: There is no traffic in the field so there wouldn't be any salt.

Student 6: The snow that falls from the sky could still be dirty because there is pollution in the air and it could collect dirt.

Teacher: That's a valid point....We are going to do start two experiments today in order to compare the two types of snow....

Once students had a grasp of the issue, and had prerequisite knowledge from the teacher planned activities, research questions were drawn up, categorized and assigned to groups. There was a shift in the roles and responsibilities of students and teacher. The teacher's role became one of guiding/synthesizing while the student's role became more active and contributing. Now, more than earlier, the teacher loosely shaped each lesson, not always sure of the final point or objective, but planning to allow room for student input and direction. It was important for the teacher to be able to initiate discussion and monitor and synthesize student contributions. Students, in turn, gradually began to appreciate the value of their own responses and became more actively involved in the format and direction of the lesson.

The following classroom exchange, taken from Lesson 5, illustrates the teacher guiding/synthesizing - student active/contributing relationship:

Teacher: Let us discuss the concerns you might have about snow dumping.

Student 1: One concern is that the meltwater from the dump will cause flooding.

Student 2: The mud, sand and things in the snow residues will pollute the rivers and lakes.

Student 3: Farmer's fields will be flooded. Local drinking water may be polluted.

Student 4: I thought we kept our drinking water in a reservoir.

Teacher: This is something we will have to check out...Does melt water affect our drinking water?

Student 5: The farmland won't be fit for planting crops because of the salt and sand.

Student 4: The sand and dirt may affect the soil and plants.

Teacher: Think about the other site near the river. Are there any problems about that site?

Student 5: There was an article in the paper that said snow is eroding river banks and making them unstable.

Teacher: Can you bring the article in?

After the students had been grouped into research teams (Lesson 8) the roles and responsibilities of teacher and student took on new meaning once again. This time the teacher became much less dominant, adopting the role of facilitator. For the most part, the teacher did not possess more knowledge of the issue than did students, but was more aware of the resources to tap in order to get the information. The teacher's task became, not one of providing knowledge, but one of steering students in their search. The students, on the other hand, became more active, taking on the duties of interviewer, reporter and researcher.

In her journal the teacher reflected on the teacher active/facilitator - student active/researcher roles in this stage of the unit:

The teacher is not the source of information but a facilitator in the "how to" collect the information. As we got into the unit, the children didn't come to me to get the answers. It is interesting to note how 1 or 2 students then tried to fill this role - when questions were asked they came up with answers based on their experience or logically extrapolated conclusions. (Teacher Journal)

The student teacher similarly noted:

I see a traditional science teacher as one who lectures and demonstrates and has students doing activities based on that. On the other hand, the STS teacher is one who directs and assists, more like a more experienced student. (Student Teacher Journal)

The latter point was not lost on students, either. When asked how the unit differed from others done in the year, one student observed:

Well, I don't really think Ms. M (the student teacher) knew any more than we did about snow dumping. (Student Interview)

When the information was presented by the research groups to the rest of the class, the teacher was once again brought back the role played previously, that of guiding/synthesizing. There was a difference this time, however. Because the teacher, student teacher and researcher shared supervision of research groups, the teacher did not have all of the pertinent information beforehand. Her role became that of compiling and clarifying the data, not only for students, but for herself and the others supervisors. The students also adopted a similar role. They became involved in the synthesis process by asking questions to clarify points or by raising questions for further study. In this phase the teacher and student shared the roles of facilitator/synthesizer.

Views, opinions and feelings were now brought to the forefront and both teacher and student were faced with interpreting and evaluating them. A classroom exchange in Lesson 21, illustrates the nature of such discussions and the approach used by students and teacher.

Teacher: Are there concerns related to the Waverley site?

Student 1: It could flow back on to the farmer's land or into the ditch.

Teacher: Could the water flow back? Someone who looked at it?

Student 2: It could if it flowed over the ditch.

Student 3: They have two ditches - they've thought about that. They put two ditches there in case one fills up.

Student 4: Mr. M (District 6 operations) said they have ditches everywhere. There's little chance they will flow over.

Student 5: Mr. K (Dept. of Rivers and Streams) said there is a slim chance - they would have to build more ditches. Farmers have already complained about the snow dump sites.

Teacher: Do you feel Mr. K. is watching the situation carefully?

Student 5: Yes.

Student 6: At Waverley they have flags to show that they can't go over the dump.

Student 3: I think they have the Lyndale site under control. Our group looked at a device which would control who can go into the site...I think they have the snow dumps under control.

Student 5: If I were a farmer, I wouldn't like the snow dump on or near my land. I wouldn't like to see that stuff nearby.

Teacher (to one of the students): You talked to the farmer, Mr. W. How did he feel about it?

Student 7: He was happy with the way it was done.

Student 8: If I was that farmer, I couldn't really say anything because it's not on my land.

Student 3: I'd argue with J. (Student 5). I wouldn't like all that dirt on my land. I would be frustrated.

As illustrated by this classroom scene, the teacher monitored and led the discussion by reiterating positions, elucidating points of view, seeking confirmation from research data, and asking pertinent questions. Feelings and values were verified and clarified, not disputed.

For the most part students adopted similar approaches. Views were presented against a backdrop of supporting evidence. When one student disagreed with the statements of another, it was done in a constructive manner in an atmosphere of tolerance. Students often expressed opinions using the format: "This is what I think and these are my reasons." An overriding attitude to conflicting views seemed to be "We don't have to agree. You are entitled to your views and so am I."

When questioned about the treatment of values and feelings, the teacher responded:

Our expectations may have been that all students understand all aspects so we all reach the same point. Perhaps that is an unrealistic expectation. We are dealing with social attitudes and perceptions. We cannot expect one point of view. In our society, no two people think and feel the same way. That is not our end goal. (Teacher Journal)

The final action plan (letters and the classroom newsletter) was a composite of teacher and student input. While the list of strategies were largely student initiated, the teacher consciously drew student attention to those strategies which were more practical in terms of time restraints, resources and effectiveness. From this largely teacher generated criteria, students as a group made the final selection.

As the unit unfolded the teacher and students adopted a variety of

roles and responsibilities to match the intent and activities of the participants. Table 3 summarizes each of these, linking them to their corresponding lessons and framework stages.

Table 3

Summary of Roles and Responsibilities of Teacher  
and Student at each Stage/Lesson of the Unit

| Lesson | Stage  | Teacher's Role & Responsibilities | Student's Role & Responsibilities   |
|--------|--------|-----------------------------------|-------------------------------------|
| 1-4    | 1, 1/2 | dominant/leading                  | receptive/following                 |
| 5-7    | 2      | guiding/<br>synthesizing          | active/contributing                 |
| 8-17   | 2      | active/<br>facilitating           | active/researching                  |
| 18-20  | 2      | active/<br>synthesizing           | active/synthesizing                 |
| 21-22  | 3 & 4  | active/probing<br>& clarifying    | active/synthesizing<br>& evaluating |
| 23-24  | 5      | supporting/<br>guiding            | active/implementing                 |

### III. TEACHER REFLECTIONS AND RECOMMENDATIONS

A key part of the research was the collection of impressions and recommendations from the teacher and student teacher. Such appraisals involved three components: reflections about the organizational framework; reflections about the age/grade appropriateness of the unit; and reflections about the implications such an approach would have on teachers and science programs.

#### The Organizational Framework

Both instructors indicated that the cycle of five stages outlined in the proposed framework provided a natural sequence, linking one level of awareness, concern and action to the next. More time was spent in the initial two stages than anticipated, however. Furthermore, there was fluctuation between Stage 1 and Stage 2 during the first few lessons as students sought information, clarified and redefined the issue, gathered more information and then re-evaluated the issue once more. With each step of knowledge (Stage 2) came new awareness, a sharper picture of the issue and a corresponding re-assessment of the problem (Stage 1). It was apparent to the teacher that there was overlap in the two steps and that the boundaries between them were not rigid defined:

The framework of the model is well designed. At the grade 4 level steps 1 and 2 may need readjusting. At this level perhaps issue clarification and guided discovery in the initial research is the primary step. From this the students can clarify the problem and the issue. Steps 2,3,4 are quite

achievable with guidance. (Teacher Journal)

The teacher suggested that rather than starting blindly into the framework cycle, existing knowledge and views should be assessed as a way of determining student perceptions and the need for further clarification.

Looking back it might have been helpful to have given a pretest at the start of the unit to determine what the students already knew. (Teacher Journal)

#### Age/Grade Appropriateness

In terms of tasks and expectations of students, the model was considered appropriate to the grade 4 level, but some cautionary notes in this regard were offered as well.

Both the teacher and student teacher felt that grade 4 students had the energy and enthusiasm needed to delve into a thorough investigation of the issue. For the most part, students had the skills, too, although remediation and assistance from the teacher might be essential at times:

The teacher commented:

The children have thoroughly enjoyed the exploration process - asking questions, getting more information. Key to their enjoyment is the interaction with professionals - being taken seriously. They have responded maturely and have accepted the concern (ownership). The data collection - sharing of results and coming up with recommendations is most appropriate. If this was done with a grade 6 class, the students may have more ability, but not necessarily the balance of motivation that these students have. The judgement of the teacher must play an important role here so as to channel concerns in a positive, constructive manner. (Teacher Journal)

The student teacher responded in a similar vein:

I think year four is an appropriate grade level for this model. The students are mature enough to find answers for themselves and seem eager to pursue their questions. At a younger grade level, they may be more dependent on the teacher for answers. (Student Teacher Journal)

Aside from considerations of student tasks and expectations, discussions of age appropriateness centered around discussions of the nature of the selected issue itself. While there was general consensus that the framework cycle was appropriate, with some modifications, to the elementary grade levels, there were some reservations about the type of issue selected for study.

The snow removal issue was complex, involving many factors that were interconnected and interrelated. According to the teacher, this contributed to student difficulties:

Having two radically different situations was confusing to some students. The snow dump issue was so broad and intricate that some students were unable to grasp the whole picture. Just assessing one site would have been more appropriate. (Teacher Journal)

While most grade 4 students were able to work through the framework cycles, the unit involved more time and resources than anticipated. It was the opinion of the teacher that if the selected issue was narrower and simpler, one involving students directly in a concern that had clear issues - perhaps one with polar views of black vs white rather than so many greys - the issue-centered approach as represented by the five stage cycle could be adapted for use at other grade levels.

At the primary grades, the model as it is presented here, would have to be modified and refined. A simplified version of it could be used with an issue that is simpler and more narrow in focus, one that is more black and white, more yes and no.

Perhaps the model is the goal. The early years might be viewed as training years, with students gradually gaining skills and confidence enabling them to tackle broader and more complex issues with hazier interpretations of right and wrong.

Even if one unit a year was approached in a modified fashion from the primary grades and up, by the time students reached grade eight they would be well equipped to implement the issue-centered approach with less assistance and input from the teacher. (Teacher Journal)

Since class interest is an essential ingredient, the teacher also felt that class as a whole should be involved in choosing the topic to be studied.

#### **Implications and Recommendations for Teachers and Science Programs**

Adopting the issue-centered approach requires some shifts in lesson planning, teacher skills and training, student preparation, time and resource considerations.

##### **1) Lesson planning:**

Because content was not the focus, but issue exploration/ resolution was, lesson planning took on a different shape from a concepts/process approach. As noted by the teacher, planning was on a day by day basis, with the teacher establishing where students were and where students wanted to go before planning what they would do next.

The planning was of a different nature. The teacher did not collect all the resources. The teacher does not select what data the children will receive or choose to collect. Preparation requires global thinking skills -what are all the possible angles and how can I lead or make contacts? Each lesson could only be outlined/ planned after the previous one was concluded due to the high student input for the greater part. The exception to this was the first few lessons where the issue of snow dumping required explanation. (Teacher Journal)

For this teacher, planning was an essential activity of the issue-centered approach, requiring a different outlook perhaps than more traditional teacher preparation, but still an important part of the teacher's job:

This unit required much less teacher planning of specific content and selection of information in a direct manner. It was still there in an indirect manner. (Teacher Journal)

For the student teacher, planning, too, became a matter of flexibility and adjustment to the needs and responses of students:

Planning for this unit was very different because most of the time I did not have a clue as to what would happen next. Planning was for what the students wanted to know, not for what I think they should learn. (Student Teacher Journal)

## 2) Teacher Skills and Training

Because the issue-centered approach necessitated a great deal of flexibility on the teacher's part and required the teacher to work without a solid base of knowledge and information about the issue, the teacher indicated that other teachers might feel uncomfortable in the role defined by the model.

What position does this place most elementary teachers who may feel they don't know enough about the issue or have sufficient science background to develop awareness of the problem?  
(Teacher Journal)

In the teacher's view, a gradual introduction to the issue-centered approach, perhaps through a mentorship-type program would be beneficial to teacher contemplating using the organizational framework for the first time:

To attempt this model without some previous experience would be intimidating for most. Selecting/narrowing an issue is essential - the goal would be to keep it simple especially at the year 4 level. Experience using the model would be the best way. Select a current topic of interest and use the model to develop it. This would be done at a more adult level through inservicing or mentoring, but discussions as to how it could be modified to student levels would be needed.  
(Teacher Journal)

### 3) Student Preparation

Many of the student tasks in this unit required specialized skills. Research involved much more than library research. It required that students contact others in the community either personally or by phone. To implement a similar unit, the teacher suggested that students should have prior experience formulating questions, conducting interviews, taking notes, keeping and organizing notes, writing letters etc. The student teacher also felt that students needed to be able to use the telephone and phone book effectively. Knowledge of government channels and departments would have also been useful.

One way of preparing students, the teacher suggested, would be to have the class could "do mini-projects which introduce many of the skills

and processes needed to successfully follow the model".

In this unit, students had not been introduced to the framework model. They were not aware of the sequence of stages and the interconnections between them. The teacher felt that had students realized the structure of the unit they might have better understood the roles and responsibilities expected of them.

By presenting the model graphically students could "see" the next general step. (Teacher Journal)

A key part of the research phase was the presentation of information between groups, an area the student teacher felt should receive greater attention:

One thing I have noticed is that the students drew a blank when it came to the organization of the final presentation. They knew what was important, but had no ideas or suggestions on how to portray that...As a result, I found that I had to push them to find out ways their studies could be presented. (Student Teacher Journal)

#### 4) Time

Several concerns were expressed about the amount of time the unit involved. The unit was started with students in March and formal classes were not completed until mid-May. The newsletter, worked on by a handful of volunteer students, was completed in June. Because of this expanse of time, the instructors felt that it was difficult to maintain student interest and momentum in the issue, especially once the snow began to melt.

Another factor compounded the time problem. Because the unit was

completed during regular science periods that were locked into a fixed timetable, science times varied day by day. Some periods were half an hour long, others an hour. As well, there were days when science was not scheduled at all. When weekends fell on either side of non-science days, there were large gaps of time between activities. It was frequently difficult to "pick up the pieces" and carry on.

Selecting a simpler issue, one that could be examined in detail in less time, would help alleviate some of the problems the teacher felt. As well, spending larger chunks of time, with smaller gaps between, would help condense the unit, giving students and teacher a chance to maintain interest and momentum in the topic. An intensive, all out effort, was recommended.

#### 5) Resources

Not "having all the answers" was not a problem in regards to the unit material. It was the organizing area - personnel and resources - that was disturbing. I was uncomfortable encouraging students to get "excited" about an idea before knowing if resources were available to answer their questions. (Teacher journal)

As indicated by this response, resources became a concern during the unit. Since much of the work involved "breaking new ground" i.e. examining a topical, relatively unexplored issue, research involved locating primary resources rather than secondary ones. Information was thus sparse and uncertain, requiring a degree of risk-taking on the part of the teacher. The student teacher suggested that some of the risk could

be handled with advance preparation:

The teacher should have an idea of the topic and how it works. Perhaps they should have a list of contact people just in case. (Student Teacher Journal)

Since much of the information came from via phone contacts, telephones became a valuable commodity. The school had a phone in the library, one in the staff room, another in the resource room and several in the office. Before teams of students could be sent to any of these places, the instructor first had to find out if the room would be free during the science period. Students, by and large, could not be sent by themselves to use the phone partly because supervision of students was necessary, but also because students often needed assistance in locating numbers and asking questions. Such transactions required considerable effort and time on the part of the instructor.

Three adults - the teacher, student teacher and researcher - worked in the classroom handling four research groups. Realistically, in a typical classroom, only a single teacher might be available, making the supervision and facilitation role even more difficult.

To do this effectively means a large commitment of time and organization. One person alone without support would find it difficult to get done. (Teacher interview)

## Chapter 5 - SUMMARY, DISCUSSION AND CONCLUSIONS

The purpose of this thesis was to explore the issue-centered STS approach as it applied to the elementary science setting. Literature reviews provided an understanding of its rationale, features and expectations of students and teachers as well as a framework to assist with organizing units. The research study utilized the proposed framework as a guide to developing and implementing an STS unit in a grade 4 classroom. In order to provide an in-depth picture of the issue-centered approach at work, student perceptions and attitudes, the roles and responsibilities of the participants, and the reflections and recommendations of the instructors were charted and analyzed.

Since the research was situation-specific, discussions of the findings must be made with an eye to the circumstances, setting and population involved in the study. In this chapter the results are summarized and discussed in the context from which they were derived and with reference to the literature previously reviewed. Such discussions entail appraisals of strengths and weaknesses as well as recommendations for future use. When possible, extrapolations to more general elementary science situations are made.

This chapter is organized into two main sections:

- I. Summary and Discussion of the Research
- II. Conclusions

## I. SUMMARY AND DISCUSSION OF THE RESEARCH

In keeping with the research results presented in the previous chapter, the following three components are summarized and discussed in this section: student responses, roles and responsibilities, and reflections and recommendations.

### Student Responses

Three aspects of student responses were analyzed in this study: issue perceptions, unit ownership and issue ownership. During the unit there were turning points in these responses, points where perceptions and ownership shifted noticeably and sometimes dramatically.

In terms of issue perceptions, there was a gradual and continuous movement away from general, simple and personal views of the issue to more abstract, complex and social perspectives. This change was particularly noticeable in the time between Lessons 1 and 4, after students had a chance for concrete experiences and general discussion. Further growth in issue perceptions was evident after Lesson 18 as students shared the information they had assimilated through research. The more obscure effects of the snow dumping issue now seemed apparent and students were able to see the broader implications.

Indications that students were directing the unit and, in effect, determining its shape and content, were viewed as signs of unit ownership. In this study, unit ownership started after students listed and grouped concerns and organized research teams (Lesson 8). It increased steadily

as students embarked on their research and was particularly strong after groups shared information (Lesson 18-20) and began to discuss possible strategies (Lesson 21).

A prime target of the research was the onset of issue ownership as evidenced by the development of social awareness and a sense of personal responsibility and commitment to the issue. During the initial lessons, little evidence of issue ownership was obvious. As students entered the research phase (Lesson 8), however, an gradual increase in issue ownership was apparent at least in regards to the narrow research areas selected by the students. Once information had been shared between groups (Lessons 18-20), students proposed strategies almost spontaneously. A major shift in issue ownership was obvious in Lesson 21. For most students, the issues were relevant, consequences were clearer if more abstract, and action seemed appropriate. Issue ownership peaked and remained fairly consistent for the remainder of the unit.

Some pertinent points are worthy of discussion. First, the shift from concrete to more abstract views evident in student issue perceptions occurred after the teacher made the decision to incorporate concrete, "hands-on" experiences. As students gained more knowledge and experience through practical research, further movement to more abstract and obscure effects was evident. This evolution of perceptions is in keeping with the literature reviewed previously. In line with Piaget's theory and the Science Council recommendations, most children at this level would seem to need prerequisite concrete experiences before being able to deal with

more formal abstractions. The more complex and abstract the issue, it would seem, the more physical experiences children would likely need before being able to actually identify concerns or determine strategies.

A second point of consideration is the link between the various aspects of student responses. The growth of attitudes and perceptions, as well as the growth of issue ownership, coincided with growth in knowledge and concepts. As the students assimilated more knowledge and understanding of the issue, their perceptions and attitudes evolved and shifted to more abstract aspects. Similarly, their social awareness and sense of responsibility to the issue intensified.

Seemingly, knowledge assimilation is an essential link for the development of attitudes and perceptions (issue perceptions) as well as the fostering of social awareness and responsibility (issue ownership). Such knowledge, however, is not knowledge in isolation or knowledge for knowledge sake. In this situation, scientific concepts of erosion, sedimentation, pollution, heavy metal deposition, drainage etc. took on meaning in the context of the issue and its implications to the individual and society in general.

While students did require a basis of knowledge and understanding before being able to devise strategies and actions, the degree of concept development was not evaluated in this study. As indicated earlier, Yager et al (1988) found that knowledge and concepts did not appear to suffer using the issue-centered approach. While this thesis cannot substantiate these claims, it cannot dispute them either. As indicated by classroom

discussions and in journal writings, students did assimilate a core of knowledge, although the amount is unknown.

The evidence in this study supports Kohlberg's views of cognitive moral development which state that development of cognitive stages is a necessary condition to the development of parallel socio-moral stages. Before children can take the role of another, before they can see the issue from another's point of view, there must be a corresponding development move away from purely concrete perspectives, to more abstract ones. In this case, once children had concrete experiences and had been able to abstract aspects of the issue, they were able to see the issue in terms of others and to develop a sense of social responsibility, a key element in issue ownership.

There is also another side to the development of issue ownership. Kohlberg proposes that moral reasoning develops in situations of moral conflict. This proposal is supported in this study. Discussions, particularly those that occurred as information was shared and strategies were proposed, brought conflicting aspects of the issue to light. There were many views of the issue, many sides to be appraised. The borders between right and wrong were blurred. It was during these discussions, and in the journal writings shortly after them, that students seem to show the strongest evidence of issue ownership.

A third matter of interest is the development of unit ownership. As noted by the teacher, achieving an initial grasp of the issue was a necessary, if somewhat difficult stage, requiring more time and teacher

input than originally projected. The unit was more teacher directed than student directed until a level of knowledge and understanding could be established and students could be released to research independently. It was at this time that unit ownership developed and strengthened. The rise of unit ownership coincides with an increase in understanding of the issue itself, the development of issue ownership, and the lessening of teacher directed activities.

As suggested by the teacher, several factors might have advanced the onset of unit ownership. A simpler and narrower issue, one more easily understood by students, might have helped. As well, if students, rather than the teacher, had selected an issue to explore, indications of unit ownership might have been visible at the start since students may have already had a prerequisite base of knowledge and understanding.

### Roles and Responsibilities

The teacher and student teacher assumed a number of roles and responsibilities throughout the unit. Initially, in the first few lessons, the teacher structured each class, selecting and arranging activities and questions to build an understanding of the issue. Students were receptive, followed the teachers, and accumulated a knowledge base. The roles and responsibilities resembled those of a traditional science class where the program is structured around a concepts-process base.

After Lesson 5, the emphasis, roles and responsibilities changed. Throughout the remainder of the unit, the teacher functioned as a

facilitator and guide. She assisted students as they researched, synthesized ideas, qualified and clarified views, and selected and implemented action plans. Students were, in turn, active contributors in the process, sometimes leading rather than following the teacher.

Discussions were essential to the issue-centered unit. In discussions, the teacher played a vital role. Facts were aired, clarified and synthesized. Opinions and views were valued and accepted, but always against a backdrop of supporting evidence. When conflicting ideas arose, one side was not taken over the other: both were valid if supported by research. Rather than seeking group consensus, the teacher encouraged each student to form his own opinions and make his own decisions. Students, in turn, modelled the teacher's acceptance by seeking confirmation and clarification of facts and opinions, and by valuing the diversity in views.

As indicated in the literature review, discussions of moral dilemmas can promote growth of moral reasoning (Edwards, 1986). By airing conflicting views of an issue, views which have both "right" and "wrong" elements, cognitive moral reasoning is advanced. In this unit, it would appear that this was true. By not aiming for uniform opinions, the teacher allowed for, and accepted, diversity as long as it was supported by evidence. In doing so, she set up an internal criteria base for students to evaluate their own perceptions and deal with apparent moral conflicts. The fact that many students were able to see the broader social implications of snow dumping and were able to argue from the

viewpoint of others such as the farmer, the city engineer, the average citizen etc. suggests that they were able to understand, and perhaps operate from, a more advanced cognitive moral reasoning level.

A quick check of Yager and Penick's (1984) list of qualities inherent to exemplary science teachers, presented in the literature review, is pertinent to this discussion. The effective science teacher, according to this list, uses societal issues as a focus, models the inquiry process, expecting students to probe, ask questions, and challenge facts and authorities. Furthermore, the exemplary teacher facilitates and encourages synthesis, self-assessment, and the development of opinions. Learning for this teacher doesn't stop at the school doors or at the end of the school day - there is flexibility in time, expectations and programs.

The roles and responsibilities assumed by the teacher in this study coincide with the features on this list. While credit should go to the teacher for her exemplary methods, another point cannot be overlooked - these roles and responsibilities are inherent to the issue-centered approach utilized in this study. In effect, the issue centered approach exemplifies the features of programs that meet the standards of Project Synthesis. Since the Science Council recommendations closely resemble those of Project Synthesis, it is fair to suggest that the issue-centered approach as it was used in this study, meets its standards as well.

And what of the student? Through its recommendations, the Science Council promotes programming that stimulates intellectual and moral

growth, that encourages students to participate in political and social choices, and assists them in developing into rational, autonomous individuals. It would appear that the roles and responsibilities assumed by students in this study lean towards meeting these objectives.

### Reflections and Recommendations

Three areas of teacher assessment were examined: reflections on the organizational framework, reflections on the age/grade appropriateness of the approach, reflections on the implications for teachers and programs. In this section these three areas are summarized and discussed against the backdrop of the findings presented previously, namely student responses and the roles and responsibilities of the participants.

#### 1) The Organizational Framework

As noted in the research, there was overlap between Stage 1 and 2 as students and teacher sought to sufficiently grasp the nature of the issue so that it could be more thoroughly researched. However, this fluctuation between stages may be due more to the nature of the selected issue itself and the manner in which it was chosen, rather than a difficulty of the framework and approach itself.

The issue was identified and selected by the teacher and researcher prior to the study. The task, then, became one of bringing students to a similar level of awareness so that it could be examined more closely. As suggested before, had the issue been student generated, an expressed

interest and concern of the class, students might have had an existing knowledge base. Perhaps less time would have been spent identifying the issue, resulting in a movement directly into Stage 2.

Another aspect of this blur and overlap between Stages 1 and 2, may have been the broadness of the selected issue. Although an effort was made to narrow the topic by choosing only two sites to examine, the mechanics of gathering information and appraising the results proved to be complex. As suggested by the teacher perhaps a look at one site would have sufficed.

Although the teacher suggested that the issue should be more black and white, and less grey, Kohlberg's research suggests that having such polar views may not assist with cognitive moral growth. Shades of grey force consideration and evaluation of the less obvious, promoting a re-assessment of existing views and the formation of new ones.

Given a narrower issue, one student and teacher generated, but still having an air of controversy and uncertainty, it would seem that the organizational framework sequence used in this study would be adaptable for elementary grade levels.

## 2) Age/Grade Appropriateness

The structure of the unit demanded certain roles, responsibilities and expectations of students. The question asked now is: Are these age appropriate for elementary grades?

A somewhat cautionary reply is necessary. While the grade four class in this study completed the unit, and successfully met the cognitive and social demands made of them, it was not without a great deal of support and supplement from the instructors.

Many of the tasks involved new skills. Students were required to test new avenues of research, utilize the telephone, compose questions, take notes, conduct interviews, synthesize, evaluate and communicate. Student success in these new skill areas was dependent largely upon teacher direction and assistance. If expectations are that students will learn necessary skills enroute, with teacher intervention where needed, then in this context, the issue-centered approach may be considered age/grade appropriate.

With advance thought and preparation, this approach could be made more efficient and relieve some of the burden felt by the teacher. As suggested by the teacher, the skills could be taught separately from the issue-centered unit and as a preliminary to it. Many of the skills are "life-skills" i.e skills needed for survival in the modern world. They are not exclusive to any subject. As a result they could be components of other subject areas or could even be mini-units taught on their own. As one example, interviewing skills could be a component of the language arts program. By preparing students in this manner, the issue-centered approach could be used more effectively.

Students could be gradually introduced to the issue-centered approach at earlier grades. For example, even grade one students might be able to tackle a classroom or school issue such as waste disposal. By examining the amounts and kinds of garbage deposited in the classroom waste basket, the students could propose actions to reduce the volume or to recycle/reuse some items. A classroom policy could be devised, implemented and later evaluated for effectiveness. Such a unit is appropriate in topic, method and student expectations.

The issue-centered approach, as envisioned in the proposed organizational framework could be appropriate to the elementary, and even primary situation, depending upon the issue selected, the tasks involved, and the degree of advance skill preparation.

### 3) Implications and Recommendations for Teachers and Programs

As indicated by classroom observation and supported by teacher and student comments and suggestions, the implementation of an issue-centered STS unit such as this demands changes of teachers and programs.

Unit planning must be approached differently than in concepts-process science. Since, ideally, the unit begins with the identification of an issue selected by students and teacher together, advance preparation is limited. Once the issue has been selected, however, the teacher can anticipate some of the needs of students and the direction the unit might take. Giving an informal pretest to assess knowledge and views might be

valuable. As well, the teacher could prepare by checking possible resources, compiling short lists of student contacts, arranging for parent volunteers to assist with research teams, checking the school schedule to determine the availability of rooms, telephones etc. Such preparations do not take away from the spontaneous input and direction of students, but prepare the teacher for every eventuality.

Lesson planning in the issue-centered approach is by necessity less long-range, more day-to-day, and more dependent upon student needs and direction. The teacher must be flexible, willing to change approaches and tasks as the need arises.

Additional help in the classroom is a plus for this type of unit, particularly once students undertake independent research. Some training of volunteers would be beneficial in order to orient them to the format and nature of the unit and their roles in the process.

The teacher is not the fountain of knowledge in this approach, a role which might pose difficulties for some. The teacher will not know all the answers or even possibly where to find the answers. Honesty with students is a must. By owning up to their lack of knowledge, by posing questions which need answers instead of providing answers, by steering students towards possible sources or methods of attaining information, teachers model the realities of the scientist's world and the quest for truth and verification that is an essential feature of science. According to the Science Council recommendations, this is an key aim of science education for the future.

The success of the unit depends greatly on the communication skills and climate modelled by the teacher. Openness and acceptance are essential in discussions. Conflicting opinions and facts should not be treated as a problem, but rather as a healthy, necessary element of growth. If children are to develop cognitively, socially and morally, the teacher must set the tone so that information, views and opinions can be presented without risk, yet are open to examination and even dispute by others in the room. Because the issue-centered approach influences cognitive, moral and social development, further study into its relationship to the issue centered STS approach deserve merit.

Because the teacher plays a vital role in the issue-centered unit, background preparation would be helpful. Knowledge of developmental theory, and skill in questioning, problem-solving, decision-making, and communication are key components of the issue-centered approach. Inservice training, observation and participation in actual issue-centered units in other classrooms, and supplemental readings might help prepare inexperienced teachers for their role in issue-centered STS.

Students need to be prepared, too. Skills can be developed in advance. Mini issue-centered units can be tackled in earlier grades. Students can be made aware of the sequence of the unit, and the stages they will encounter. Such preparation will shorten the time required and make the unit flow more efficiently.

Class times for the STS unit should be as close together as possible. Rather than sticking to a fixed timetable of slotted science

periods, which might extend over many weeks, momentum and interest can be more easily maintained with larger blocks of time arranged in closer proximity. This may also facilitate the use of volunteers, resources, telephones etc. and cause less long-range disruption to the school and personnel.

Concept and process development is still a nebulous area. While there is evidence that students picked up a great deal of knowledge and understanding, not just of science, but also of the political and social process inherent to the issue, how many scientific skills and how much scientific content was developed is undetermined. How this approach compares to traditional methods, organized around a content and process core, is uncertain and worthy of further study.

## II. CONCLUSIONS:

Given certain considerations, issue-centered STS as organized around the proposed five-stage framework is a viable approach to STS at the elementary level.

Ideally, the issue identified for exploration should be jointly selected by the teacher and students. It should be concrete in terms, local in nature, not too complex in scientific technicalities, yet one that has a degree of conflict and controversy. Early "hands-on" experiences are a key to developing issue and unit ownership.

The teacher in the issue-centered unit must be flexible, willing to

put long-range planning aside, to work without a strong knowledge base, and to be a facilitator as well as a participant in the learning process. The teacher must be astute in observing and listening to students, attempting to grasp opportunities as they arise, striving to link science to other disciplines, and developing skills and concepts as they are needed.

Strong communication skills are an asset. The teacher must skillfully guide discussion, promoting an atmosphere of honesty and acceptance where conflicting views can be aired without risk. At the same time the teacher should encourage students to critique and validate views, an essential component for cognitive moral development.

Students need to be prepared for their roles in the exploration cycle. Skill lessons can be included and a preview of the stages sequence given. Students must be encouraged to ask questions, to step outside the school setting to seek information, to value the viewpoints of others, and to weigh the many sides to the issue in selecting and evaluating strategies.

Other factors to consider when implementing an issue-centered approach include: time boundaries; availability and access to resources and personnel in the school and community; and the flexibility and adaptability of the school, teachers and community to this approach.

While the effects on scientific skill and concept development are uncertain and such considerations must play a part in impending decisions to use this approach, other significant outcomes were noted. Students

involved in the research showed steady growth in their knowledge and understanding of the issue and its implications for themselves and society in general. Coinciding with this development of knowledge and experience, students showed greater acceptance for the direction and content of the unit as well as greater ownership for the issue and possible ways of dealing with it.

While this approach to STS may not be for every teacher or student, it merits consideration. According to the Science Council report, students need to learn of the interplay between science and technology, how social/political climates shape and determine science activity and vice versa, and of the limits of scientific knowledge. This is one step towards developing an aware citizenship, one with a realistic view of scientific activities and the means by which they can be influenced.

Based upon this study it would seem that an issue-centered approach to science promotes this realistic view of science, showing students how social and cultural forces shape and determine how science is used. Furthermore, since it involves students in an active search for meaning and ways to become involved, the issue-centered approach encourages participation in the decisions facing society and takes a step towards promoting science literacy for the present and the future.

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Appendix A:

LETTER TO PARENTS

Dear Parents,

In the next few weeks, students will be continuing their study of the unit, Water and Land, one of the themes in the Grade 4 science program. In addition to a number of other activities, the unit will explore the issue of snow removal and snow dumping on the banks of Winnipeg rivers, a concern recently publicized in various media. The students will investigate the problem, define the issue, devise strategies to deal with it, and implement them.

Throughout the unit, a researcher from the Faculty of Education at the University of Manitoba will be present in the classroom in order to collect data for a Master of Education thesis. He will be determining the effectiveness and usefulness of the science approach being used in the unit. Information will be gathered through classroom observations, interviews with the teacher and students, and journal writing activities.

Should you have any questions or require further details, please contact me at the school. Thank you for your cooperation.

Sincerely,

(Year Four Teacher)

## Appendix B

### FINAL TEACHER & STUDENT TEACHER JOURNAL QUESTIONS

1. To what extent do you think this unit was appropriate for this grade level?
  - a) To what extent do you think this model (i.e. the STS organizational framework) is appropriate to this grade level?
  - b) To what extent do you think this topic (i.e. snow dumping) is appropriate for this grade level?
2. What changes, if any, do you think might have to be made to the organizational framework to adapt it to this grade level?
3. In what ways did you find the planning stages of this STS unit different from those in a more traditional science unit?
4. Compare the role of the teacher in this approach and that of a more traditional science approach. How do they differ?.
5. Compare the role of the student in this approach and that of a more traditional science approach. How do they differ?
6. In your view, what might be some of the positive aspects of this type of science approach?
7. In your view, what might be some of the drawbacks of this type of science approach?
8. If you could isolate a point at which students seemed to be able to clearly identify the issue at hand, where would it be? (i.e. what lesson, date, or point in the framework?)
9. If you could isolate a point at which students seemed to "own the issue", where might it be? (i.e. students took the view that they were shaping and directing the content of the unit rather than the teacher alone.)
10. What preliminary skills did students need in order to do this unit?
11. What preliminary skills does the teacher need in order to utilize this approach?
12. In your view, could a single classroom teacher handle this approach? Please elaborate.
13. How did you feel not "having all the answers" and not being totally able to control and predict the direction of the unit?

## Appendix C

### FINAL STUDENT INTERVIEW QUESTIONS

1. What are some of your concerns about the Lyndale site?
2. What are some of your concerns about the Waverley site?
3. What do you suggest we do with the snow on the streets?
4. What precautions would you take at the snow dump sites?
5. Who is responsible for the snow dump sites?
6. If you had concerns and opinions about the way snow is being dumped, is there anything that you as a student could do about it?
7. What did you like about this unit? What did you dislike about this unit?
8. How did this unit differ from other science units you have done before?
9. What did you learn through this unit?

## Appendix D

## SCHEDULE OF LESSONS AND ACTIVITIES

| Lesson                 | Date/Time           | Topic/Activity                                                                                                                | Stage |
|------------------------|---------------------|-------------------------------------------------------------------------------------------------------------------------------|-------|
| 1                      | Mar. 7<br>60 min.   | Introduction:<br>- posing the problem<br>- setting the stage<br>Student journal: What is the<br>problem? (1)                  | 1     |
| 2                      | Mar. 13<br>60 min.  | Investigations of snow samples                                                                                                | 1,2   |
| 3                      | Mar. 15<br>60 min.  | Review snow experiments<br>Getting ready for the field trip                                                                   | 1,2   |
| 4                      | Mar. 16<br>180 min. | Field trip (1) to snow dump sites<br>Discussion of field trip<br>observations<br>Student journal: What is the<br>problem? (2) | 1,2   |
| 5                      | Mar. 21<br>60 min.  | Review experiments<br>Student journal: List questions that<br>need to be answered                                             | 1,2   |
| -----Spring Break----- |                     |                                                                                                                               |       |
| 6                      | Apr. 3<br>60 min.   | Review questions from Lesson 5<br>Classify questions                                                                          | 2     |
| 7                      | Apr. 5<br>60 min.   | Review question groups<br>Students select research groups<br>Video: Salt                                                      | 2     |
| 8                      | Apr. 7<br>60 min.   | Introduce interview techniques<br>Groups meet with group leader<br>Research begins                                            | 2     |
| 9                      | Apr. 11<br>60 min.  | Small group research                                                                                                          | 2     |
| 10                     | Apr. 12<br>60 min.  | Small group research                                                                                                          | 2     |

|    |                               |                                                                                                                              |     |
|----|-------------------------------|------------------------------------------------------------------------------------------------------------------------------|-----|
| 11 | Apr. 14<br>75 min.            | Small group research<br>Representation of students visits<br>District 6                                                      | 2   |
| 12 | Apr. 17<br>60 min.            | Small group research                                                                                                         | 2   |
| 13 | Apr. 19<br>60 min.            | Speaker: Independent researcher<br>studying Lyndale site                                                                     | 2   |
| 14 | Apr. 20<br>(a.m.)<br>60 min.  | Small group research                                                                                                         | 2   |
| 15 | Apr. 20<br>(p.m.)<br>180 min. | Field trip (2) to dump sites<br>Discussion                                                                                   | 2   |
| 16 | Apr. 24<br>30 min.            | Small groups - preparation for<br>presentations                                                                              | 2   |
| 17 | Apr. 25<br>60 min.            | Small groups - preparation for<br>presentations                                                                              | 2   |
| 18 | Apr. 25<br>60 min.            | Group presentations                                                                                                          | 2   |
| 19 | Apr. 26<br>30 min.            | Group presentations                                                                                                          | 2   |
| 20 | Apr. 27<br>60 min.            | Group presentations - conclusion                                                                                             | 2   |
| 21 | Apr. 28<br>60 min.            | Review and clarify information<br>from presentations<br>Discussion of views<br>Student journal: What are your<br>concerns?   | 2,3 |
| 22 | May 3<br>60 min.              | Discuss and list concerns<br>Student journal: What do we do now?<br>(strategies)                                             | 3   |
| 23 | May 4<br>75 min.              | List strategies<br>Discussion of strategies<br>Student journal: What should we do?<br>Evaluation and selection of strategies | 3,4 |
| 24 | May 8<br>60 min.              | Draft letter<br>Begin newsletter                                                                                             | 4,5 |

## APPENDIX E: Student Research Questions and Categories

### Group 1: Questions About Water Flow and Drainage

1. Which way will the water flow?
2. How long will it take the snow to melt at the sites?
3. Has Winnipeg ever had a flood?
4. What happens when the ice breaks?
5. Why can we see the culverts one year, but not the next?

### Group 2: Questions About Site Locations

1. Are there other snow dump sites in the city?
2. Why did they pick those sites?
3. Why did they put the dumpsites beside the bridge?
4. Is anyone in charge of the snowdump sites? Who?
5. Does the farmer have a choice? Why was the site placed beside his property?
6. Does it matter where the dumpsite is?

### Group 3: Questions About Contaminants

1. Where will the mud and sand go when the snow melts?
2. What damage will be done to the farmland?
3. Will the salt stay in the mud?
4. Should snowdump sites have someone checking to see what is dumped there?
5. Will the contaminants affect the wildlife?
6. What contaminants are in the snow and get into the rivers?

### Group 4: Questions About Erosion

1. Will the land erode as the snow melts?
2. Will the water erode the riverbank?
3. Will the water affect the power lines?