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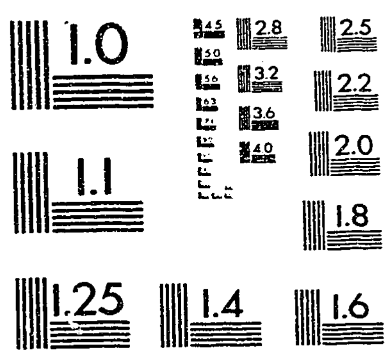

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Language Powering Science: Talk About Gender Differences

by: Heather Ryan

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RELEASE FORM

HEATHER RYAN

LANGUAGE POWERING SCIENCE: TALK ABOUT GENDER DIFFERENCES

MASTER OF EDUCATION

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Heather Ryan

March 13 , 1992

A word is not a crystal, transparent and unchanged; it is the skin of a living thought and may vary greatly in color and content according to the circumstances and time in which it is used. (Oliver Wendell Holmes Jr., Bartlett's Unfamiliar Quotations. (1971). p.328.)

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled LANGUAGE POWERING SCIENCE: TALK ABOUT GENDER DIFFERENCES submitted by HEATHER RYAN in partial fulfillment of the requirements for the degree of MASTER OF EDUCATION.

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March 13, 1992

Abstract

Evidence of declining interest, achievement, and enrolment of girls in science classes beginning at junior high was presented (Fensham, 1990). This study investigated whether gender differences were apparent in two rural Alberta grade eight science classrooms and sought to determine origins of observed differences. A socio-cultural thesis concerning origins of differences was contrasted with genetic attribution hypotheses which suggest that girls are responsible and deficit. Socialization, image of science in education, and nature of discourse in science classes were seen as socio-cultural origins.

Language interactions in the two classes were observed and videotaped to detect the impact of gender differences on self-concept, problem solving approach, and achievement. Four instruments were administered; analyzed by *Anova, two way test*. Variuables assessed were learning motives and strategies; perceived problem solving inventory including personal competence, planning and control; reasoning ability, and general science knowledge. No significant difference by gender or school was found on surface approach to problem solving, but significant effect (F=.004**) on deep and achieving approach with school two scoring higher. Significant difference (F=.018*, df=1,) favoured males in perceived personal competence. Means on personal control were 3.16 for school one; 3.29 for school two. No significant difference was found in reasoning ability or general science knowledge but boys and girls in school two scored similar high scores on *TASK* after two outliers are disregarded, and the highest individual scores were in this class.

Gender differences in classroom discourse were richly illustrated from videotape/notes. Interpretation was from a

naturalistic enquiry approach. Suggestions were made for improving girls' involvement and achievement through increased teachers' attention, use of challenging questions and assignments, single sex lab and activity groups, and increased informal science talk with the teacher and peers.

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This research project would not have been such a rewarding experience without the assistance of my committee, my family, and friends. In particular I would like to thank the following individuals:

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1. INTRODUCTION

A review of worldwide research indicates that girls have a relative decline in achievement, interest and enrollment in science (compared to boys or their earlier performance) in the early years of secondary school (Girls in Science and Technology Conference proceedings, 1986). This study focuses on the experience of boys and girls in science classrooms and critically analyzes how scientific knowledge, and the implicit messages concerning gender and power relations, are communicated between teachers and students. It is also argued that language is central to the development of the emotional, perceptual, social, behavioural and cognitive whole of personality (Vygotsky, 1986). Vygotsky stressed the importance of instruction to development, noting that language plays a pivotal role as synthesizer of all meaningful human experience(Wertsch, 1985; Vygotsky, 1986; Bain, 1975). Vygotsky notes that concepts are formed through language which is in turn embedded in the socio-cultural environment surrounding the developing child. **This study will investigate, from a Vygotskian perspective, how language in the science classroom shapes student self-concept, understanding of abstract concepts and knowledge of relationships between science concepts.**

It was a goal of this study to construct a conceptual framework for the role language plays in society in directing the growth of both young boys and girls. A number of heuristic questions were asked. For example: Are there differences in discourse between teachers and boys and girls in Alberta schools? If differences in the language are clearly demonstrated, do they coincide with the achievement, interest, and approach of students in science classes today?

Matyas (1985) cites a U.S. study by the National Assessment of Educational Progress (1978) which shows that girls do not receive the same treatment in science classes as do boys. In studies of junior high and senior high schools in the U.S., Matyas found that by age 13, the achievement of girls is lower, their number of scientific experiences in and out of class are fewer, and they have less positive attitudes than their male counterparts (p.28). This disparity apparently increases between 13 and 17 years of age (Matyas, 1985; Kahle, 1987, Whyte, 1986). A 1981-82 National Assesment of Science (U.S.) project (Hueftle, et al,1983; cited in Kahle,1987) reports that fewer than half of the 13 year-old students thought their science classes were interesting; a majority said they did not like to attend science classes and felt they were unsuccessful; and described science subjects as too difficult (p.54).

All of the concerns cited, for example, interest, self-concept, science experience and the image of science and scientists, experienced as part of science education require investigation as potentially important influences on the differential achievement, approach to science and technology, and career choices of boys and girls.

A discernible impact of gender differentiated experience in science studies and achievement seems to be an alienation of females from science and science-related careers. This alienation is apparent in a virtual absence of females in the general use of technology and political decision-making involving science. The far reaching impact of underrepresentation of women in science and the socially powerful and lucrative careers for which science education acts as a filter will be argued.

The language and interactions of the science classroom will be studied to determine if there is a gender bias in the above components that produce lower achievement and alienation for girls. Status and power in the community at large may be directly related to perceived competencies, commonly reflected by academic achievements, income and career choices. The knowledge of status and power is transmitted through language in the classroom and how this differentially affects girls will be developed.

Meta-analysis techniques, which synthesize findings of published research, and process analysis, which characterizes cognitive skills used in complex tasks were applied to studies from the last 20 years to determine the nature of this gender difference.(Linn & Hyde,1989)

Evidence shows that the magnitude of gender differences in cognitive and psychosocial domains have diminished but the earning power for females compared with males remains unchanged, with females' averaging 59% of males' salaries. Female access to mathematics and science careers has increased but has remained low, going from 8.6% female in 1975 to 13.4% female in 1986 (National Science Board, 1987, reported by Linn & Hyde, 1989. p.17)

Undeniable inequities exist in the status and power held by the sexes, across occupations from academic positions in universities, to professions, management and executive roles in the private and public service internationally. The Report of the President's Commission for Equality and Respect on Campus (University of Alberta, Mar.,1990) is one indicator that this inequality still exists, in spite of a legislative effort in Canada to remedy this situation.

For example, at the University of Alberta, 28 of 94 departments have no female as professor of any rank. Only five departments had more than 51% women and these are mostly in stereotypically female ares such as education, nursing, and home economics. Ninety-one percent of full professors are male.

Kruse and Wintermantel (1986) note that although women make up about 40% of the work force in countries like West Germany and more than 50% in the United States, they do not hold more than 2-4% of the top positions. No more than 15% of middle management positions are held by women. Women are consistently paid lower salaries than men in spite of anti-discrimination laws and the salary gap is widening.

In Canada in 1990, 22% of members of Parliament and 14%

of Senators are women. In 1989, 14.1% of management in the federal public service were women (statistics provided by an interview with provincial legislature librarian, Lorne Buhr, Nov.9, 1990). These facts are to be considered part of the social, cultural, and educational framework that profiles the surrounding community and awareness of the power relations brought to students each day by classroom discourse and media. The language in the science classroom is part of the filter system which produces and maintains this inequality.

Background and Rationale

The world was on the edge of a massive ecological and human disaster created by a high technology explosives attack on Iraq by United Nations-supported forces in 1991. This compelling event and resultant destruction vividly illustrate the predominant public belief in Science, and the impact of a biased use of language by those in power. The media and political talk given to "smart weapons" and "precision targeting" may have lessened public dread of what happened in Iraq and Kuwait but also illustrates (a) how pervasive is the scientific world view identified with Galileo and Newton (Matson, 1964) and (b) how pervasive is what Bain (1987) refers to as "word magic" which hides the intended meaning of the message.

It sees a hope of the developed world that science will eventually know, explain and manipulate all phenomena for human purpose. This desire has created technology and a prevalent mind set that made greater destruction possible than before. It is disturbing that there has been limited public outcry in response to this war or to vast destruction that occurs in oilspills, clear cutting of major forests, or depletion of ozone in the Earth's atmosphere. What role has education and academic research played in interpreting experience of crisis and identifying alternative processes? Have they been asking appropriate questions to open peoples' minds to understanding the phenomena?

Science education is the usual vehicle for providing information about technology and the ecosystem to students. *Reaching for Possibilities in Science Education,* (Jacknicke and Rowell, 1984), describes the "world of science" being offered through school science as misrepresentative and dominated for decades by rational empiricism, leading to narrow interpretation of science by both teachers and students. The author concurs with this assessment. This dominant 'world view' of science has central themes of control, efficiency, precision, predictability and standardization.

Jacknicke and Rowell (1984) describe this technical approach to science education as "reconstructed logic" which separate the learner from the process of science. The student is presented with a "fixed body of knowledge related to and derived from 'real' science that young people need to know in order to understand the world in which they live" (p.15). This underestimation of the disagreement amongst both educational theorists and scientists, as to acceptable goals, methodology and scientific practice is integral to the problem at hand.

The loss to students of a human/personal context and of the tension created in the lives of both the scientists and society by their struggles to solve problems or make sense of the world in which they live, is loss of significant context that provides colour, relevance and interest. For example in this researcher's teaching experience, introduction to Einstein's background and difficulties in school will intrigue disheartened students, perhaps giving them some hope for success in science. That scientific discovery is often the product of lucky accidents in the presence of a disciplined mind is not stressed in the curriculum.

The key to changing the predominant educational paradigm may be a focus on relationships of participants in science and technology. It seems reasonable to assume humane interpretation of the evolution of human history within a personal context would not only reduce our precarious dependence on the false god of traditional science but also draw a larger and **different kind of population** to studies and careers in science.

A creeping unease at the focus of science education can be found in both media and research journals across the developed world. The growing recognition by curriculum researchers, ecologists, and citizen action groups, of the need for a more humane science strengthens the feminist cry for equal involvement and advancement opportunities for girls and women in the scientific and technological world. Critical theorists (Apple & King, 1976; Spender, 1980; Smith, 1987) addressing the power differential between men and women maintain that increasing womens' access to and mobility in these domains may contribute to a gentler, more representative approach to serving a rapidly changing world.

An important consideration is whether society can afford to continue to exclude values and cooperative problem solving strategies of females from research in science. The fields of genetics and biomedical studies have great economic impact requiring humane bioethical consideration, and yet women are still poorly represented in this field (President's Report, University of Alberta, 1990).

The awareness that "in Polanyi's phrase, 'knowledge is personal'--and most profoundly when it is knowledge of other persons " (Matson, 1964, p.238) suggests a conscious effort by educators to provide students an understanding of science as a human activity. In the process of civilization, it may facilitate humanizing change. Greater recognition through science education of uses of technology and economic basis of science may encourage women and men to redirect resources to improve quality of life.

A useful way of understanding the role that schooling plays in perpetuating the myths of science is simply to study the interactions of teachers and students. The classroom is a kind of ecosystem, reflexively shaping the actions and choices of teachers and students. **The purpose of classroom ecology research (Shulman,1990) as implemented in this study is not to blame teachers nor to label students as victims, with deficiencies contributing to their state. The intent is to examine the relationships in the classroom and interpret their impacts on students.**

Sometimes studies of gender differences in school achievement and interest were abrasive in reporting their data (eg., Tobin, Kahle & Fraser (1990). The approach adopted in this study does not attack the participants and then expect their cooperation or interest in research insights. The intent is to allow the evidence to speak. Jacknicke and Rowell (1984) explain recognition by Groome (1980) of the need to change teacher practices; "this recognition of discrepancies between interests and the existing quality of life must be followed by modification in attitudes and actions in everyday life. This reciprocity between thought and action is often referred to as praxis." (p.14).

Before doing this study, this author taught high school science for eighteen years. Personal experience, which can be the basis for rational prediction, brought recognition of students' desire for growth as the most powerful guiding factor for their actions. Students' choice of action is determined by the diversity of language and other symbols they understand and use (Bain, 1990). The joy of sharing understandings of science with several thousand students was too often dampened by young women coming to class, apprehensive about their abilities to succeed in this class or in a science career. Eventually, sadness at young women showing so little confidence in their own abilities, in spite of academic achievement equivalent to or often better than their male peers, turned to frustration that this fear and distrust of science learning was not being adequately addressed in the school system. This context provided personal impetus to begin this project.

Nature of the Study: Sharing Science With Children

This investigation seeks to determine if the widely published gender differences favoring males' school achievement and interest in science are apparent in junior high science classrooms and if so, how may they be related to differences in the language experiences of boys and girls in these classes.

The challenge is to determine if the phenomena of gender differences in interactions between teachers and male or female students, described in the literature, does exist in these classrooms and whether or not it has significance to these students, with respect to relating to their interests or achievement.

Procedure:

The nature of language and interactions were observed and videotaped in two rural grade eight science classrooms in central Alberta. The rural study was selected because of:

(1) interest of the researcher in local schools;

(2) curiousity about language practices in these rural schools, particularly whether or not it had varied from personal experience in a rural school many years ago;

(3) recent experience in city schools as a parent, teacher, and faculty consultant.

The observer's verbal behaviour inventory, adapted from Kelly (1955), was used for analyzing videotapes. These records represent the interactions and nature of language used in each classroom.

Four questions found in George Kelly's Personal Construct Theory (1955) guided selection of the instruments and interpretation of data:

(1) What views do the children have of themselves as learners?

(2) How does their approach to the subject affect their assimilation of science concepts?

(3) How is interest expressed

(4) Does the way that students describe their understanding differ?

Kelly developed Personal Construct Theory to integrate his theory of personality with theory of knowledge. He considered that each person uses language constructs to join unfamiliar information about the world to what he or she already understands, thus reconstructing experiences to make sense of them.

According to Vygotsky, talk in the classroom is central to this process. Clearly, freedom for students to question and offer their explanations of science concepts as they are introduced, are critical to reaching their cognitive development and accurate self-perception.

Cazden (1988) expands on the Vygotskian perspective that through language, a child develops increasing competence and responsibility for independent performance through help from an adult or teacher in a social situation such as the classroom. Cazden (1988) notes that Vygotsky's construct of the *zone of proximal development* is often linked in current research to the concept of classroom language as scaffold "providing visible and audible support... that allows the novice to take over more and more responsibility for the task at hand." (p. 107) Cazden (1988) describes and illustrates "four cognitive benefits of discourse; discourse as catalyst, as the enactment of complementary roles, as relationship with an audience, and as exploratory talk instead of 'final draft'." (p. 126)

Tobin, Kahle, and Fraser (1990) describe a learning model involving cooperative learning and social collaboration in small groups that produced success in mathematics for Yackel, Cobb, Wood, Wheately, and Merkel (1988) and note that there has not been research in science classrooms to describe similar student activities (p.8). The study was investigating a process that demands problem-solving activities that are meaningful to all participants, producing learning with understanding rather than by rote. The student must understand task demands and role expectations provided by a teacher who acts as facilitator and maintains an environment favorable for learning. Tobin et al (1990) found that rote learning of scientific terminology was promoted in response to the volume of such formal language, presented by teachers as source for subsequent evaluation. The verbal behaviour inventory catalogued related behaviours observed in the current study.

Within the classrooms, the researcher interpreted the language used by teachers and students to get some sense of:

(1) how understandings of events are constructed by the participants;

(2) how these understandings are enframed by the culture of the school, community, and socio-economic climate.

Demographic factors considered here include sex, age, and training of the teacher and students, the abilities and attitudes of students, the context of the classroom, school, and community. Elements such as use of praise, control of time, allocation of resources to students and emotionality, which are significant in transmitting appraisals of students and providing control (Apple and King, 1976) were also reported.

The interactions of teacher with students and between students were carefully recorded to discover observable changes in pupil behaviour that may promote growth in both self-concept and achievement and influence their adult personality and career choices.

Journalling was done in each class to give a sense of class environment and interactions as well as factors that may influence interpretations of notes or videotapes.

A model for the study of classroom teaching (Dunkin & Biddle, 1974; cited in Shulman, 1990) provided precise areas to be investigated. This model is presented in *Appendix A*.

Methodological and statistical methods described in Chapter three will be used to discern predominant patterns or interactions with gender differences in the experiences. Interpretation focused on the perspectives of male and female students and of the teacher in the classrooms.

The study attempted to identify learning strategies, cooperative efforts and language use to understand and apply science knowledge to everyday problems. Recognition of the great deal of energy required to provide a stimulating environment for learning and of the self-reflection engaged in by teachers, ensures that proposals for future research or changes in praxis will remain firmly grounded in the real language of today's classroom.

Assumptions and Aims:

There are three assumptions:

(1) that the critical researcher must question not only the content **and** the mode of presentation of school science, but also the intent of those deciding content, and whose interests the curriculum serves;

(2) that preconcieved values and assumptions about men and women and their place in the world are the root metaphors currently operating in traditional science classrooms. Once root metaphors are identified, they provide fuel for change in classroom language practices.

It is evident that there has been insufficient research into socio-cultural factors that produce well documented gender differences in scientific achievement.

(3) It was an assumption in this thesis that these gender differences in attitudes, interest and achievement can neither be adequately explained nor provide direction for possible solutions in the classroom through hypothesis favoring biological or cognitive differences between sexes.

The aim of this research is to determine ways of promoting a new consciousness, a new willingness on the part of teachers and others to look at what is done and how it is communicated in science classrooms in rural Alberta.

Significance of the Study

There is a need to reconstitute the practice of science education. A review of the literature, grounded in a wealth of experience in science classrooms, should provide some insights that can be applied by teachers and curriculum developers toward improving experience for both male and female students. Implicit in this re-evaluation of the science classroom is a recognition of inequity of power distribution to students to discover and pursue their scientific interests. Responsibility for changing the curriculum of classroom interactions and nature of language and examples used in science instruction must begin at the grass roots level, with reflection by classroom teachers. Teacher praxis may be more sensitive to insights gleaned from classroom observation and student performance measures reported by a veteran teacher, **if** that research focuses on an aspect of behaviour that can be identified and changed to benefit students. Language usage in the science class is one such feature.

Cazden (1988) has noted: "Science educators face particularly difficult pedagogical issues in trying to help students understand, and not just verbalize, new ways of conceptualizing natural phenomena." (p.119) She suggests that the child may not embrace the view presented by a teacher, unless that teacher is able to speak with understanding to the world experienced by the child. Cazden supports Vygotsky's (1986) premise that the child shares reference with the adult before they can share meaning. If this sharing doesn't happen, Cazden (1988) says; " the result can be misunderstanding, conflict, and invalid inferences about a child's ability to learn." (p. 117)

Definition of Terms

(1) classroom language:

> Spoken language is the medium by which much teaching takes place, and in which students demonstrate to teachers much of what they have learned... spoken language is an important part of the identities of all the participants.(Cazden, 1988, p.2-3)

(2) classroom ecology research:
The study of the relationships that can be observed within a classroom. Important variables are listed in Figure 2, p.135.

The following terms are limited and defined by their context of use.

(3) stereotyping language:
Words which in a particular context connote a stereotypical response.i.e. attributed to a particular gender.

(4) assertive language:
Words which express authority and assert the power and knowledge of the speaker.

(5) collaborative language:
Words which are supportive, and invite dialogue and cooperative interaction with the speaker.

Limitations

Although the insights were gained in only two settings and investigating interactions and contexts not individuals, with prudence they may be generalizable to other settings. Efforts were made to identify and report idiosyncratic features of this population, to aid the reader in wise use of these findings.

The dire condition of the Alberta farm economy now, was one exogenous factor whose direction and intensity of influence on the perceived classroom behaviour of students and teachers could not be measured within constraints of this study.

Overview of the Thesis

Chapter Two reviews related literature and recent research. Significant gender differences in student interest, motivation and achievement in science will be demonstrated. Theories attempting to explain the origin and impact of these gendered differences will be critically analyzed in light of research. The role of language in conveying identity and predominant cultural practices are woven together into a heuristic, the conceptual framework regarding how language in the science class shapes the knowledge, interests, expectations and behaviours of the participants. A commonsense interpretation of the experiences of the other participants in the classroom was the aim of the qualitative portion of this study. The experience of the researcher will be presented under headings of themes that arose from the context.

The researcher developed a verbal behaviour inventory, adapted from Kelly (1955) and based on language exchanges identified in the research literature as promoting interest, self-confidence and achievement in science classes. This inventory was used to analyze the videotapes and the procedure is described in detail in Chapter three.

In Chapter Three, subjects, instruments and procedures will be outlined. Data analysis and discussion of classroom observations will be included in Chapter Four. Summary and discussion of findings with suggestions for future research constitute Chapter Five.

II. REVIEW OF LITERATURE

Literature selections will offer historical, philosophic and practical rationale for what events unfold within science classrooms. Classification of this literature is somewhat arbitrary, but the sources defined the extant research, and suggest a promising context to understand the problem of science education.

The review has been organized into three areas that impact upon the interest, motivation and personal achievement of girls in science classes:

(1) the image of science and science education;

(2) classroom practice/student achievement;

(3) the role of language as synthesizing learning and identity.

Suggestions for change to make science a rewarding experience-- for both boys and girls-- will be drawn from the literature.

The Image of Science and Science Education

Impersonal, objective science has limited appeal. This image problem has been identified from studies around the world as a significant contributing factor to the inadequate number of girls in science classes and careers in science. Sjoberg and Imsen, educational researchers in Norway and contributors to the Girls And Science And Technology conferences, state:

> ... that girls' cultural codes divert them away from science in spite of talents and interests. Science in most cultures is defined as a masculine domain. Boys engage in science and technology to reinforce their masculinity - while this is not a way for girls to become feminine. For a girl, a choice of science may lead to sanctions from her female peer group and from the boys! (in Fensham, 1990, p. 224)

The Girls Into Science and Technology project in Britain (Whyte, 1986) was an effort involving a team of researchers working in 10 widely differing schools to attempt to encourage more girls to enroll in sciences in secondary schools. They observed classrooms and administered questionaires to discover childrens' opinions of science and sex roles. This project identified gender differentiation as boys dominated class discussion and use of resources. The boys were more biased in their image of appropriate sex-roles. The impact of boys' stereotypical views upon their female classmates was of concern. This project involved prominent female scientists who talked about their studies and careers, in an attempt to alter gender stereotypes. Judith Whyte (1986), a teacher and researcher, found that the project had less impact on subsequent enrollment patterns than it had on girls' attitudes and identifying new research questions and intervention strategies. These contributions helped raise awareness and interest in the educational community.

Another aspect of the lack of appeal of science is the relationship between teacher and students traditionally found in the curriculum of many introductory science and technology courses. The science teacher must represent themselves to their students as an expert who can efficiently impart information and techniques outlined within curriculum guides. The separation of student from teacher according to expertise in curricular content is an alienating element, one that provides the teacher power and control over classroom experience and lessens students' involvement, a point made by Jackson (1968), Grumet (1988), and Jacknicke and Rowell (1984). Habermas (1971) and Polanyi (1973) both claim that science is not neutral, impersonal or objective. Moreover, teachers and students are trapped by science curricula that primarily display the values of a class-based, male society (Apple, 1982).

This uncritical acceptance of a way of thought led Apple (1975) to state "that scientific outlooks have become so engrained in our consciousness that they have become values, not merely ways of gaining knowledge" (p.123).

Pressure is on the teacher to accurately transmit the most important, useful ideas and skills to ensure a reasonable level of student achievement on external evaluations. Continuous evaluation is regarded as essential to monitor progress in acquiring this fixed knowledge. This accountability demand may limit teacher time and freedom to focus on providing needed context or 'flesh for the bones' offered in the highly structured curriculum guides and allow little opportunity for the human nature of knowledge to be visible. A common observation of all studies reviewed was that cooperative relationships and nature centered interests of girls, contrasted with the objective, impersonal and competitive image of science, result in an alienating science for girls.

Concern about impact of accountability for teachers and constant evaluation on the behaviour and beliefs of the student is described as another alienating element in classroom life (Apple & King, 1976; MacDonald, 1975). This researcher shares their concern with the assumptions that educators bring to curriculum and suggest the need for an investigation of the discourse modes they employ.

Valuable support for the perceived need for this study was provided by the writing of the Brazilian Liberation theologian, and Marxist-humanist, Paulo Friere. Friere (1972) is a renowned proponent of social reconstruction in education, who focuses on the historic, social, and environmental contexts. His goal in teaching is to develop a sense of context and the power of the learner in their own world. To Friere, gradual development of self-awareness within the community and world transforms the individual and reality. Friere views the teacher as an ally to the learner in this process, reflecting his own experience as a teacher who helped bring about transformations among common people. A similar transformative intent is revealed by the

Austrian/Mexican emancipation theologian Ivan Illich (1970).

> The current search for new educational funnels must be reversed into the search for their institutional inverse: educational webs that heighten the opportunity for each one to transform each moment of his living into one of learning, sharing, and caring (p.viii).

Historically, the science curriculum has been very narrow, too often developed by external experts in scientific disciplines or in educational pedagogy with implementation left to teachers. Since these developers were usually not in classrooms, the resulting programs of study showed little sensitivity to the personal knowledge, individual differences or interests of students. The student was treated to the fallacy of universalism, that the same knowledge was valuable to everyone and would be received in the same way.

This pattern is changing in the Alberta school system as teachers develop units to be selected for provincial curriculum. Many teachers however still pursue a narrow view of their subject (Harding, 1986) with the aim of training students to pass standardized exams, and too often evaluation produces a ranking of the students that labels them far into the future and limits their interests and career choices (Whyte, 1986).

Inherent socio-cultural influences allow boys and girls to develop side by side with very different goals, interests and expectations (Gilligan, 1982; Grumet, 1988; Kelly, 1987). These two co-existing cultures can contribute to real differences in the students they produce. The evaluative climate furthers the difficulties because girls are seen to be deficient in science skills or achievement (Kelly, 1987). Smith (1987) argues that these cultural differences are what drive the political and educational machinery and until feminine culture and language use are given greater social value, women will continue to be disadvantaged.

This is a serious problem that the educational system needs to address. Experience in the classroom and related research supports this bicultural influence in the current educational environment as origin of gender differences in science performance.

Alberta Education's policy statement Partners in Education and Secondary Education in Alberta, 1985 made a commitment to excellence, illustrating James MacDonald's (1975) suspicion that all curriculum design and development is political in nature. "Education should foster ideas of risk-taking, innovation and the pursuit of excellence"(*White Paper: Proposals for an industrial and science strategy for Albertans, 1985-1990, p.67*). Part of this commitment concerned the return to core curriculum with the majority of instructional time to be spent on core curriculum with a smaller remaining time available to a shrinking choice of options.

The policy further suggests this will require less variety in teacher specialization, save on costs, and increase accountability of teachers and school boards. But these changes seem more a reflection of the political shift of this government towards achieving a closer fit between the needs of this economy and the educational outputs than a policy designed to achieve a science curriculum that involves all parts of society.

The technical perspective of science curriculum in Alberta in the ideologically-driven tight economic conditions of today is clearly articulated. These economic pressures reinforce the competitive nature in science classrooms, and force parents to push their children to excel to gain entry to post-secondary institutions (Decore & Pannu, 1989). The competitive nature of traditional science classes is antagonistic to the cooperative, shared learning preference identified in girls (Harding, 1986).

Under these competitive conditions, it will require creative instruction and modification of the science curriculum at the grass-roots level of the classroom to serve students. Without this effort by concerned educators, many students, including many young girls will be restricted from the academic achievement, career options, and social power that higher education in science has to offer. This study will investigate whether this alienating image of science differentially affects girls, limiting their interest, achievement and career choices.

Explanations of origins of identified gender differences in attitudes and performance toward science stretch the imagination.

Origins Of Gender Differences Offered:

Whyte (1986) in a report to the *3rd International GASAT Conference* presented three models identified in anthropology, psychology and womens' studies literature. These models underscore accounts of sex differences in attitudes, behaviour and choices made:

(1) The genetic deficit model denies that women have the same range of intellectual abilities as males;

(2) the cultural deficit model that implicitly accepts structures and practices of the world as it is and sees women to be lacking qualities leading to achievement in these structures;

(3) the bicultural model that sees sex roles as socially constructed and thus recognizes no theoretical limit on the ability of each sex to display or practice characteristics of the other.

There is unanimity among the writers in that they all reject the notion of innate differences. There are criticisms of the studies of gender differences in science related abilities as having serious inconsistencies, a lack of conclusive evidence and difficulties with the construct (Caplan, 1985). Most cite stereotyped male/female roles in society as the cause for gender differences. Many blame the schools for consciously or unconsciously reinforcing these stereotypes.

A sociological interpretation based on thinking developed during the growth of the womens' movement in the U.S. (Smith, 1987) describes how children learn that "it is a man's job to be in charge and that girls should not display their expertise and knowledge openly- especially in the company of boys". The stereotypical female orientation to males is helplessness. This learned response eventually denigrates their belief in their own abilities until they view themselves as less competent than boys and failed attempts at a task as due to lack of ability.

DeCharms (1977) argues that students learn to act as pawns or as self-initiators because of how they are taught by their teachers. Self-control and self responsibility are tied to behaviours required for pursuing academic objectives. DeCharms found that teachers whose belief systems are open, complex and interpersonally sensitive were more apt to accept and encourage influence attempts from their students. Teachers dominate the talk in the classroom when language is used for controlling and shaping behaviour (Kelly, 1987; Lemke, 1990). Peer group pressure works to reinforce the internalized social norms, thus limiting the range of many girls before they have determined their particular strengths.

Operating from psychoanalytic theory, Head examines ego-development and Harding and Sutoris examine object-relations theory (Kelly, 1987). They suggest that the impersonal nature of science has greater appeal to boys because the perceived stability and power of a scientist in society addresses their greater anxiety over early identity separation from their mother.

Critical theorists (eg., Apple, 1982; Anyon, 1988; Jackson, 1968; and Eisner, 1985) look into the world experienced by students in classrooms to analyze what is learned and how this ritualized experience transmits the world view of the dominant culture, excluding or attacking all others, and thereby maintaining the status quo. Educational psychologists(Bain, 1983; Bruner, 1983; Cazden, 1988; Harris, 1983; Spender, 1980; Kramerae, 1981; and Vygotsky, 1986) examine the language and interactions to provide theory toward understanding origin and impact of gender differences. The insights of philosophers (Habermas, 1987, and Foucalt, 1980) add a broader dimension to the social construction of the feminine gender.

Gender Differences reflecting power and authority or Evidence of a Feminine Culture?

According to Eagly and Steffen (1986) and Deaux (1976) males are more aggressive, both physically and verbally. Deaux (1976) reviewing related research and a study of competition in game playing concluded that neither sex is more competitive but women are more frequently concerned with the social aspects of the situation than men. Women may employ different strategies and achieve different goals than men. Recognition of male dominance was suggested by a Weitz (1976) observation that young boys make more attempts to dominate adults than girls do and both sexes are more nonverbally anxious when interacting with men than with women. This has implications for this study as the small number of females teaching the 'hard' sciences such as physics and chemistry, provide girls with role models and inclusion into their own gender group, which is commonly provided to boys in these classes by the large number of male science teachers.

The consequences of sex stereotyping affect both men and women and colour their ability to share experience and emotion. Males' greater need for power was documented by McClelland (1975). Hoyenga and Hoyenga (1979) listed many differences from past research. These findings included:

(1) girls were given more help upon request than boys, and this was associated with high verbal ability. Thus, if daughters are encouraged to do well and are reinforced for seeking help, affiliation is combined with achievement for girls and separated for boys;

(2) Women more consistently take the social route to competence and achievement;

(3) Cross-cultural evidence supports greater female self-disclosure and more accurate display and recognition of emotions from body language.

There is ample evidence for differences in communication style and values (Hoyenga et al, 1979). These differences include the following tendencies: men talk more and interrupt women more; women are more correct in grammar use, and apologize more; more often women request while men command; women sound more tentative; women use more emotional inflection in their voices, and give more agreeable replies.

Nonverbally, women require less personal space between themselves and others than men do and use more eye contact than men. Both tendencies foster affiliation and ease communication. Males touched females more frequently than the reverse and females who displayed physical contact upon greeting a male were evaluated less favourably(Hoyenga & Hoyenga, 1979). Deaux(1976) found that women also smile more.

Phillips (1985a) when studying research on sex roles, found stereotyping that is offensive to most women but is common both in educational institutions and among the public. This stereotyping includes the ideas that: women are better at verbal tasks, think more globally, are more empathic, are more apt to allow intuition and emotion to influence their judgment, and are less aggressive.

Women more often associate transgressions with guilt (internal locus of control) while males more often associate transgressions with fear (external locus of control), (Eagly and Steffen, 1986; Hoffman,1975, cited in Hoyenga et al, 1979). Thus female behaviours are more often internally mediated while males more often show fear of getting caught or external mediation of their behaviour. A common suggestion throughout literature reviewed was that failure and guilt may be more internalized in women by socialization; and affiliation, as a sign of achievement, may be the result. This study will investigate gender differences in personal control and perceived self-competence through the *PPSI* and compare these factors to reasoning ability measured by *OLMAT* and general science knowledge as measured by *TASK*.

Classroom Practice/Student Achievement

In 1981, Allison Kelly, an educational researcher who had taught high school physics and math in England, searched out and edited theoretical or classroom-based articles into *The Missing Half*, a look at the question of girls in science. Thus began a new subject for research attention resulting in a growing body of critical and pragmatic literature.

The initial approach was to question why girls avoided science and the conclusions suggested deficits in the girls rather than studying the curriculum or classroom experience to explain the reality. Kelly's reasons included:

(1) girls' low self-confidence as the root of the claim that science is too difficult;

(2) conflict between girls' image of science as masculine and their perception of what is feminine practice;

(3) the impersonal image of the scientist as not focused on people as girls traditionally have been socialized.

This movement in research caused intervention programs intended to simultaneously strengthen the female ego and improve the image of science and it's practioners to make it more appealing to girls.

Kelly had changed her perspective by 1987 when she edited *Science for Girls?* to a belief that science must change, not girls. Kelly proposes that more classroom investigation is needed, supported by a theoretical analysis of the process of change in science education.

In an exhaustive review of the related literature (298 independent samples consisting of 83 articles from five data bases from 1965–1981, standardized test results from test agencies and University of Illinois, and sex comparisons in national and international studies) investigating sex-related differences in motivation related to achievement in school science (Steinkamp & Maehr, 1984) used meta-analytic techniques to determine:

(1) if there are gender differences evident in elementary and secondary school science achievement;

(2) if evident, what is their nature?

(3) and, what is their origin?

Meta-analysis sums statistics of published studies on matching variables looking for significance, interactions and trends that yield more stable generalizations than typical of individual studies.

It was found that small differences in both motivation and achievement do occur and that they favour males. Steinkamp and Maehr (1984) concluded that the small differences in means in motivational orientations toward science at these levels cannot be used as a primary explanation for females' underrepresentation in science professions or as justification for disappointing performance records in these fields. However, girls gave more negative responses than boys about their relationship with science. They were less involved with science-related extra-curricular activities. Steinkamp and Maehr suggest that the small number of girls who consider science as girl-appropriate or careers in related fields as likely, may be due to the scarcity of female role models.

Powerful support for a cultural explanation for sex differences in motivation toward science can be drawn from Steinkamp and Maehr's (1984) comparisons of data by country. In Israel, where efforts are made to remove stereotyping from all tasks, girls' science orientation exceeded boys. By comparing the position of women in society and the orientation of girls in each country, they found that girls' orientation may be a function of attitudes toward women. The social climate may be more important than social action policy in the countries. For example, although mass education and anti-discrimination laws are found in the U.S. and New Zealand, only 22 and 14% of their youth studied described belief in equal rights for women.

Socioeconomic status contributed significantly. Girls had a more positive orientation toward science in disadvantaged communities while boys orientation was more positive in middle and upper class communities. Their interpretation was that disadvantaged children receive less attention from parents and do not assimilate stereotypic attitudes more commonly found in middle and upper classes. The disadvantaged boys also receive less of an experiential advantage due to less exposure to science-related hobbies with their fathers. Girls were found to be more positively motivated in biology and chemistry, while boys surpassed girls in physical sciences (subjects supported by male out of school learning). Steinkamp and Maehr's (1984) criticism of the literature was that the gender issue is not being addressed in a straightforward manner.

Shaw and Doan (1990) investigated the difference in attitude toward achievement in science between boys and girls in grade two and grade five, to see if differences reported to be largest at the junior high age level when students' motivational orientation undergo transformations, apply to elementary students. They report that there were no gender differences in achievement and attitudes toward science at these grades. Shaw and Doan suggest that reported differences in later grades indicate such differences probably begin after the elementary grades. Steinkamp and Maehr (1984) found this effect was most pronounced at age thirteen. This insight was pivotal to selection of this age group for this project.

Steinkamp and Maehr found increasing sex differences toward science in recent years. Similar conclusions of an increasing gender gap are cited from international studies (Kahle, 1987). This is most disturbing in light of international efforts to remove stereotypic labels eg. *Girls And Science And Technology conferences*, 1981, 1985, 1987.

A second troublesome consideration is that those countries with populations that supposedly best know how to nurture scientific talent through educational resources are producing women who are less motivated or prepared for careers in science.(Steinkamp & Maehr, 1984, p.57). Eylon and Linn (1988) note that a (U.S.) National Commission on Excellence in Education (1983) found that the curriculum in introductory science courses is fragmented, labs lack depth, and concepts are poorly related into a meaningful frame of reference. This weak curriculum may be interpreted by girls as indication of their own inadequacy and discourage them.

Many students never do get to physics because of preliminary courses required in other sciences. The textbooks cover too many concepts, illustrated by "the new vocabulary in a one-week science unit often exceeds that for a one-week unit in a foreign language." (Eylon & Linn, 1988, p.252). This description of the state of American introductory science curriculum matches the experience of this Alberta researcher teaching a variety of introductory science courses over the last two decades. Eylon and Linn propose in-depth coverage of a few science topics, providing multiple examples, can counteract students' inaccurate explanations of concepts and promote growth of problem-solving skills appropriate to the achievement and cognitive development of individuals in science classes. It is a reflection of how little research has been done in this area that there is little empirical evidence whether these commonsense suggestions will help or not, although they have been discussed in the proceedings of the *1985 GASAT international conference*.

GASAT conference (1985) report on classroom practice:

This report summarizes findings of questionaires and observations of classroom studies on science classroom practices around the world:

(1) girls' learning style in science and technology shows chronic lack of self-confidence;

(2) a small number of students, usually boys, dominate teacher contacts and the teacher's time was primarily focused on controlling the boys;

(3) boys called out and interrupted, waving their hands and moving about;

(4) girls were more often embarassed to talk in front of the class;

(5) girls were observed to prefer working in small groups and to plan their work together;

(6) girls were hesitant in physics experiments suggesting doubt in their ability to solve the problem;

(7) girls more often than boys described themselves as not being good at science, citing this as reason to avoid further science courses while boys said they had not received adequate preparation;

(8) teachers generally held lower expectations for girls than for boys in science and math;

(9) female teachers favoured boys in their classes as often as did male teachers.

These factors will be monitored in the classrooms studied.

Impact on Girls and Interpretation of Differences in Classroom Practice

The gender difference is further corroborated by Spear (1987), who identified a biasing influence of pupil sex in a science marking; boys received higher marks than identical work attributed to a girl (p. 50).

These gendered differences in classroom experience must be acknowledged when we consider career and social impact of differential attitudes, enrollment and achievement in science for girls and boys. Males in the U.S., in the last two decades have had greater access to science careers according to the National Science Board (1987) and greater earning power than females. Many researchers report that enrollment of teenage girls in classes other than math or science prevent them having prerequisites for later science study. (Harding, 1986; Kahle, 1987; Craig & Harding, 1986)

While gender differences in cognitive and psychosocial domains have diminished, earning power for females compared with males, remains unchanged at 59%. (Linn & Hyde, 1989, p. 17) Linn and Hyde used meta- and process analysis on studies of gender differences in math and science skills and achievement. They found that cognitive gender differences have declined in all areas studied and are no longer valid for verbal ability, spatial visualization, or mathematics computation and concepts. In science, they analyzed others' data for gender differences in knowledge and scientific reasoning and conclude that gender differences are greater for science knowledge than for knowledge of processes: are declining in high school, and accompany gender differences in learning experience.

These conclusions are supported by the findings of Gaalen and Lynda Erickson's 1984 province-wide study in British Columbia on science achievement. They analyzed results from tests (created to minimize both gender bias in questions and emphasis on specialized content) administered one day to all students in grades 4, 8 and 12 present in English classes (compulsory while no science course is, at the grade 12 level). They found no differences at any grade level for understanding scientific processes, insignificant differences in scientific literacy, but males outperform females in physics, chemistry and earth/space sciences at all three grade levels. They examined both a biological interpretation and sociological interpretation of these results and compared achievement to enrollment patterns in the senior science courses, finding very limited effect upon performance differences.

The Ericksons (1984) also looked at the sex-role content of individual items with great performance differences between the sexes and concluded that boys greater familiarity with electricity and carburetors (as just two examples where sex roles would make an experiential difference) could account for the better performance by males. They refer to assessment data that most girls are as competent as most boys and suggest that relevant, science-related experiences be provided for both boys and girls. They strongly recommend that the educational system be more sensitive to the perceptions and beliefs held by students regarding science curriculum.

The Erickson's want the school system to provide broad science background. This experience, often lacking to young girls, is necessary to increase their interest and reduce negative attitudes toward the subject as irrelevant or male dominated.

Like Linn and Hyde (1989); Whyte (1986); Matyas, Birke, Easlea and Harding in Harding (1986), the Ericksons suggest that socio-cultural factors are giving boys an early experiential advantage in science. The Ericksons argue that a biological interpretation is incomplete. Evidence for spatial ability or brain lateralization differences are weak and that sex-related differences in science achievement appear before the age at which spatial abilities differences are generally recorded.

An interesting exception to generally reduced enrollment in science classes is provided by biology. In the studies referred to, gender differences in biology were insignificant, where it is common for girls to equal boys in enrollment and where it is more common for female teachers to be available. For example, 30% of the teachers in Calgary public high schools in 1989 were female and most taught biology (Livingstone, 1989).

Aggressive Behaviour, Confidence and Classroom Involvement

Linn and Hyde (1989) reviewed studies of gender differences in aggression and in confidence and found that aggression differences were greater than cognitive differences and may contribute to male success in careers and in earning power. A study by Dweck (1986) found males' more aggressive questioning may result in more attention and information from the teachers, greater success and encouragement and be seen by the teachers as a sign of intelligence rather than a gender-related behaviour. Their review of current studies of gender differences in confidence can be summarized as males have greater confidence in their abilities in math and science even when they perform equally; differences emerge in high school and coincide with differences in enrollment in advanced courses. They suggest that greater confidence invites greater creativity in problem solving, promotes interest and produces and perpetuates the greater numbers of males in these careers.

Linn & Hyde (1989) report that males and females in elementary grades report equal interest in math and science careers but by the end of high school about 40% of college-bound males and 20% of college-bound females report such interests.

Are Science Perspectives Guided By Language?

Awareness of science administrators that there is a problem is indicated by Dr. John Kendall, Dean of Science at the University of Calgary in an April 21,1989 Calgary Herald article, *Why does science still intimidate most women,* who stated that " young children, boys and girls, are all interested in science...but in junior high, the interest for girls seems to stop and the problem begins." A common assertion in many references cited was that girls are unlikely to pursue science careers but instead seek nurturing professions (Whyte,1986, Fensham, 1990).

This inability to view science careers as attractive options for themselves may be due to interaction of early socialization, degree of involvement with the subject in and out of class, perceived image of science careers, and the lack of role models for young women in science. All of these interacting factors are conveyed to students through the vehicle of language.

Based on reading of the literature and classroom experience, it is contended that differences in classroom language usage and interactions between teacher and male or female students in the science classroom may have long range impact on their achievement in the sciences and on career choices.

According to Vygotsky (1986) and evidence that supports him (Bruner, 1984; Cole, 1985) language and other symbols are central to an individual's grasp of reality. To fill in a gap in the literature, a conceptual framework for the role discourse plays in society in directing the growth of both boys and girls is essential.

Matson (1964) attributes William Graham Sumner with a Darwinian view that the individual is the passive agent of natural forces.

> Everyone of us is a child of his age and cannot get out of it. He is in the stream and is swept along with it. All his science and philosophy came to him out of it. (p.24)

Habermas (1987) offers a more optimistic view of the individual's consciousness and focuses on the **process** of becoming, as open-ended and continuing to evolve.

> Since at every stage it strikes at the dogmatic character of both a worldview and a form of life,the cognitive process coincides with a self-formative process. But the life of a self-constituting species-subject cannot be conceived as the absolute movement of reflection. For the conditions under which the human species constitutes itself are not just those posited by reflection... the self-formative process is not unconditioned. It depends on the contingent conditions of both subjective and objective nature: conditions of the individuating socialization of interacting individuals on the one hand, and on the other, those of the "material exchange" of communicatively acting persons with an environment that is to be made technically controllable... The conditions of instrumental and communicative action are also the conditions of the objectivity of possible knowledge.... The embeddedness of cognitive processes in life structures call attention to the role of knowledge-constitutive interests: a life structure is an interest structure. (p.210-211.)

The neo-Vygotskean Israeli scholar Feurstein (1980) further suggests that the teacher and the classroom environment in which understandings are shared act as mediator.

> This mediating agent, guided by his intentions, culture, and emotional investment, selects and organizes the world

> of stimuli for the child. The mediator selects stimuli that are most appropriate and then frames, filters, and schedules them; he, determines the appearance or disappearance of certain stimuli and ignores others. Through this process of mediation, the cognitive structure of the child is affected. The child acquires behaviour patterns and learning sets, which in turn become important ingredients of his capacity to become modified through direct exposure to stimuli.(pp.16-17), cited in Eisner, 1985, p.144)

Abraham Maslow (1987), the American humanist and psychologist, argued that if restricted by our caretakers to narrow symbolic forms, we are much less open to new experience and less likely to acheive our potential. An example is the jargon so replete in science curriculum which is held by Brouwer (1991) to mask ignorance of understanding by portraying the use of a name by a student as equating with knowledge.

The teacher is often swayed in evaluation by a student's efficient recall from rote memory of a list of names for items on a test, not supported by the ability to explain how this concept actually occurs in nature. The language used in classroom discussion and in test items thus guides both the nature of the student' language and often the depth of understanding.

Lemke (1990) describes the most common form of dialogue occurring in science classes as triadic dialogue in which the teacher asks a question, a student is selected to answer, and then the teacher either repeats the student' answer or elaborates on it. Lemke (1990) describes this formal pattern for language interaction as having one major virtue; that of providing the teacher almost total control of classroom dialogue and social interaction (p.168). However, he identifies the disadvantages of this formal language pattern as manyfold:

(1) overuse in most classrooms;

(2) illusory high level of participation, that is low in quality;

(3) drawing out student answers that are brief;

(4) it does not stimulate students to use scientific language. In agreement with other authors who becry the lack of sufficient classroom talk that encourages students to practice and form references with the formal scientific terminology or jargon, as identified by Brouwer (1991), Lemke (1990) recommends:

> Teachers should use question-and -answer dialogue less than they do now and organize more class time for student questions, student individual and group reports, true dialogue, cross-discussion and small group work. (p. 168)

Sternberg and Caruso (1985) have documented the importance of mediated learning in adapting to a classroom and apply it to the childrens' interpretation of what the teacher's expectations and rules for the class are. If a child shares the cultural expectations of the teacher, this provides a distinct advantage in meeting the teacher's expectations and gaining a favorable impression."Early bad impressions can be quite difficult to correct, and early favorable impressions often serve one long after they cease to be justified." (p.150) Thus differences in learning experience produce differences in both formal and practical knowledge but also create a pattern of expectations for future learning.

Illich (1983) describes gender as that process that changes male and female into masculine and feminine. This interprets gender to be dynamic and socially constructed as does Grumet's (1988) integration of authors such as Virginia Woolf (1929), Kristeva (1981), Merleau-Ponty (1964), Apple (1982), and Sartre (1966). Gender development is described by Birke (Harding, 1986) as " a continuing process, in which one's biology and cultural environment are in constant interplay..." (p.197)

Such dynamism stands in contrast to the perception of school and the gendered roles of its clientele, described by authors in Curriculum studies (Apple & King, 1976; Eisner, 1985). The process of assimilating one's gender and appropriate sex-role is mediated in a significant way by the appraisals of teachers (Breakwell in Harding, 1986; Kahle, 1987).

If there are more successful women in academic, professional, and leadership roles in the future, they will model success for other females (Fensham, 1990; Kelly, 1987) However the more male-dominated and prestigious a profession is, the lower is the probability that women find access to and acceptance in the upper ranks of the profession. Graumann and Moscovici (1986) discuss research suggesting that when the percentage of women in typical male occupations is increasing, the social prestige of the occupation declines.

These research findings of gender differences vividly illustrate the existence of cultural dissimilarity presented to young people.

Feminist scholars like Spender (1980), Harris (1983), Kenway and Willis (1990) insist that these differences are not to be regarded as deficits, with education too often instigating remedial programs designed to make girls think more like boys. As a result, responsibility for these differences is placed on the girls instead of on those in power and female culture is not given value.

Both experience and the majority of authors used in this study, suggest an outward change in interest by the science teacher in the pursuits and contributions of girls to science classes would change the social relationships in class and may reinforce behaviour elicited by the teacher's interest.

As shown by Linn and Hyde (1989) and Erickson and Erickson (1984), gender differences in cognitive skills have declined, and those that remain can be largely explained by experiential difference and interaction with socialized roles. Harding (1986) suggests "changing the presentation of science curriculum to emphasize the relationship between science and the human condition and to encourage a range of teaching/learning approaches to accomodate differences in cognitive style" (p.166).

It has been the experience of the author that the resultant change in self-perception of both students and teacher, the practice effects of shared learning and the desire to believe in what you work at, contribute to the internalization of shared curriculum. Measures of self-concept, approach to problem solving and classroom interaction and language observations made possible by a verbal behavior inventory should provide insights into learning styles and gendered behaviors in the classrooms studied.

Identity Development Through Language

In his thoughtful treatise *Thought and Language* (1986), Vygotsky defined the role of language as first to define concepts and then to employ them. This gradual process of synthesis of thoughts, memories, and attention evolves into higher mental functions due to social and cultural environment.

Vygotsky suggests that social dynamics as mediated by language are internalized and become the foundation of individual mind. **Verbal thought for Vygotsky involves abstraction and knowledge of social relations.** He believed that education, as one form of social relationship, places particular stress on language use. To share ideas requires the formation of thoughts into language appropriate to the context to name something. This recognition of the need for a student to be able to combine his own concepts of the world with the formal ideas presented in school is central to Vygotsky's belief that cognitive development can be nurtured by verbal help or cues from adults or competent peers.

Based on classroom studies, Staab (1991) notes that the relationship between talking and learning centers on the role of student talk in focusing information, clarifying information, and formulating opinions (p.33). Staab's study of classroom talk in twelve randomly selected grade three classrooms and twelve randomly selected grade six classes, found that students only talked in front of a large or small group for 2.2% of the total activity time; student-led discussions, such as role-playing, brainstorming, or cooperative problem-solving, only occupied about 1% of the activity time.

During science classes, Staab (1991) reports that teacher talk used 59% of classtime; students talked formally for 3% of the time and informally for 14%; and students were asked to work quietly and independently for 25% of the time (p.42). Some teachers encouraged student-led discussions and formal student talk and the times recorded for these activities were localized in these classrooms and virtually absent in most others.

Comparing figures for the percentages of each of these classroom discussion types recorded in this study to previous research, Staab concludes that "the overall amount of students' oral language in the classroom has not changed significantly in the past 20 years" (p.43). This evidence of a continuing lack of encouragement for students to talk in classrooms to facilitate learning, indicates that Vygotsky's recommendations are not being taken to heart by today's teachers.

This framework, along with an awareness that twelve to fifteen year old students are intensely involved in defining their own identity, is central to the choice of grade eight students for this study.

Sternberg(1985) found evidence that verbal cues to increase learning can be measured, and that the necessary skills can be taught. Sternberg's evidence supports the value of peer-group learning and discussions of study skills, learning styles and alternate approaches to academic learning between informed teachers and incoming classes. Experience with peer group learning in small groups in a variety of classrooms has convinced this author of the efficacy of Vygotsky's theories.

Bruner (1983) suggests that children are taught our shared contexts and expected to transfer these relations to new settings. How well this cultural knowledge matches the expectations for performance in the school evaluatory process may be a significant determiner of academic success, as suggested by the work of Friere (1972); Apple & King (1976); and Anyon (1988). Curriculum theorists contend that the value placed on organizational efficiency, assertive socialization and normative meanings in the curriculum in use in science classrooms results in a differential distribution of classroom knowledge. Apple & King (1976) propose:

> that the study of the relationship between ideology and school knowledge is especially important for our understanding of the larger social collectivity of which we are all a part. It enables us to begin to see how a society reproduces itself, how it perpetuates its conditions of existence through the selection and transmission of certain kinds of cultural capital upon which a complex yet unequal industrial society depends,and how it maintains cohesion among its classes and individuals by propogating ideologies that ultimately sanction the existing institutional arrangements which may cause the unnecessary stratification and inequality in the first place. Can we afford not to understand these things? (p.126)

Anyon (1988), *Schools as Agencies of Social Legitimation*, concludes that the teacher can make students aware of their own potential social power and that it would be a real failing on the part of teachers if they did not "confront the classroom and curriculum representation of an unequal social order and thereby increased the power of schools as agencies of social legitimation, reproduction, and control"(p.195).

Eisner (1985) in the preface to *Learning and Teaching the Ways of Knowing* describes the moral responsibility of education that this author shares:

> ...the mind is not given at birth, but rather is shaped by the experiences a growing human has during the course of his or her life. Second, the potential of mind is not yet fully understood. What humans have the capacity to think about is related to the context in which they live. Since contexts change, the capacities of mind themselves alter. Third, the roads to knowledge are many. Knowledge is not defined by any single system of thought, but is diverse. What people know is expressed in the cultural resources present in all cultures. Fourth, the school has a special responsibility to develop the mental potential of the young. The major vehicles it employs to achieve this end-intentionally or not-are the curriculum of the school and the quality of teaching that the school provides."(p.xi).

Phillips (1985a) suggests that early research by Sullivan (1953), Mead (1934) and Cooley (1902), describe children as recipients of "reflected appraisals" which develop their self-concepts. If the child receives positive, constructive appraisals, the self-concept is likely to be positive and approving; if the appraisals are mostly derogatory and rejecting, the self-concept formed is likely to be disparaging and hostile. Thus language directly determines self-concept and indirectly influences it through the cognitive structural limitations of pre-operational-thinking children who cannot yet weigh the value and bias of those giving the appraisals.

Phillips (1985a) agrees with Piaget that children are under adult constraint and take into themselves the linguistically expressed view that others have of them . This matches the observations and conclusions of Cazden (1988), based on extensive experience and research with elementary school children.

Maslow (1987) describes receiving a positive appraisal of oneself as leading to feelings of self-confidence, worth and capability. He felt these feelings allow the individual to lead a productive life. For this thesis, the Beane and Lipka (1986) definition of self-concept as the description an individual attaches to himself, will be used. The teacher and classroom context act as another mediator, providing the young with a verbal appraisal of their appearance and abilities. It is crucial that this environment help students to develop an accurate and dynamic self-concept. This is particularly true for the young adolescent going through rapid changes in their bodies and feelings.

Beane and Lipka's (1979) statement that "self-esteem seems to have a stronger relationship to school achievement than ability or motivation" (p.4) clearly illustrates the impact that the reflected appraisals of teachers and classmates may have. Lawrence (1988) concludes that "although there are many aspects of classroom environment that may influence the student's self-esteem, the research shows that it is the teacher's day to day contacts with the students that has the greatest effect" (p.27). According to

Lawrence (1988) the teacher with high self-esteem is likely to produce students with high self-esteem and the teacher with low self-esteem is likely to produce students with low self-esteem.

Thus, it is important for teachers to reflect on their attitudes and actions in their classrooms and on their self-concept they portray to their students. Weiner (1990), a well respected researcher of motivation in education, describes the current perspective:

> ...school motivation requires the development and the incorporation of the values of others. Hence, we have to consider frameworks larger than the self, and older motivational constructs, such as "belongingness" must be brought into play when examining school motivation. This has been implicitly part of the trend toward cooperative learning but it must be explicitly recognized and studied. In sum, school motivation cannot be divorced from the social fabric in which it is embedded, which is one reason that claims made upon motivational psychologists to produce achievement change must be modest (p.621).

Cole (1985) notes that Piaget believes that the modern school produces cultural differences and that it is thus possible to rank these cultures in terms of academic achievement. Findings in literature presented would suggest that feminine culture as illustrated by *Gender Differences or Evidence of a Feminine Culture?* are labelled by many teachers and boys in classes as distinct and in some way deficient to succeed in science studies or science careers.

Spender (1984) argues that the lack of value given to female experience produces different language structures and expression of personal power. Personal power has two components of interest here, the will to attempt the task and the perceived ability to succeed. The appropriateness of the task for a female also may be determined by sexual labelling and influence personal power.

The emergence of gender differences in confidence and in interest in mathematics and science during high school may coincide with increases in awareness of societal expectations of roles for males and females. These perceived role differences also may increase in mixed sex group interactions (Linn and Hyde, 1989).

Harris (1983) states

> the new member of any language community internalizes a pre-existing social semiotic, a system of linguistic relations which expresses social relations, domination and hierarchy. ...Although the initial language instructor is usually a woman, the language system also is an expression of patriarchy. (p.106)

That language precedes the individual and guides one's entry into what to think about and what is acceptable in social contexts is not a new notion- it is found in the writings of Foucault (1984), philosopher and Lacan (1982), Neo-Freudian psychoanalyst. Lacan presents the modern view that

> the child is constituted through language and bound to the distinctions, divisions, and laws of culture through language learning. .. For example, as we learn about the biological categories important in our culture we learn about our gender identity. (Kramerae, p.66-67)

The growing area of research into gender differences in academic achievement in the sciences illustrates this desire to rank proficiency of different cultures or subcultures. Cole and Bruner (1972) noted that school achievement is linked to access to the basic contexts where wealth and power are brokered and that cultural deprivation can be defined as cultural difference that arises when an individual is expected to perform in a manner inconsistent with past cultural experience (Cole, 1985, p. 239).

Fahey and Phillips (1981) found that disadvantaged children have a poor view of self components which relate to possessions, skills, and schoolwork. Interpretion of her previous finding by Phillips (1985a) is that self-concept depends on socio-economic status and on the changing verbal appraisals of others "as one acquires socio-economic power, increases in maturity, or learns to express or develop one's potential and talents." (p.137)

Phillip's conclusion that children internalize evidence that one can change class, age, and socio-economic status but not sex and the associated language is based on research including that of Lakoff (1979). If we accept, even in part, the assumption that linguistic behaviour is learned and that this is the way male/female power heirarchy is internalized and reproduced in differing linguistic styles; then we can by commonsense, extrapolate to child rearing practices and community customs that demonstrate this affect. This study will investigate whether self-concept as learner developed through classroom language and interactions is integral to the competence and attitudes displayed by girls in the classrooms studied.

Stereotyping Practice in the Science Classroom

Belief in the stereotyping impact of family and school practices upon many young girls was expressed by most of the contributing authors in Harding (1986), Whyte (1986), Kahle (1987), Kenway and Willis (1990). To overcome this stereotyping impact, teachers in science classrooms need to make a conscious effort to stimulate and motivate young girls to pursue science studies with confidence. The *GIST* project was a classic effort in this direction.

Examples of how the language of the science classroom contribute to reinforcing traditional stereotypes abound in the Whyte (1986) account of the GIST study in Britain. Gender biased language in the classroom is described in depth in Whyte (1986), Kahle (1987), Kenway and Willis (1990), Fensham (1990), and Lemke (1990). Examples include the masculinization of the language by teachers and boys, sexual stereotyping of skills and behaviours and sexist jokes or comments. An illustration is instruction to a girl by her teacher to wear safety glasses in an experiment, because "you want to stay beautiful, don't you?" (Whyte, 1986, p.28).

In keeping with the stereo-typing influence upon girls in these classes, observers note that the sexes are constantly divided in classes and boys hog the resources while girls fetch and carry for the boys or act as secretary during lab activities. Cooper (1987) describes how women are marginalized by education content and by classroom interaction processes. She found:

(1) sex role stereotyping in curriculum materials at all educational levels;

(2) in the classroom, teachers communicate sex-role expectations through use of sexist language, calling on male students more often than female and asking males higher level questions;

(3) criticism of female students focus on lack of knowledge or skill whereas criticism of male students focus on disruptive behaviour.

If, we are going to change the image of science or its very nature, to attract superior students from all cultures and language backgrounds, we are going to have to add a value-oriented dimension to science. **New language will be needed to express these values and to change the current stereotyped image.** This need for study of the language use in science classrooms has been documented throughout the literature review.

If we accept the role of language in shaping our experience we must then try to alter the social deficiencies that power is capable of creating. Michel Foucault (1984), the celebrated French philosopher, describes the task as:

> It seems to me . . ., that the real political task in a society such as ours is to criticize the working of institutions which appear to be both neutral and independent; to criticize them in such a manner that the political violence which has always exercized itself obscurely through them will be unmasked, so one can fight them. (p.6)

The purpose of struggles to change institutions, such as the environment providing science education in Canada, is to change the power relations in them.

Foucault (1980) illustrates that power relations can be altered, in response to a question on what has been the outcome of the women's movements in the nineteenth century.

> Ultimately, a veritable movement of de-sexualization, a displacement effected in relation to the sexual centering of the problem, formulating the demand for forms of culture, discourse, language, and so on, which are no longer part of that rigid assignation and pinning-down to their sex which they had initially in some sense been politically obliged to accept in order to make themselves heard. (p.220)

The literature reviewed unfolds some significant aspects and impacts of these relations of power in the science classroom that can be addressed by science educators. The practical way to alter some elements of this inequity may be to alter the language of the science classroom through teacher training and curriculum change. Slugoski (1991) arguing for the use of non-sexist language and language reform, argued that an outward change in behaviour can affect an inner attitude.

> First, the change in outward practice constitutes a restructuring of at least one aspect of one social relationship, and the experience in the new social relationship may affect the inner change by reinforcing the behaviour that engendered it. Second, there are various social-cognitive mechanisms that predict internalization of outward practice, including cognitive dissonance, self-perception, and 'saying is believing.' (p. 25-26)

A common masculine image presented in science classes is illustrated by the expression " acids attack metals." This restricted view or the role of acids as dangerous ignores their essential nature in supporting life through the digestive process or their user-friendly nature in technology, such as etching printing plates. Never before in this author's opinion, has the political and public sentiment been more receptive to discussion of changes in these language relations.

111. METHODOLOGY

Introduction

This chapter will describe the design of the study, population studied, data collection techniques, instruments and analysis, and internal and external validity.

Gaining Entry to the Schools

At an informal meeting over coffee in May, 1991 with the Superintendent of Schools for a rural county, I initiated overtures for permission and cooperation for this study. A warm reception was followed by a short written proposal in August, given to the Superintendent for his presentation to the appropriate teachers upon their return to school.

A request for cooperating teachers and classes was supported by phone calls and personal visits to three different schools. The principals and interested teachers were then given the proposal with a letter of permission designed to inform and request parental support, and encouraged to ask any questions they liked or make suggestions that would facilitate their involvement and research success.

Individual discussions were held, first with each principal and then with the appropriate teacher, allowing each freedom and privacy as to the nature of the discussion. The ongoing involvement of thesis Committee members was sought to address functional design, hesitant recruits, and assurance of complete anonymity for all participants. Dr.Bruce Bain spoke by telephone with both the Superintendent and one principal (associated with an anxious teacher/recruit) to expand on the value of the study and creditability of the researcher. The investigator was looking for classes that were different from each other and would have liked to have a female teacher participate. It was not possible to find a female teacher due to the small number of female science teachers available at this level in the County. Two classes were selected with cooperation of their teachers and principals.

Permission to Participate

Permission was requested for students in the selected classes to participate in this study, be videotaped, and complete the four instruments. Permission was solicited from students, parents or guardians by a letter which described the nature, rationale and implications for this study. The procedure was briefly discussed and the interest and background of the researcher was defined. An assurance of confidentiality and the right to withdraw at any time was stressed. Written permission was secured for all of the 53 students in the 2 classes. A copy of this letter may be found in Appendix B.

Design and Schedule

This study was designed to be a blend of classroom observation and contrasting quantitative evidence provided by four carefully chosen student performance instruments. Each of the instruments used and their rationale is listed below.

At this point, it is necessary to briefly alert the reader to the nature of the instruments. The researcher was the instrument for observing and recording classroom interactions through daily journal entries which detail the context, participants and major verbal exchanges of grade eight science classes in two rural K-12 schools. A verbal behavior inventory was developed listing significant language behaviors and interactions, raised by the literature, to discover relative occurence rates for boys, girls and teacher in each class. Classes on Monday and Wednesday from October 2- November 4, 1991 were outlined by journal. Videotaping of all class sessions was intended to add depth and richness to this participant observation. Videotaping was given a trial run on October 2 to acquaint all participants with the presence of the camera and to work-out mechanical problems.

The first two days of videotaping were fraught with mechanical high-jinks and performance anxiety by all participants. The resulting verbal exchanges were not considered for analysis. All subsequent classes were videotaped, excluding quizzes or time out for photo taking. The times chosen were dictated by timetable considerations of both schools and the Tuesday/Thursday classes of the researcher.

Instruments, Administration, and Rationale

Four instruments were selected for their efficacy at unearthing **motives/strategies for learning, self-concept as problem solver, scholastic aptitude, and general knowledge of science** and administered at times other than the observation phase.

These instruments were checked for clarity of wording and ability to draw out responses from individuals that would not only give a measure of some ability or self-knowledge but also stimulate the student completing them. The intent was to disrupt the regular class activities as little as possible. These specific instruments were also selected for their non-intrusive nature in either length of time needed for completion by students (20-40 minutes) or in the appearance of the measure or its script for administration. National and/or provincial norms where available will be used for comparison.

Standardization samples for these instruments were large and the items showed evidence of minimal racial, ethnic or cultural bias, beyond the inescapable problem of the student who has such poor grasp of verbal or numerical reasoning that the test results suggest slight chance of academic success.

The descriptions to be provided to parents or students for all these instruments were sensitive to the problem of interpreting borderline scores and gave both age and grade level norms in most cases. The measures were easy to administer and appropriate to the context in which they were used.

(1) The *Learning Process Questionaire* (Mulcahy, 1987) is an adaptation of the high school *Learning Process Questionaire* (Biggs, 1987) for use in elementary and junior high schools. The *LPQ* is a 36-item self-report questionnaire in a Likert format appropriately worded for the context.

Like its predecessor, it investigates the nature of a student's motives and strategies when facing learning tasks. It distinguishes between surface motives and strategies, which focus on short term learning such as memorization for a unit test, and deep motives and strategies which demand a longer term commitment to learning and task relevance. It differentiates three approaches to learning. Biggs (in press, p.8) describes surface-related approaches to learning as "rich in detail but poor in structure while deep-related approaches produce well structured outcomes .... Achievement- related approaches produce institutionally rewarded outcomes (high GPA)."

The student using the achieving approach will organize their time and study techniques between deep and surface strategies, with the self awareness that they pursue optimal academic success.

Alberta norms were used for comparison and profile descriptors were included, to reduce misuse of assessments. This measure of a student's self-knowledge of motives and strategies allows insight into their thinking about task demands, interest in the task and perceived long range relevance of the task. The profile that can be drawn from this measure may increase student awareness of their own learning style and promote interest in reduction of surface approaches while providing information about deep and achieving alternatives.

The LPQ was administered on October 30th following a photo session that disrupted regular class activity for Class 1 and during a donated Health period for class 2. Due to copyright restrictions, a copy of the *LPQ* is not included in an appendix.

(2) The *Perceived Problem Solving Inventory, PPSI*, developed by Hepner and Peterson (1982) for use in high schools was adapted for use in elementary and junior high schools by Mulcahy (1987). It investigates student perceptions of their actual personal problem solving confidence, approach or avoidance strategies to problems, and control. *PPSI*

consists of 32 items with a 5-point Likert format that asks students to choose the response that is most like them.

Mulcahy (1990) confirmed concurrent validity through findings of statistically significant correlations with students' ratings of their own problem solving abilities and their perceived satisfaction with their problem-solving abilities. Construct validity was supported by statistically nonsignificant correlations between student scores *PPSI* and on intelligence and achievement tests.

PPSI was administered on November 6th in the last 25 minutes of a lab period with Class 1 and at the outset of Health with Class 2. Due to copyright restrictions, a copy of *PPSI* is not included in an appendix.

(3) The *Otis-Lennon Mental Ability Test, OLMAT,* (Psych. Corp., 1967) is a widely used and highly regarded measure of broad reasoning abilities, important for scholastic success.

It is composed of 80 items of verbal and nonverbal nature to sample verbal, numerical, and abstract reasoning in a 45 minute timed context. It is not curriculum based and has a spiralling increase in difficulty which holds the attention of the students. The questions had an alternating selection of five choices(1 was a-e; 2 was f-j) to keep the students' focused and reduce response set.

American norms were based on testing nearly 200,000 students all across the United States. Items chosen are judged by reviewers to have been chosen to minimize racial, ethnic or cultural bias and reliability and validity measures are high. Normative data is reported by age- and grade-equivalence using deviation I.Q's, percentile ranks and stanine scores. Verbal descriptors are given to match each of the total score categories.

This test was given on November 7th during a regular Science class in both classes studied. Administration was simplified by giving students ordinary note paper to record their answers, name and birthdate; rather than using computer score cards, which in this researcher's experience, introduce a formal context and may distract from the task. Due to copyright restrictions, a copy of the *OLMAT* is not included in an appendix.

(4) The *Stanford Test of Academic Skills(Form E) Level 1 Science Subtest* is intended to measure students' understanding of basic science concepts and skills learned prior to the eighth grade. American norms are provided for this widely respected and recommended measure. Descriptors are provided for interpretations of total scores, a help for discussion with parents or students.

This test was easily administered in a normal classroom setting on November 13th. It has a 50 item, one best answer multiple choice design. Students recorded their answers, and names on regular note paper. Due to copyright restrictions, a copy of this test is not included in an appendix.

5).A brief written interview was presented to the cooperating teachers on November 13 to provide them a voice about this experience and to gain insights they felt might facilitate interpretations of videotape or measures. The intent was to honour my position in the class as guest and to reflect true appreciation of the students' and teachers' cooperation in this study. A copy of this interview is in Appendix C.

Presentation and Validity

The research project was presented to each class at outset as:

(1) not reflecting in any manner on the grading in the classes;

(2) as essential to attempted understanding of patterns observed in language used by students and teachers to construct meaning from actual events in these science classes.

An attempt was made to establish a reasonable level of control through selecting educational contexts with a significant degree of commonality. Factors such as absenteeism, a photo-session, a volleyball tournament, and other idiosyncratic features of each environment made conditions variable. The design was sensitive to these problems and encorporated flexibility to meet the demands of unexpected events.

Internal validity is a measure of how well study design controls for alternate explanations for performance on the dependent variables(Wolery et al., 1988) and is described as threatened by history, maturation, or instrumentation.

History refers to events which occur prior or during a study which may influence outcomes. The prior events can not be accounted for, but the short duration of the study should have minimized the influence of concurrent events or maturation changes in the individuals, such as physical or mental changes or adaptation to the experience.

It is admitted that the presence of an interested stranger focusing on the language of the science classroom may have some minor but unmeasurable influence on self-knowledge, motives and strategies, general science knowledge and nature or frequency of participation in the class dialogue.

Videotaping the interactions to provide a record of events, was chosen to improve accuracy while enriching qualitative data. Selection of instruments, whose administration created a minimum of disruption or stress to the participants and were easy to score should lessen the instrumentation threat.

As a guide to further research, interpretation of results and discussion will generate hypothesis that emerge from the content. The results of this study will have practical importance and are not to be overlooked for potential to influence the praxis of teachers and teacher educators.

It is noted that individual differences and the reactive effect of being studied on both behaviours of students and teachers, and the personal professional history of the veteran teacher as researcher limits the external validity of this work.

Study Population

The two schools that volunteered contain one class each of K-12, serving small communities in central Alberta, with a primarily rural population. The schools are also sites for club and citizen meetings. Both communities bus students to other County schools for sports or special classes and both occasionally will bring teams or classes into the city. Rural communities in Alberta are presently suffering from widespread financial shortfall with costs of production exceeding the income from seeded acreage and a dreary projection for the upcoming year due to low world prices for most agricultural commodities.

School 1 Characteristics

School 1 serves a community of approximately 900 people, located about 50 kms. from a large city. School 1 is near several industrial plants which offer employment to some community residents. There are a substantial number of acreage subdivisions within the area. A significant proportion of the students are from farm families. Class 1 designates the grade eight science class, with 24 students (9 boys and 15 girls), instructed by a highly respected teacher, 2 years from retirement. He described himself privately in the first day of observation as "an old math teacher, teaching science".

The lectures were held in a classroom. The lab activity was moved to the science lab, several moments away from the classroom. This posed a logistics problem in this study as the time to move camera, convention microphone, and all other paraphenalia was far from adequate between class bells. Every attempt was made to make a facilitative environment in these hectic circumstances.

Camera set-up occured as the class was underway in the lab and assistance in transport from helpful students was provided on many occasions. The purchase of a wide-angle lens for my camera was necessary to film a significant proportion of the nearly square lab with students sitting only a few feet from the camera. Focusing and fanning the camera to record most interaction, made continuous note-taking a nearly comical challenge. Persistence and routine did improve the product as the days sped by.

Science 8 was the first class held Monday - Thursday.

Wednesday was scheduled as double Science in periods 1 and 2. As our work progressed, the teacher suggested that since he had these students for Math after Science, he would change class scheduling and have a double class of Science on Monday and Wednesday. His rationale was that the students did not become bored or irritable because the lecture in period 1 would be followed by a lab in period 2. This decision was willingly accepted by class members and several were heard to comment that they preferred Science anyway. Support at this level was characteristic of both observation and instrument phases of this study.

School 2 characteristics

School 2 serves a community of 500 located about 80 kms. from a city. School 2 has no industrial employment base. Its' student body is composed of farm children and children of families operating small local businesses that serve the farm community. Class 2 consists of 29 students (13 girls and 16 boys) taught by a Biology major in his forties. The number of students on the initial register had been 28, but a new girl joined the class, left partway through the observation period and was subsequently replaced by another new girl. Visitors were not regarded as unusual, evidenced one day by a non-resident boy who came to class with his cousin.

The observation timetable with this group was a double class involving period 5 (following lunch hour) and period 6 on Monday and a single class on Wednesday in period 6. The loss of two days of observation on October 14 (Thanksgiving) and 16th (volleyball tournament) created an imbalance of observational data available.

The lab activities were interspersed between lecture and discussion. Class 2 was observed in the Science lab until we moved to an upstairs classroom on October 23. This room was crowded and nearly square in shape causing similar difficulty in filming as in Class 1.

November 15 was used to return to each of these schools and supervise students while they wrote measures that they had missed due to absenteeism. A similar context to that of their regular classroom was provided.

The students were initially anxious about these measures on October 30th. With each subsequent reassurance of the lack of impact on their evaluation by their teacher and reminder of intent of the study and the insight such instruments can provide about their performance in this context and time, they happily completed each instrument.

Data Analysis

All videotapes were timed with the counter on an Emerson video cassette recorder, model # vcs955h and each class was divided into approximately seven 5 minute segments, excluding the organizational and announcement phase at onset of each class, for purpose of analysis on the adapted checklist of major verbal interactions.

Two of these segments were randomly selected. EAch segment was identified by analysis of approximately 100 counter units recorded for each class and the verbal behaviour inventory was completed for each day's class(es) at each school.

The Classroom Verbal Behaviour Inventory summary for each classroom, (Appendix D) represents the total number of each of these behaviours by girl, boy, or teacher identified in the segments from all classes. To whom the talk was directed was noted in the summary, whenever it was possible to identify from videotape or notes. This procedure provided a randomly selected sampling of the major forms of talk occurring in each of these classrooms and relative frequency of verbal behaviours identified in the literature as significant to interest and achievement for both girls and boys in science classes.

The relative duration of interaction between students, students and teacher, and comparison of relative interaction of boys and girls in class dialogues was reported. Level of challenge or difficulty of questions asked of and by boys relative to girls were illustrated by quotations to attempt fair representation of the nature of the exchanges. The emotional response and interpretations of verbal interactions by the researcher were claimed. This was in keeping with a philosophy of empathic observation accompanying non-judgmental reporting held to be ideal in qualitative research literature (Patton, 1980) and central to the design of this research.

The trends and patterns in dialogue in the Science classrooms were a contrast to the quantitative data reported. There were no inferences made at this stage of the thesis; the data was allowed to speak for itself. Total and subtest scores for all students were reported in *Table 1* allowing easy differentiation of boys' and girls' results for each class on each instrument.

Total scores on the *LPQ* and *PPSI* were compared with their subtest scores by using multiple correlations and any differences between girls and boys for each class and in total were determined.

The results of the *OLMAT* and *Stanford Science Achievement Test* were submitted to a t-test to determine if there was significant difference in performance between girls and boys. If a significant difference was detected on the *OLMAT,* all other tests of male and female differences on the other instruments should roughly covary. If there was interaction of gender and school in *TASK,* a *2x2 ANOVA* would be used to see which school contributed to the difference in performance. Trends were reported.

To summarize the analysis of verbal behaviours:

(1) The verbal behaviour inventory sheets completed for

each day of classes in each score were summed for each verbal behaviour listed and a summary sheet prepared for each school.

(2) Comment on the nature and frequency of each of the verbal behaviours studied, provided a comparison of who by and how often, these exchanges were occurring.

(3) This analysis also gave evidence as to whether the nature of the classroom dialogue in each classroom was promoting interest in science and what kind of learning strategies were evidenced.

IV. RESULTS

This section will identify the nature of the science as being bound by the way it was articulated with students. Analysis of notes taken throughout the classes and of approximately forty hours of reviewing and summary of verbal behaviours in the videotapes on the Verbal Behavior Inventory found in Appendix D, form the basis of comparison of language interactions between participants in each classroom.

Summary of Classroom Verbal Behaviors

School 1

Teacher 1 generally used assertive language. It was often demanding, with placement of emphasis on technical terms and high voice volume during lectures. It suggests a managerial teaching style.

This sense of tight control over activities and information sharing was clearly understood by all of the students, as they were careful to ask questions only on the precise concept being discussed and seldom questioned teacher interpretations. For example, during segments analyzed from all thirteen classes in School 1, only once was the teacher asked a question by a girl and twice by a boy (see item 7 on the Verbal Behaviour summary for School 1, Appendix D). High focus on control can be seen to produce both a patriarchal image of science and that this science teacher as master of knowledge and classroom activities.

Stereotyping comments were identified as being made by this teacher on three occasions (item 13). Neither boys nor girls were found to use stereotyping comments.

The information shared was lectured in an authoritarian manner, neither inviting comment or accomodation to how the students may view the concepts. Challenging questions (which demand application or detailed adaptation of knowledge and promote interest in the discussion topic) were asked four times by Teacher 1 of the class as a whole, twice to boys, and twice boys directed a challenging question to their teacher.

Verbal Behaviour item 11 (participation in or encouragement of peer group learning or joint problem solving) was only identified as being engaged in once by Teacher 1; four times girls encouraged other girls, twice a girl encouraged a boy to work together.

Both boys and girls in this class were polite, hesitant in asking questions of either the teacher or each other, until they had visible teacher approval. However, there were discernable gender differences detected by some of the items in the Verbal Behaviour Inventory summary.

Consider as evidence, the small number of questions asked in total by students (four in all) reported in item 7 ; in contrast to a discernable gender difference in the eleven questions asked of boys by the teacher and only six to girls. In item 1 and 2 of the Verbal Behaviour summary for this class, no boys were identified assuming responsibility for a success or failure in the class. However, different girls on three occasions, assumed responsibility for mistakes or failure. Once, a girl was observed assuming responsibility for success in the class. Praise was seldom given. The teacher praised different boys twice and once he praised a girl (item 3).

Criticism was much more common in this classroom. The teacher criticized girls eleven times, boys three times, the whole class three times; a boy criticized a girl once, another boy once; and four times a girl criticized another girl (item 4). Correcting others' behaviour (item 5) showed some similarity; twice the teacher corrected the whole class; twelve times he corrected girls, eleven times boys; twice a boy corrected another boy and once a girl.

During lecture, triadic dialogue and teacher monologue dominated each class observed, with no more than ten uninterrupted minutes allowed for quiet independent work by students. Lecture was interrupted for students to complete diagrams, began by the teacher, to encourage students to visualize concepts presented.

This approach was used by Teacher 1 whenever possible. Examples, key formal science terms, assignments, or diagrams comprised the notes written on the board. Occasionally, names of students who had been rebuked were written on the side of the board.

During classes in the lab, less than four-fifths of the students sat in pairs or groups and talked informally, often discussing outside interests along with working on exercises or lab activities. In this setting, informal student talk was the most common dialogue and students were noticeably more relaxed. During lab, Teacher 1 used reprimand or disciplinary practice, such as assigning an offender to cleanup duty, only in the case of overt misbehaviour.

Students were called to order at the beginning of lab periods or when a new activity was to begin and then were expected to quickly grant their teacher silent attention.

Students were not heard to use the formal language of science in discussions with each other during labs or problem solving, although formal science language was attempted frequently in answering teacher' questions. On no occasion in this class, during this study, was there encouragement given by teacher or students for out of class activities related to science (item 12); nor was science discussed as important to a good career or lifestyle (item 10). On five occasions, videotape segments contained excerpts in which the teacher was relating science curriculum to everyday life (item 14).

The students most frequently asked questions by Teacher 1 (five boys and two girls) were outgoing and high achievers, both on instruments used in this study and in the perception of the teacher. Other than doing labs in assigned groups, there was no occasion in which cooperative learning strategies, student-led discussions on topic or role-playing occured. The greater interest of girls to work together, compared to boys, was apparent in their seating arrangements during labs or informal discussion with each other and by their greater involvement in giving advice to each other (item 6) or encouraging each other to work together on problems (item 11).

Teacher 1 seemed to be fond of his students, as displayed in conversation with the researcher out of student hearing and by his willingness to give them helpful advice (item 6); but he was detached and firm in most of his interactions with students. Girls' questions or demands sometimes appeared to unsettle him; for example, their request on photo day to be allowed as a group to freshen up their appearance in the washroom. He suggested that I could take charge of that responsibility and changed the topic. He never appeared flustered in his talk with boys. Such incidents may have contributed to the girls' apparent awareness of exclusion from the male group in the class.

Observing who is actually manipulating apparatus in labs (Item 9) resulted in evidence in full agreement with research findings in the literature, that girls are less active in performing labs or hands-on science experience.

Twenty-two boys were counted actually working with the apparatus in contrast to twelve girls.

In combination with gender differences in verbal behaviour detected with this technique in this class, it seemed reasonable to conclude that the environment and classroom language was not equal for all students.

School 2

The language used by Teacher 2 was collaborative, inviting questions and dialogue, and use of everyday examples and expressions to relate scientific terminology was common. For example (item 12), Teacher 2 encouraged students to go home and look at the gears on their bikes and try to figure out how they give a speed or force advantage. Teacher 2 related science curriculum to everyday life or social issues on seven occasions (item 14).

Involvement of the students in the learning activities was a major focus of this teacher. Management considerations, such as control, were given less teacher talk than were dialogues to expand on some concept that students were having difficulty in understanding or applying in their current discussions, homework assignments, or tests. Students often led discussions of the formal curriculum in a particular direction or application.

Teacher 2 encouraged such 'problem- solving' (as he referred to it) and would encourage students to offer ideas without correcting them as they expressed the formal science language as a first draft, often requiring revision. In this open and receptive environment, large numbers of students volunteered insights and formal language practice, including two boys who were clearly at a disadvantage in understanding the curriculum as shown by their off-target answers and comments during teacher-led discussions and by their poor performance on both *OLMAT* and *TASK*.

Students did not question their teacher often but would offer their perception as a statement about some concept to the whole class to get feedback. During the segments of ten classes analyzed from videotape of this classroom, to prepare the Verbal Behaviour Inventory summary for School 2 (see Appendix D), the teacher was questioned by one boy and by one girl (item 7). Student formal talk was a major time consumer in many classes, observed when the class was reviewing a unit of curriculum before an evaluation or after tests or homework had been marked and returned by the teacher.

Peer pressure was a common source of control in this classroom; if a student was rambling in his explanations, off topic, or fooling around, it was accepted by all participants that students as well as teacher could voice their objection. A striking example of this and the collaborative nature of language interactions in this class was a teacher-led discussion of speed advantage offered by large wheels that Rob turned to a discussion of the classic bicycles with the disproportionately large front wheels. He noted how hard they would be to get up onto as well as saying they could go five hundred kilometres an hour. He quickly reflected on this and when Jack questioned him about how fast they could go, he smoothly offered "fifty kilometres an hour". Although his first comment was clearly heard by many, no criticism was offered; teacher and class accepted his offering as first draft and the revision as final draft.

In videotape segments analyzed, Teacher 2 was not heard to give criticism; in whole class experience, criticism was directed to groups or behaviours rather than to individuals. For example; when a number of the volleyball team members had incomplete homework following a tournament, they were told they must get their homework done if they want to stay on the team.

Stereotyping comments were only identified once, by a boy. Teacher 2 was heard on several occasions to quiet the dominant students in the class and call on reserved girls to offer their interpretation or answer. He conveyed a democratic approach to his students, commenting that "everyone has a right to explain if they wish" and stating that there is "no point in going on, if we don't understand."

Challenging questions were asked by the teacher twelve times of the whole class and four times of the teacher by boys. Girls did not ask challenging questions in the videotape segments analyzed, although the researcher sensed their input was desired by the teacher. Encouragement for cooperative learning or problem solving (Verbal behaviour item 11) was detected ten times by Teacher 2; four times by girls; and four times by boys .

All participants in this class were courteous to each other and friendly and helpful with this study. Boys would come to meet me as I arrived at the school and offer to carry my equipment or direct me to whichever room we were to be holding class in that day.

Initially I believed that this generosity was directed by their teacher but soon realized that several boys wished to aid in any way they could. Operation of the camera and performance on the instruments administered were a greater source of interest to the boys than the girls, although the girls were warm and freely discussed many topics with me.

Other discernable gender differences recorded from the videotape segments summarized for School 2 (See Verbal Behaviour Inventory), include: item 7 - nineteen times boys were asked questions by Teacher 2, 12 times for girls; item 3 - praise was given by the teacher to boys eight times, to girls three times; item 5 - correcting other's answers or behaviour, the teacher corrected boys nine times, a girl once; item 6 - advice, once the teacher gave advice to a girl but six times to boys; item 9 - eleven girls were counted actually manipulating lab apparatus compared to twenty-six boys.

Although two girls, one boy and the teacher were noted to have claimed responsibility for a mistake or failure in the class (item 1); only one boy and the teacher were noted to have claimed responsibility for a success (item 2). The researcher found students to be open with each other and they exchanged criticism (item 4), corrected each other (item 5), or gave advice to each other (item 6) with no appearance of ill will. Only one student appeared to have any difficulty in getting along with others, and he was performing behind everyone else, which may have contributed to his attitude. After this study was completed, this boy was relocated to a class, hopefully better suited to his abilities.

In spite of the interactional style of Teacher 2 and a relaxed classroom environment, it is apparent from the above interpretation of the verbal behaviour inventory and impression of all classes experienced from reviewing notes and videotapes, that there was not a uniform language interaction or science experience by boys and girls in this classroom. However, awareness of these observed discrepancies when brought to this teacher may be reasonably expected to change some of these interactions in the future. The Verbal Behaviour Inventory, supported by class notes, seemed to function as an effective instrument for studying the predominant patterns of discourse. This instrument also efficiently gathered evidence regarding gender equity, and found a variety of verbal practices that contribute to inequity in learning environment for girls, as proposed by the literature to plague science classes.

Quantitative Findings and Interpretation

The analysis of the data gathered in this study are presented in two sections:

(1) results of statistical procedures on data from instruments administered to students;

(2) identification of learning and instructional environment within the context of themes which arose from classroom discourse.

Examples and quotations from the language interactions in both classes studied were included to demonstrate the nature of the environment in which learning and evaluation occur; thus expanding on the sense of the nature of talk and its impacts in each classroom.

A *Table of Descriptive Statistics,* presented in Table 1, provides a profile of the performance of each individual on each of the instruments administered. Means for girls and boys in each school are presented; as are means for each category and the entire school; thus allowing easy comparison of relative performances of all groups.

TABLE I

TABLE OF DESCRIPTIVE STATISTICS

COMP.: Perceived Self-Competence
PLAN.: Planning
CNTR.: Control

Student ID	DIQ Otis Lennon	TASK x/50 Science	LPQ Surface x/60	LPQ Deep x/120	Comp.	PPSIx/5 Plan	Cntrl	AGE Yr.	AGE Mo.
SCHOOL 1									
ID Boys (9)									
151081	97	35	31	67	2.80	2.94	3.40	14	5
91081	101	46	32	60	3.10	3.18	4.00	13	5
21081	103	42	29	73	2.90	2.53	3.60	13	10
131081	107	39	42	67	3.90	3.00	2.60	12	10
231081	111	47	38	58	4.50	2.71	4.00	13	7
31081	115	43	44	55	3.40	2.24	2.00	12	10
171081	117	43	23	66	4.00	1.88	2.60	13	3
101081	117	48	33	77	4.30	3.35	3.60	13	7
121081	132	43	27	83	4.90	3.65	4.20	13	
Averages	111.1	42.9	33.2	67.3	3.76	2.83	3.33		
ID Girls (15)									
212081	85	28	46	77	2.6	3.06	2.8	14	0
192081	97	34	39	65	3.2	3.12	3.2	13	6
52081	98	32	35	56	2.7	2.76	3.6	13	7
82081	98	40	37	51	3.4	2.76	3.2	13	3
222081	98	25	34	62	3.1	2.06	2.8	13	5
72081	100	39	47	71	3.6	2.82	2.4	13	7
112081	104	35	43	48	2.7	2.47	2.2	13	3
182081	105	29	35	83	3.5	3.35	2.2	13	5
62081	106	38	40	82	3.3	3.24	3.2	13	4
42081	108	43	45	100	4.2	3.41	2.6	13	2
202081	109	47	29	66	3	3.41	3	13	7
162081	115	46	36	67	3.3	2.94	2.8	13	1
142081	117	45	36	86	4.3	3.53	3.6	13	2
12081	117	46	39	75	3.9	3.65	3	12	9
242081	118	44	36	82	3.7	3.41	4.2	12	10
Averages	105.00	38.07	38.47	71.40	3.37	3.07	2.99		
SCHOOL 2									
ID Boys (16)									
131082	69	22	44	91	4.4	3.59	2.6	13	2
71082	78	21	29	77	3.6	3.18	3.6	14	10
241082	89	31	36	82	3.8	3.53	2.4	13	8
221082	92	33	33	74	3.3	2.94	2.8	14	11
201082	95	31	33	76	2.8	2.06	3	13	3
261082	96	38	46	83	3.3	3.53	3.4	13	5
41082	97	43	40	89	4.2	3.76	3	13	11
251082	99	29	36	80	0	0	0	13	7
291082	101	31	38	72	3.7	3.18	2.8	13	3
111082	107	40	39	104	4.6	3.71	3.4	14	3
61082	108	44	26	97	4.4	4.18	4.6	13	4
271082	109	46	28	99	3.9	3.35	3.4	13	7
31082	110	42	36	81	4.4	3.41	3	13	7
231082	115	49	34	55	4.2	3.41	3.4	13	1
141082	121	45	24	98	4	4.47	3.4	13	2
11082	121	50	31	91	4.4	4.24	3.8		5
Averages	100.44	37.19	34.56	84.31	3.93	3.50	3.24		
ID Girls (13)									
102082	88	26	33	102	3.6	3.53	4.2	14	9
162082	92	36	39	74	2.63	2.67	2.25	15	0
192082	93	34	34	85	4.1	3.65	3.6	14	2
92082	97	31	38	82	3	2.82	3.6	13	10
212082	107	24	33	68	3	3.12	3.2	14	4
52082	108	43	47	91	3.7	2.76	2.6	13	4
82082	109	43	34	79	4.3	3.76	3.8	14	2
182082	109	49	32	80	3.4	3.53	2.8	13	7
152082	109	42	34	66	3.2	2.71	3.6	13	11
122082	110	45	31	93	4.1	4.53	3.8	13	2
282082	114	46	39	43	4	1.59	3	13	0
22082	116	40	34	69	3.8	3.41	3.8	13	1
172082	125	40	44	66	3.3	2.12	3	12	11
Averages	105.92	38.38	36.31	76.77	3.55	3.09	3.33		

Results from *OLMAT* and *Task*:

Using the *Scheffe' Post-Hoc Fairwise Contrasts,* no significant difference was found in performance on the *OLMAT* between boys and girls. Using a two-way *Anova,* with *Scheffe's Multiple Comparisons of Main Effects* on the *TASK* science achievement results, no statistically significant difference was found by gender or by school. However the boys in school 1 performed at a higher level (Mean of 42.89 that translates to a grade equivalent of 12.4) than the boys in school 2 (mean of 37.19; grade equivalent of 8.8) and higher than the girls in either school 1 (mean of 38.07; grade equivalent 9.2) or school 2 (38.39; grade equivalent 9.4). This disparity in performance between the boys in the two schools may be linked to the impact of two boys who were clearly having difficulty and performing below grade level on both these instruments and classroom evaluations in school 2.

Girls in both schools performed similarly regardless of apparent differences in instructional strategies and discourse patterns. Girls in school 2 performed at about the same level as boys in their class. This instrument was apparently lacking in challenge for these students, as the means were very high and may have been insensitive to actual significant gender differences in general science knowledge.

That a gender difference does exist is suggested by the observed greater willingness of boys to speak out with examples, elaborations or challenges (items 7 and 8 of the Verbal Behaviour Inventory) to ideas presented by the teacher or other students. Girls in both settings were less likely than boys to volunteer elaborations of answers or offer applications of concepts to everyday experience.

LPQ Results:

The six subtests in the *LPQ* are reported in the *Table 2 Summary of 2 Way ANOVA on Study Variables* and evaluated independently. Surface motives and strategies are grouped together to describe the relative extent of a student's shallow, short term planning approach (surface approach = sum of surface motives and surface strategies) aimed at just getting by on evaluation. This is compared to a deep motivation to understand as well as achieve at a high level characterized by the deep and achieving approach of a student who scores high on both deep and achieving motives and strategies (deep achieving approach = sum of deep motives, deep strategies, achieving motives and achieving strategies). There was no significant difference by gender or by school on the surface approach of the students.

There was a significant main effect of the deep and achieving approach and most interestingly a significant effect (F=.004**) on this approach by school with students scoring considerably higher in school 2. It is important to note that in School 1, the boys'mean was 67.33; and the girls' mean was 70.40. In school 2, the boys' mean was

TABLE 2

SUMMARY OF TWO WAY ANOVA ON STUDY VARIABLES

Variables	Main Effect For Gender			Main Effect For School			Interaction of Gender and School		
LPQ	SS	DF	Sig of F	SS	DF	Sig of F	SS	DF	Sig of F
Surface Motives	33.13	1	.140	13.50	1	.343	67.38	1	.037*
Deep Motives	.06	1	.956	127.10	1	.017*	86.10	1	.047*
Achievement Motives	63.59	1	.073	114.93	1	.0[illegible]*	8.87	1	.497
Achievement Strategies	1.10	1	.805	177.69	1	.0[illegible]*	8.83	1	.486
Deep & Achieving Approach	106.13	1	.436	1588.20	1	.[illegible]*	354.89	1	.158
PPSI									
PERCEIVED COMPETENCE	1.88	1	.018*	.41	1	.260	.00	1	.911
PLANNING	.19	1	.472	1.24	1	.066	1.30	1	.060
CONTROL	.14	1	.525	.27	1	.384	.59	1	.202
OLMAT	.36	1	.235						
TASK	.41	1	.401	.91	1	.214	.11	1	.166

84.31 and the girls mean was 76.77. This is consistent with the greater number of motivational and learning cues provided by their teacher as well as benefit from more peer group learning situations.

***PPSI* Results:**

The *Table of Descriptive Statistics* (Table 1, p.90) informs about the relative awareness of girls and boys of their planning for problem solving, suggesting the relative effects of the classroom discourse in the two classes. It is apparent from comparison of means that the School 1 boys (at 2.83 out of possible five) and girls (at 3.07) use less planning and are less aware of alternate approaches to problem solving than School 2 boys (at 3.50) or girls(3.09).

A noteworthy difference was found between perceived competence of boys (3.85) tested in both schools and the girls (3.46) out of possible five. This difference was statistically significant at .018*(df=1); and supports classroom experience shared with students and literature conclusions that girls see themselves as less competent in solving problems. The disturbing disparity between the actual strong performance of the girls on *TASK* and their perception of their competence at problem solving as indicated by the personal competence measure on *PPSI* becomes apparent in Figure 1.

The impact of this perception on girls' approach to science studies as described in Chapter Two can be further

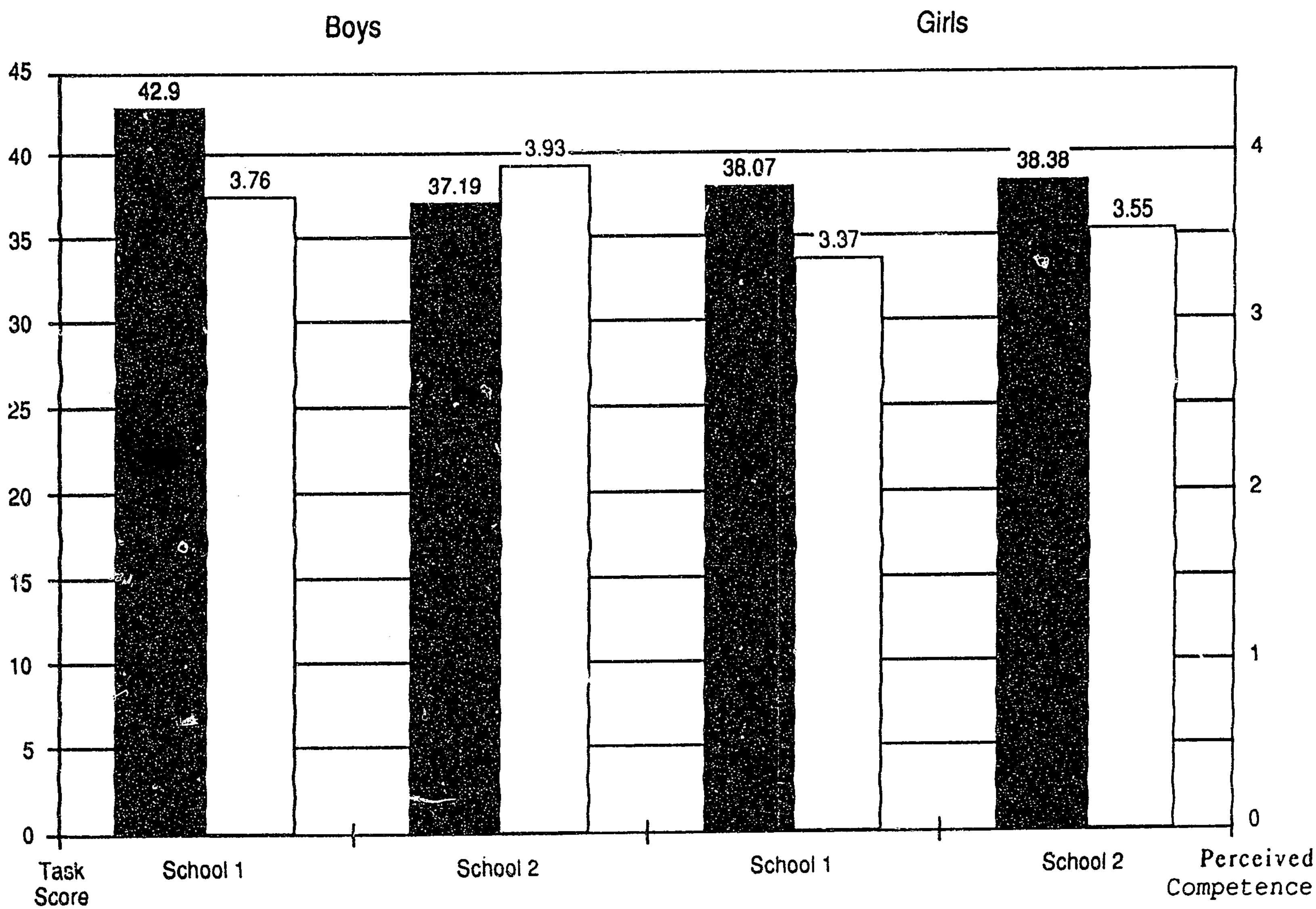


Fig. 1: Comparison of General Science Knowledge (TASK) and Perceived Competence at Problem Solving (PPSI)

explained by their perception of less personal control than that held by the boys. One striking example of this gender difference in self-concept is offered by boy # *0131082* who performed abysmally on both the *Otis-Lennon Mental Abilities Test* and on the *TASK* science achievement, but, at 4.40 (out of a possible score of 5.00) on perceived competence, compared to girl # *0172082* who scored very well on these knowledge and abilities measures, but, only 3.30 on personal competence. Although this girl is regarded as a strong student by her teacher and performed very well on the appropriate measures, she does not see herself as favorably as does the boy who was described by his teacher as being in the bottom five students in the class.

It is also informative that the mean of school 1 for personal control is 3.16, and school 2 is 3.29. Although this was not statistically significant, it did correspond with the noticeable differences in personal control of classroom interaction experience for students in the different settings.

Lack of shared construction of curriculum meaning and interaction was a trademark of the grade eight science class in school 1. This class in question was under strong teacher control during lectures with a domination of talk by the teacher, enforced through admonitions and threat of expulsion if classroom rules are violated. For example, an expression heard on several occasions that seemed familiar to the students was "once more and you are out." Relaxation of control was apparent during labwork or seatwork during periods held in the science lab, where groups were allowed freedom in discussion during cooperative work with apparatus or on questions in the textbook.

Students in the grade eight science class in school 2 shared in controlling direction and content of classroom discussion and science curriculum presented. Students regularly contributed to dialogue beyond answering teacher questions, questioned concepts presented, or extended discussions by adding examples or applications. This grasp of their freedom to pursue an idea was illustrated by Rob's contributions on classic bicycles, mentioned earlier, or by Jim and Jack's dialogue with each other and their teacher about how tongue, teeth and jaws act like wedges, cutting into the food. As illustrated by item 8 in the Verbal Behaviour Inventory summary for School 2, students were also observed to challenge teacher or other students' ideas more frequently.

Further discussion of the environments of the two classes and the perceived impact will be presented with examples, under the following themes reflected in classroom discourse.

The Image of Science and Science Education Presented:

As evidenced by differences in classroom discourse style, there is an imbalance of power between teachers and students in the science classroom. Control over the nature of dialogue is firmly held by the long-term teacher in School 1 whose traditional subject-centered style is illustrated in interactions such as:

> "Diffusion? Mary, read out the definition. She read from the text. Yes, intermingling of particles." He drew a sketch of a beaker of fluid pouring into another container of fluid with different sized contents; and simply asked them to "sketch what happens." The students weré busily and quietly writing notes and drawing the diagram without speaking to the teacher. Upon noting that one boy was not attentive; he said: "Particles? Abe, we will wake you up over there."

This type of evidence suggests a certain validity to Jacknicke and Rowell's (1984) claim that through authority, grounded in the rules of the classroom and the institution, the community demands adolescents respect teachers and other adults. The teacher presents naive students with a view of science and science studies as a formal, authoritarian, demanding search for knowledge contributed by experts.

This approach appeared to produce student alienation from the teacher and from the subject before the students learned how to talk the language of science and build meaningful and useful relationships between the massive amount of science terminology presented. For example, in one lecture on October 16, teacher 1 presented 19 definitions from the curriculum in about 33 minutes of class time and asked students for examples of most of these. Although this teacher emphasizes putting definitions that he or students recite in class into "your own words" and "What meaning does it have to you?"; students seldom led discussions of a term or how it may be applied in their daily life or what commonsense meanings it might hold.

The students treated this teacher with impressive respect, always calling him "sir" and only a handful of students called out without first bring selected, as the classroom rules dictated. Target students, who were called on most frequently and called out more than other students, included five boys and two girls. Teacher 1's usage of local examples of the chemistry of ground water and well water contents and related local industries did not seem to spark enthusiasm in more than the small number of target students. It was doubtful that if a follow up question were asked on another day that any of the students could recall the content of the example. This lack of involvement in the concepts they were served was illustrated several days later when lecturing on the water cycle, Teacher 1 referred to past discussions of ground water and no one could recall what he had said were the contents. He had to repeat them for the class. Their trust and good humour in the face of restricted freedom to take part in formal or informal talk during lessons was a source of wonder to this researcher.

Discourse and Classroom Environment:

Lemke (1990) refers to the most common form of classroom interaction (teacher defining some content, asking a question and then selecting a student to answer) as triadic dialogue.(p.32) He describes it as reducing the opportunity for commonsense ways of relating themes in science and preventing teachers from hearing how students understand or talk about science concepts.

The lack of value given by such discourse patterns to personal contributions of students to the topics or form of verbal exchanges provides increased control to the teacher. However it may contribute to a poor self-image and a distorted view of the construction of science knowledge. This phenomenon can be seen in the following case...

> "Come to this microscope and see the particularly good crystals". While the teacher was genuinely impressed with the quality and size of this demonstration, the students filed past and peered through the microscope with little apparent understanding or appreciation.

What this meant to the teacher was not understood by the students or they simply didn't have a basis for comparison. No information to entice them for their own sake was provided. Adherence to classroom rules meant an opportunity for a shared awareness of beauty in nature was overlooked.

Control is essential in all classrooms to keep students on task allowing specific required curriculum to be covered, in response to the institutional and political demands of the time. How this control is executed may greatly differ from classroom to classroom. Getting students focused by beginning a topic with a story or personal disclosure, is an alternative to calling for attention or admonishing those talking off-topic. One example provided by Teacher 2 was:

> "I went to Science Council this week-end and was told by a speaker that there will be a shortage of 70,000 engineers by the end of this century. That is a very good career. You should stick to your science and math classes, if you want access to such a secure career."

Bringing out bonus cards when intended content had been completed on some days, with questions each worth points towards their class marks, was another popular device of this teacher to keep students on track. Since each student was given an opportunity to answer a question (5 seconds) before another could call out an answer, they listened intently to what each person had offered. Authoritarian language was not the usage style of this teacher.

> "O.k., restless bodies, Shh. Let's look at the picture and figure out what load advantage and speed advantage would be here. You can see, we have five eager people ready to do this lab."

The relative power of the students in the two classrooms can be seen in such exchanges. Discipline was another distinct difference between the two classrooms observed. Teacher 2 was able to influence students through his involvement with them out of class in sports activities. On one occasion when he was returning homework assignments;

Teacher 2 said:

> Many of you are having trouble with the wheel and axle questions. Some are talking and are doing poorly - cheating yourselves! Those on teams are missing classes and thus not getting assignments. That is your responsibility. To stay on the team, you've got to get the work done."

This control manouver was accepted without objection, although these students complained immediately when they felt a test question did not provide the correct multiple choice answer. They also defended each other with real gusto if they felt a student was being unfairly disciplined. One such incident occurred when two boys were moved to the front for talking, inspite of warning.

> Many voices questioned, "Why move Ike? It was Charle's fault. Charles should be wearing his glasses." The teacher said " that is his responsibility" and went on to another question.

The harder edge of control was the rule of teacher 1. When a student had left the lab unnoticed until her return, she was greeted by the teacher pointing to her and saying: "Cleanup duty!" No resistance was offered and such incidents seemed to be accepted as normal practice and appropriate punishment by other students.

There was only one incident with this group of students during the study, that exposed a sense of peer group support in the face of authority.

> When dictating notes on crystalization, the teacher was asked by a boy to slow down. He replied; "Always ask me and don't worry. I have a habit of going faster than

> some can keep up." Voices chorused in agreement and someone said "a lot faster." The teacher in defence, suggested: "You have to crank up your speed a little too."

As is common practice in Alberta classrooms, much of 'the dialogue' was teacher monologue in both classrooms. Teacher 2 was careful not to bore the students by long periods of any one activity or notetaking and inserted short activities with free movement in the classroom to maintain interest. For example, in a double period of science in the cramped conditions of 29 students in a small lab, he brought in papers for them to cut out triangles of paper and had them wrap them around their pencils and move about in the lab trying to figure out what simple machine this was and how it provided some advantage. After some agreement was reached through open discussion on the wedge or inclined plane, they returned to notes and seatwork. Teacher 1 would follow a lecture class by a move to the lab for their second science period on many days.

More frequent group practice of the scientific jargon in addressing lab or homework questions appeared to give the students in class 2 greater self-confidence in the class and they eagerly called out terminology or discussed use, or modifications of concepts. On demonstration day, as the spokesperson for each group outlined the three simple machines found in the machine the group had designed and built from Lego building sets, they were very confident in describing the class of levers they had chosen or what type of advantage was offered by each component. When each spokesperson had finished their presentation, the questions of other students were on topic and their appreciation was made apparent by comments on the quality of the machine or functions.

Note, that, although there was no significant difference in relative performance of the two classes on the *TASK* general science knowledge measure, the presence in class 2 of two boys who perform well below the rest of the class and would in a larger school probably not be kept in this class is in contrast to a smaller group of 9 stronger boys in class 1 (7 scored 42 out of 50 or greater on *TASK*). Note, that the highest scores on this measure came in class 2 with one boy getting 50 out of 50 and a girl scoring 49. Both teachers tried to simplify scientific jargon by requesting that students "explain concepts in their own words' or "figure out how it works for us". Both teachers were sensitive to evaluative demands of external agencies such as the Department of Education and this may have contributed to a predominance of the formal language of the curriculum.

Social Construction of the Image of Science:

Rarely was the social construction of science knowledge discussed in either class. Only once in school 2 was an example given of how commonsense applied to scientific knowledge came to the rescue of someone.

> This story involved the failure of a skidoo in the cold and darkness of the Arctic and how a Inuit got it running and saved lives by carving a replacement for a damaged gear from a cariboo bone. The students were fascinated by this story. One exceptional boy in this class, asked several questions about how this could be made to work.

Greater respect for the capabilities and useful science-appropriate knowledge of students was apparent in the language of both students and teacher in class 2. One day, Peter explained how the screwdriver was a like a wheel and axle. When given credit for his insight, he confidently replied: "I'm too smart for these guys." When a student was having difficulty explaining the simple machines in a pencil sharpener; other students called out in response to the teacher's request for help.

> In presenting the concept of molecules, Teacher 1 asked a girl; "What is water?" She replied: " A liquid." He said: "Right, got to start some where." He then began to write the letters of the alphabet on the board. Several of the boys started to grin and offer: "Hydrogen and oxygen." Teacher 1 said: "You're slowly catching on."

Teachers were continually called upon to make judgements about the value of student comment. Evidence of gender differences in this area may be seen in the greater number of challenging or total questions asked of boys compared to girls in both classes (item 8 and 7 on the Verbal Behaviour Inventory summaries) and praise was more often given to boys (item 3; 10 to boys versus 4 to girls).

The conflicts that are apparent between young adolescents and teachers in classrooms are simple reflections of differences in values operating in the community at large. When a teacher is heard to say to a boy asking a question off topic, "Wait till we get to it. That is a derailment again."; we are witness to the social emphasis on order and efficiency. That question may have interested other students or led to fruitful discussion that could not only broaden understanding in science but could also build friendly relationships between the participants, if only science education encouraged such practice.

Teacher judgment appears to influence a student's willingness to ask other questions or risk criticism.

> During a lesson on how to graph data in an experiment with the accompanying jargon of dependent and independent variables, quadrants, abscissa, and many others; most of the students of Teacher 1 appeared confused and unable to work on their own. In these conditions, not even the target students were willing to risk answers and several girls who were completely lost as to what to do began talking to each other. Immediate criticism of the initiator of the conversation and moving her to the front near the teacher's desk brought her apparent distress.

This incident may be properly attributed to traditional teaching practice, rather than individuals trained in that practice.

Classroom rules were hardly ever violated in either class. Inattention or chatting during lecture in class 1 were sharply dealt with by admonishments like "once!" or "one more time and you are out!".

Teacher 2 had more subtle control strategies, like directing a question to students who appear to be off task. This tactic worked wonders and he often engaged them as allies in lab preparation or explanations by saying "we have a good start on this and we will ..." Students treated teacher 2 as a confidant on several occasions and offered to drop off homework to absent students.

This interactional strategy seemed to give students more control and the teacher was sensitive and responsive to class boredom, mood or need for a break. An example occured at the end of the first class of a double period of science:

> " You need a change of pace when you have two science classes in one day. You guys stand up and stretch." Teacher 2 allowed them about a two minute break to move around and visit with each other, before calling on group two to come to the front and demonstrate their lab.

Teacher 2 ignored other discussion when working with a group of students on lab set ups or seatwork. When he wished for attention, he would say so and students would "shh" any of their peers who did not quickly adhere to his request. This support from his students and their quick return to task illustrates the regard with which he is treated and gives insight into the classroom environment.

The friendly discourse patterns of class 2 were reflected in the acceptance of a visiting relative of one of the girls in class or the warm reception of a new girl who transferred into the school near the end of the study. The boys in one group immediately invited her to join them in working with gears and engaged her in conversation.

Unlike school 1's daily announcement of student and community activities followed by a listing of all students on detention that day, school 2 had a student gossip grapevine through which knowledge of who was in trouble for what, could be accessed.

Administration and teachers appeared to be supportive and joked about student misbehaviours with the culprits before using more drastic punishments. Expulsion from school for several days for one boy in class 2 was regarded as a serious matter by other students and conveyed to me upon my arrival, to get my reaction. Difference in teacher attitude toward responsibility and relationship with students was demonstrated when I asked in a final written interview for insights that might aid interpretation of instruments or videotapes. Teacher 2 shared his concern with the researcher:

> ... I know that some of these students are carrying large language deficiencies and as a result they tend to miss the connections that are being made in their classes.

In contrast, the only insight that Teacher 1 provided was that "they are all individuals." This language suggests that Teacher 2 sought an explanation for behaviours that he knew I would have witnessed and felt some responsibility to share his insights with the researcher, unlike Teacher 1.

Thus it seems that the Verbal Behaviour Inventory enables us to effectively describe the patterns of conflict management and to sense the language patterns that contribute to the image of the science shared with students.

Language in the Science Classroom Reflecting Appraisals of Identity:

The language of the science classroom can clearly be seen to project the idea that the world view shared with students through the curriculum is the right way to talk about the world. Seldom were students seen to challenge this formal view.

The existing stereotypes of the larger community were seen to be applied in science class as well.

> On photo day, teacher 1 was very concerned about how the girls, who were badgering him before class, would leave class in small groups to do their hair and "could you be responsible for them?" but never did he ask the boys if any of them would care to get ready for their photos.

Use of "that colored stuff, girls put on their nails" as example of a suspension was another example of generalization and stereotyping although such comments were always made with a smile.

Relationship of Formal Language to Evaluation of Students:

The formal jargon of large numbers of concepts may cause students to retaliate from such dry and serious curriculum that often is presented as something that must be accepted without argument or explanation. When boys called to their teacher, saying:

> Sir, there is something moving on this slide; he looked at the slide, agreed with them and left without explanation. The boys continued to speculate what it was for a moment and then moved to something else.

This type of evidence suggests missed opportunities to share the weird and wonderful events studied in science result in loss of interest in future studies, as suggested by the literature review.

Emphasis for evaluation purposes on students being able to recall definitions and functions, as stressed by their teachers when telling them about upcoming tests, devalues the students' understandings in more colloquial forms of language that had been stressed in both classes. When going over test answers, Teacher 2 used only the formal language to answer the problems and failed to use common language until he answered a problem on the board incorrectly and had to find the source of his error.

> He sought help from his class by saying "I have done something wrong; I had no problem when I made up the answers. We can all learn from our mistakes. I must have forgotten something". At this point, one of the target boys suggested some alternatives, an answer and even dropping the question from the test since it was too hard if you get it wrong.

A similar case of the impact of formal language in an evaluative context could be seen in the discomfort of both strong and weak students when questioned by their teacher during the lesson on graphing. Without some understanding of the jargon of graphing, the students could not work independently on that assignment and were forced to wait or ask simple questions to even get started. Communication is undoubtedly impeded by these evaluative demands.

The classroom practice is also seen by students to be contradictory, moving from common language to formal. To tell the teacher about the subject it is necessary to "put it in your words" but don't forget the precise terms for the multiple choice or matching questions on the test! Understanding that a bigger gear provides a speed advantage on a bike does not give the student a definition of speed advantage for a test.

Lemke (1990) found in a 1983 study he conducted for the National Science Foundation that students are three to four times as likely to be highly attentive to 'humanized' science talk as they would be to 'normal' science talk in the classroom (p.136). This finding was supported in this study. When ordinary language was used or personal examples were provided by the teacher or another student, as in the discussion of the functions of the jaw and mouth parts or gears and wheels on bikes or automobiles, everyone appeared to feel more familiar and interested in the idea.

Such an approach also improves students' self-concept as science learners, when they realize they can understand after all. Like Vygotsky (1986), Lemke (1990) suggests that the value of peer group learning and talking science in a less formal setting did improve the involvement of students in class 2 and contributed to impressive results for many girls and boys on the TASK measure of general science knowledge.

The apparent confidence in becoming active in discussion of curriculum concepts or suitability of test questions with which such students approached problems may be more accurately reflected by their scores on the *LPQ* and *PPSI*, two measures that assessed learning motives and strategies, self-concept, control, and planning skills. The confidence in their own abilities to grasp a problem may transfer to participation in decision making on future directions for science and technology in society!

Increasing the familiarity of students with science as demonstrated in classroom 2 in this study may allow those who are often excluded from educational or scientific decision making to find their voice and reduce the power of "experts". It would surely lead to science having a more humane face!

Girls' Experiences:

The experience of girls in classes observed, as interpreted by the researcher, corroborates that experience described in the literature. Teachers did talk more often to boys both to praise their understandings and efforts (twice as often, item 3) or to control them (almost twice as many questions asked, item 7); boys did more of the 'hands on work' during labs or demonstrations (twice as much, item 9) while the girls behaved stereotypically as recorders or displays.

A clear example of such stereotyped behaviour was observed when an attractive young girl, self-confident in discussion, hung back while her male partners worked with pulleys in a class demonstration but acted "like Vana White" (the sexy hostess on Wheel of Fortune, a popular game show on television) when called on to show the chart of results. This act was such a good mimic that many students called out "Vana, Vana."

This stereotypical image of the role of a female in sharing information or in contribution to solving problems was understood by both this young performer and her audience. What this speaks about the image of themselves held by girls in this class is unfortunate. That this also lost the focus of the discussion on a worthwhile demonstration for a while was clear.

In group work in class 2, or in the lab with class 1, the adoption of stereotypical roles for girls relative to their male teacher or male peers was obvious. The girls paid more attention to their male lab partners than to the lab. Giggling, chatting and fooling around was much more common in the mixed sex groups than when the girls were working in a group together. This was clearly seen in both classes with assigned groupwork. Girls were more likely to be criticized for how responsible they were, or blamed for not listening, as illustrated by the young girl being chastised for not listening during the lesson on graphing or the question directed to a girl who was not yet organized at beginning of a lecture as to "who is responsible here?" as source of their apparent lack of ability. If partners were not assigned, girls tended to work together and there was very little sign of disharmony in these arrangements and the work was productive.

In the mixed sex groups, individual interactions to establish relationships often interfered with or overshadowed the intent of the class activity. This became apparent with the total attention given by two of the boys in the group to the new girl in their class, resulting in eager informal discussion and side talk but little work on completing the gear assignment until the end of the class neared.

Girls were asked simple questions requiring low challenge or dichotomous answers more frequently than even those boys working at a level below the class average. Teacher 2 asked one of the top achieving girls in the class a question during a review and her immediate response was to read an answer directly from her notes. This expectation of a simpler response from girls was clearly recognized by many of the girls who would quickly provide a shallow answer to a question directed to them, diverting attention to the next victim; rather than holding the floor to reason or discuss their answer in greater detail. It is the belief of the researcher that teachers in both classes were caught up in this practice, although teacher 2 did try to ensure that girls provided answers to each question and occasionally would tease an answer from them rather than let them off the hook.

The evidence suggests that it was not clear that boys intended to monopolize the resources. A more likely observation is that social norms encouraged the girls to let the boys be the more active members in groupwork. Girls did engage more willingly in group activities than did some of the boys who preferred to work alone. Girls, when allowed, would usually move together to talk, share answers or work on homework. This supports the suggestion from past experience and the literature that girls are more cooperative in science classes and show a somewhat different focus than many boys.

Girls' suggestions were commonly greeted with "yes" or "that's right" in class 1, but seldom was any further recognition made of their contributions to the lesson. The small number of students who answered a large number of the answers and regularly call out responses were almost all male in class 1.

Perhaps insensitivity to feelings was illustrated in teacher 1's dealings with many of the girls in examples already cited. Another example occurred when the bell rang at the end of a class and a girl asked "Can we go now?" The teacher answered: "No, you're not going anywhere, that is why I gave you two sheets. I'm going to give you an example." This girl did not know that the class was going to be allowed to run over into the next class (math, with the same teacher), and was embarassed.

It was apparent that these very busy teachers have not been made aware through research or pedagogical literature of the current interest in promoting girls' involvement in science through changes in classroom practice. Only once during the study did a teacher offer an example of a scientific invention by a woman. This was a reference to an entry in the textbook. Other than teacher 2's efforts to keep the girls in the classroom dialogue and to praise their contributions in the same ways as he praised the boys, no efforts to increase the interest or pursuit of science studies was made by either teacher.

Both of these teachers assumed much of the responsibility for their students' learning. They were interested in students as individuals and tried to share concern for their success in the class with them. However, an observed gender difference was observed repeatedly in how these teachers helped a student having difficulty. The tendency was to show the girl having trouble how to do it without much discussion; the boy was talked through the process to get a solution. An incident of such direction to complete the task to a girl was provided by the simple directive "to go up by threes on this axis and by fives on that axis", while a boy was questioned and explanation was provided as to what the contents of each axis represented.

In a lab measuring effect of water temperature on the amount of sugar required to reach saturation, several girls asked the teacher what they should do next, he simply told them. However a boy was questioned "what happens to the amount of sugar that will dissolve as you increase the temperature?" This difference in interaction may have been due to socialization and the desire not to get the girl upset or make the task take longer; or due to an unconscious unease with the girls. Girls were also allowed to engage in more side conversations than the boys without reprimand. Is this also a reflection of stereotyping?

Both teachers in this study had specializations partially outside of the demands of the curriculum they were teaching in these classes. Teacher 1 is a math teacher. Teacher 2 is a biology teacher. In light of the teaching load- four different subjects per day for Teacher 1, five for Teacher 2, demands of teaching this integrated science program may have contributed to the information sharing approach apparent in both classes. Teacher 2 was able to engage students in this process to a greater degree because of his student-centred personal interest and belief in the virtues of hands-on learning in science lab although there were inadequate resources in this lab for everyone to do every lab. Teacher 2 also posed a lower risk level for students to talk science and learn from each other.

There were a small number of students, mostly boys, who always were ready with answers and if an answer was important to building the lesson, both of the teachers would ask one of this group. These students were also described in the interview as top students by the teachers.

Some girls were able to be minimally engaged and anonymous for much of the classes. In class 1, five such girls were rated by the teacher as at the bottom end of the class, although three of these girls showed science knowledge on *Task* above five of the nine boys. Their lack of interaction with the teacher may have worked to their detriment in creating a negative impression on the teacher. They may also have felt uncomfortable in using the formal language of science because of lack of practice in engaging in science discourse with the teacher.

V. SUMMARY AND DISCUSSION

In a study of this nature, one in which various methods and concepts were involved, it seems clear that the resulting findings can not be taken individually. The whole is greater than the sum of the parts.

This study found no significant difference in intelligence or general science knowledge between these two classes by gender or by school. In practice, they were providing very different learning environments for students and even for individual students within the same class.

Gender differences in experience were demonstrated by the nature of discourse summarized in the Verbal Behaviour Inventory and excerpts of dialogue from each classroom. There were discernible differences in the interactions between teachers and male or female students. Although this study did not address the issue of how interest in science is related to the number and nature of questions asked by students, there was a difference in the amount of involvement in the class reflected by the larger number of questions asked by boys and of boys in each class.

Interviewing of individual students would have been required to draw such a comparison or investigate if a gender difference in interest existed.

This observation matches the findings of Tobin, Kahle and Fraser (1990) in an indepth study of this age group in Australian science classrooms. **Evidence has been presented**

on how this differential environment was perceived to be influencing student self-concept, interest in science and the classroom behaviours of both teachers and students, as reflected in language use.

The significant gender difference in personal competence and control was also displayed in the nature of verbal involvement of girls and boys in the class. Contribution to girls' poorer self-concept were certainly evident in the interactions described in class 1. The tendency for the girls to be less actively involved in both classes than the boys, may have influenced the girls' overall higher surface approach and lower deep and achieving approach to problem solving than held by the boys.

The science class acts like a mirror reflecting to the students an impression of future science studies and likelihood of achieving or enjoying a career in this area. School 2's much higher score on deep and achieving approach is at least partially a reflection of the relative science classroom experience of these two groups of students.

Suggestions for changes in Classroom Practice:

Since both of these teachers were perceived to be sincerely concerned about their students, a discussion of the findings of this study with them may promote an increased sensitivity to how particular teacher and student practices may differentially affect student interest, involvement and performance. It has been my experience that teachers spend a lot of time reflecting on classroom events, and the point can be easily made in order to provide for changes to be instigated. If knowledge does lead to change, as is commonly believed, the findings of this study suggest that awareness of stereotypical practice which occurs in classrooms may bring about the desired changes in classroom language.

Further suggstions for classroom practice stemming from this study are: (1) efforts to get and keep girls actively involved in the class must be increased, (2) girls should be challenged as much as boys and encouraged to complete complex activities rather than getting the teacher to show them how to do it, (3) girls could be grouped in single sex groups or with non-dominating boys during lab work to increase their hands-on experience, (4) outside readings and science related activities could be encouraged by the teachers to increase interest and experience for all students, (5) teachers should make a point of engaging in informal science talk with girls.

If teachers were allowed the time to study the nature of the interactions in their own classrooms, and provided research findings on the impact of such relationships from around the world, many would become proactive and work to improve the environment for all of their students.

The language of the science classroom should also undergo some change. Use of more real life examples that would interest both girls and boys should be used to enrich lessons. Reduction of science jargon and sexist language and replacement by more commonsense language would reduce the alienation and boredom often evident, as in this study in the videotapes, on the faces of many students.

These findings speak to Vygotsky's theories on group interactions, namely, that increased amounts of classtime could be spent on focused group activities allowing students more practice using the science language and building relationships between the concepts.

Such an approach would increase student responsibility for their own understandings and their power to affect the environment for learning. It is reasonable that these changes in learning context should impact on self-concept and motives and strategies for learning.

Greater recognition of the value of student questions and contributions would certainly build a stronger tie between teacher and students. Students in science classes would likely benefit from higher expectations being expressed by their teachers and girls it would seem, need additional reminders and 'real' evidence of their ability to learn and enjoy science. **It is not clear from this study whether such practices would improve academic performance but it would provide a more enjoyable environment for all concerned.**

Other researchers have suggested that girls need to be encouraged to take math courses to aid their competence in the secondary sciences. In order for teachers to change the trend of few girls to pursue math beyond minimal requirements, they would have to seek out and work to change girls' perceptions and fears that produce this trend. Integration of concepts between the various grades and science courses has also been recommended by many researchers. "Research suggests that students benefit from multiple approaches to the same concept."(Eylon & Linn, 1988, p.272). This multiple approach is offered to students at all grade levels by teacher guided peer group learning situations as advocated by Vygotsky (1986).

Suggestions for Future Research:

This study did not look at the personality characteristics or cognitive style of individual students or how well that matched the personality and style displayed by the teacher. In interactional analysis, greater resources in time and researchers are needed to consider this relationship and its impact on student perceptions of science studies or careers and achievement. However, if some insights could be gained in this area it might provide administrators and teachers guidance in placing students in particular classes or in relating to them in classes.

The tough economic times are certainly influencing attitudes and goals of both teachers and students at this time. Research should be directed to determine both the extent and direction of its impact. The majority of social and economic forecasts indicate that women will need to become wage earners. Maximizing human resources through education may be critical to helping humanity find its way out of the "black box" that it has created.

The value of female role models in influencing girls to pursue science knowledge and related careers also deserves critical research. Does having greater exposure to contributions of women in science and knowledge of how they have conducted their lives encourage more girls?

A critical evaluation of existing interactional teacher training for science and its impact on student attitudes and achievement should be a high priority, allowing the profession to assess the value of new methods and goals in the classroom. Until such findings trickle out to the schools through literature or personal involvement, alternate strategies or new environments will not take hold.

BIBLIOGRAPHY

Adey, P., Bliss, J., Head, J.& Shayer, M. (1989). Adolescent Development and School Science. London: Falmer.

Anderson, G.L. (1989). Critical Ethnography in Education: Origins,Current Status, and New Directions. Review of Educational Research, 39(3), 249-270.

Anyon, Jean. (1988). Schools as Agencies of Social Legitimation. In W. Pinar (Ed.), Contemporary Curriculum Discourses . (pp.175-200). Scottsdale: Gorsuch Scarisbrick.

Apple, M. (1975). The hidden curriculum and the nature of conflict. In W. Pinar (Ed.). Curriculum Theorizing: The Reconceptualists. Berkeley, Calif.: McCutchan.

Apple, Michael W. & King, Nancy R.(1976). What Do Schools Teach? In Curriculum Theory. (pp.108-128). A.S.C.D.

Apple, M. (1982).(Ed.). Cultural and economic reproduction in education. London: Routledge & Kegan Paul.

Bain, Bruce.(1975). Toward an Integration of Piaget and Vygotsky:Bilingual Considerations. Linguistics: An International Review, 160, 1-19.

Bain, Bruce.(1983).(Ed.).The Sociogenesis of Language and Human Conduct. New York: Plenum Press.

Bain, Bruce. (1987). Sign, Signal, Symbol: A Plea to Social Science and Semiology. Recherches/ Semiotic Inquiry, 7, 267-283.

Beane, J.A. & Lipka, R.P. (1979). Enhancing Self-concept/esteem in the Middle School. Middle School Journal, 1?(3), 4-6.

Beane, J.A. & Lipka, R.P. (1986). Self-concept, self-esteem and the curriculum. NY: Teacher's College Press.

Brouwer,W. (1991). Let's Ban Scientific Jargon from Introductory Science Classes. Alberta Science Education Journal, 24(1), 25-27.

Bruner, Jerome. (1983). Child's Talk. New York: W. W.Norton.

Burns, James MacGregor. (1978). Leadership. New York: Harper & Row.

Caplan, P.J., Macpherson, G.M.& Tobin, P. (1985). Do sex-related differences in spatial abilities exist? American Psychologist, 40, 786-799.

Cole, Michael. (1985). Mind as a Cultural Achievement: Implications for I.Q.Testing. In Elliot Eisner (Ed.), Learning and Teaching The Ways Of Knowing (pp.218-249). Chicago: National Society For The Study Of Education.

Cole, M. (1985). The zone of proximal development: where culture and cognition create each other. In J.V. Wertsch (Ed.), Culture, communication, and cognition: Vygotskian perspectives (pp. 142-161). New York: Cambridge Press.

Cooper, P.J. (1987,November). *In or Out of the Pumpkin Shell*. Paper presented at the Annual Meeting of the Speech Communication Association, Boston, MA.

Craig, J., & Harding, J. (Eds.). (1985). Third International GASAT Conference Report. London: King's College,Univsity of London, Centre for Educational Studies.

Deaux, K. (1976). The behavior of women and men. Belmont, Calif.:Brooks-Cole.

DeCharms, R. (1977). Pawn or origin? Enhancing motivation in disaffected youth. Educational Leadership, 34(6), 444-48.

Decore, A.M. & Pannu, R.S. (1989). Alberta Political Economy in Crisis: Whither Education? Canadian Journal of Education, 14(2), 150-169.

Eagly, A.H., & Steffen, V. (1986). Gender and Aggressive Behavior: A Meta-analytic Review of the Social-Psychological Literature. Psychological Bulletin, 100(3), 309-330.

Eisner, Elliot. (Ed.). (1985). Learning and Teaching the Ways of Knowing. Chicago: The National Society For The Study Of Education.

Erickson, G.L., & Erickson, L.J. (1984). Females and Science Achievement: Evidence, Explanations, and Implications. Science Education, 68(2), 63-89.

Eylon, B.S.,& Linn, M.C. (1988). Learning and Instruction: An Examination of Four Research Perspectives in Science Education. Review of Educational Research, 58(3), 251-301.

Fensham, P. (1988). Development and Dilemnas in Science Education. London: Falmer.

Forman, E.A.& Cazden, C.B. (1985). Exploring Vygotskian perspectives in education: the cognitive value of peer interaction. in Wertsch, J.V. (Ed.), Culture, Communication and Cognition: Vygotskian Perspectives. Cambridge: Cambridge University Press.

Foucault, Michel. (1980). Power/Knowledge. New York: Pantheon Books.

Foucault, Michel. (1984). The Foucault Reader. New York: Pantheon Books.

Franklin, U.M.(1984). Knowledge Reconsidered. A Feminist Overview. Proceedings of the 7th Annual General Meeting and Conference, Canadian Research Institute for the Achievement of Women.

French, Marilyn. (1985). Beyond Power. New York: Ballantine Books.

Friere, Paul. (1972). Pedagogy of the Oppressed. Harmondworth, Middlesex: Penguin Books.

Friere, Paul. (1970). The Adult Literacy Process As Cultural Action For Freedom. Harvard Educational Review, 40(2), pp.205-225.

Goetz, J.P. & LeCompte, M. D. (1984). Ethnography and Qualitative Design in Educational Research. San Diego: Academic Press.

Graumann, Carl F.& Moscovici, S. (Eds.). (1986). Changing Conceptions of Leadership. New York: Springer-Verlag.

Groome, T. (1980). Christian Religious Education: Sharing Our Story and Vision. San Francisco: Harper & Row.

Grumet, M.R. (1988). Bitter Milk. Amherst: University of

Massachusetts Press.

Habermas, J. (1987). Reason and Interest: Retrospect on Kant and Fichte. Knowledge and Human Interests. Cambridge: Polity Press.

Haladyna, T. & Shaughnessy, J. (1982). Attitudes Toward Science: A Quantative Synthesis. Science Education, 66(4), 547-563.

Harding, J. (Ed.). (1986). Perspectives on Gender and Science. London: Falmer.

Harris, Adrienne. (1983). Language and Alienation. In B. Bain (Ed.). The Sociogenesis of Language and Human Conduct. New York: Plenum.

Heppner, P.P. & Peterson, C.P. (1982). The Development and Implications of a Personal Problem-Solving Inventory. Journal of Counselling Psychology, 29, 66-75.

Hoyenga, K.B. & Hoyenga, K.T. (1979). The Question of Sex Differences. Boston: Little Brown Publishers.

Illich, I. (1983). Deschooling Society. New York: Harper & Row.

Illich, I. (1983). Gender. New York: Pantheon Books.

Jacknicke, K.G. & Rowell, P.M. (1984). Reaching For Possibilities In Science Education. Occasional paper No. 33, Department of Secondary Education, Faculty of Education, University of Alberta.

Jackson, P.W. (1968). Life in Classrooms. New York: Holt, Rinehart and Winston, Inc.

Kahle, J.B. (1987). Ed. Women in Science. London: Falmer.

Kelly, A. (1987). Science for Girls?. Philadelphia: Open University Press.

Kenway, J.& Willis, S. (1990). (Eds.). Hearts and Minds: Self-esteem and the Schooling of Girls.

Kramerae, Cheris. (1981). Women and Men Speaking. Rowley, MA: Newbury House Publishers.

Kramerae, Cheris; Schulz, Muriel & O'Barr, William M. (1984). Language and Power. Beverly Hills: Sage Publications.

Kristeva, J. (1981). Women's Time. (A. Jardine & H. Blake, (Trans.). In N. Kechane, M. Rosaldo, & B. Gelpi (Eds.) Chicago: University of Chicago Press.

Kutz, Dorothy E. (1983). The Use of Participant Observation in Evaluation Research. N.Y: Pergamon Press.

Lakoff, Robin. (1975). Language & Woman's Place New York: Harper & Row.

Lasswell, Harold D. (1976). Power and Personality New York: W.W.Norton.

Lawrence, D. (1988). Enhancing self-esteem in the classroom. London: Chapman.

Lemke, J.L. (1990). Talking Science. Norwood,N.J.: Ablex Publishing.

Levinson, L.L. (1971). Bartlett's Unfamiliar Quotations. Chicago: Cowles Book Co.

Linn, M.C.& Hyde, J.S. (1989). Gender, Mathematics, and

Science.Educational Researcher, 18(8), 17-19, 22-27.

Livingstone, Barb. (1989, April 21). The Scientific Mystique: Why does Science Still Intimidate Most Women? Calgary Herald, D1-4.

Luria, A.R. (1961). Language and Cognition. New York: John Wiley.

MacDonald, J.B. (1975). Curriculum and Human Interests. In Pinar. (Ed.). Curriculum Theorizing:The Reconceptualists.

Maslow, A.H. (1987). Motivation and Personality. Third Edition. New York: Harper & Row.

Matson, F.W. (1964). The Broken Image: Man, Science and Society. New York: Anchor Books.

McClelland, David C. (1984). Power: The Inner Experience. New York: Irvington Publishers.

Merleau-Ponty, M. (1964). The Child's Relations with Others. (W. Cobb, Trans.) In J. Edie (Ed.). The Primacy of Perception. Evanston, Ill.: Northwestern University Press.

Mulcahy, R. (1990). Perceived Competence, Self-Concept, and Locus of Control for High Ability Students, as Compared to Average and Learning Disabled Students. Canadian Journal of Special Education, 6(1), pp.42-49.

Patton, M.Q. (1980). Qualitative Evaluation Methods. Beverly Hills: Sage.

Phillips, Shelley. (1983a). Self-Concept and Sexism in Language. and (1983b). Sexism and Self-Concept in the

Language of Children: A Middle Childhood Survey. In B. Bain (Ed.), Sociogenesis of Language and Human Conduct (pp.131-151).

Polyani, John. (1988). How Discoveries are Made. Keynote address to the Science Council of Alberta Teachers' Association Annual Convention, Banff, Alberta.

Ruskai, M.B. (1991). Are there innate cognitive gender differences? Guest Comment. American Journal of Physics.59(1), 11-14.

______, Report of the President's Commission for Equality and Respect on Campus. (Mar. 1990). Univ. of Alberta.

Sartre, J.P. (1966). Being and Nothingness. (H.E.Barnes,Trans.). New York: Washington Square Press.

Shapiro, Bonnie L. (1989). What Children Bring To Light: Giving High Status To Learners' Views and Actions In Science. Science Education, 73(6), 711-733.

Shaw, E.L. & Doan, R.L. (1990). *An Investigation of the Differences in Attitude and Achievement between Male and Female Second and Fifth Grade Science Students*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (63rd, Atlanta, GA, April 8-11, 1990).

Shibley Hyde, Janet & Linn, Marcia. (1988). Gender Differences in Verbal Ability: A Meta-Analysis. Psychological Bulletin 104(1), 53-69.

Shulman, L.S. (1990). Paradigms and Programs. Research in

Teaching and Learning, Volume 1 New York: Macmillan.

Slugoski, B.R. (1991). Is Language Powerless? Canadian Psychology, 32(1), 24-26.

Smith, D.E. (1987). The Everyday World As Problematic. A Feminist Sociology. Boston: Northeastern University Press.

Spear, M. (1984). The biasing influence of pupil sex in a science marking exercise. Research in Science and Technological Education, 2, 55-60.

Spender, Dale. (1980). Man Made Language London: Routledge & Kegan Paul.

Staab, C.F. (1991). Teachers' Practices With Regard to Oral Language. Alberta Journal of Educational Research, 37(1), 31-48.

Steinkamp, M.W.& Maehr, M.L. (1984). Gender differences in motivational orientations toward achievement in school science: A quantatative synthesis. American Educational Research Journal, 21(1), 39-59.

Sternberg, R.J. & Caruso, D.R. (1985). Practical Modes of Knowing. In E. Eisner (Ed.), Learning and Teaching the Ways of Knowing. (pp.133-158). Chicago: National Society For the Study of Education.

Vygotsky, L.S. (1986). Thought and Language. Boston: M.I.T.

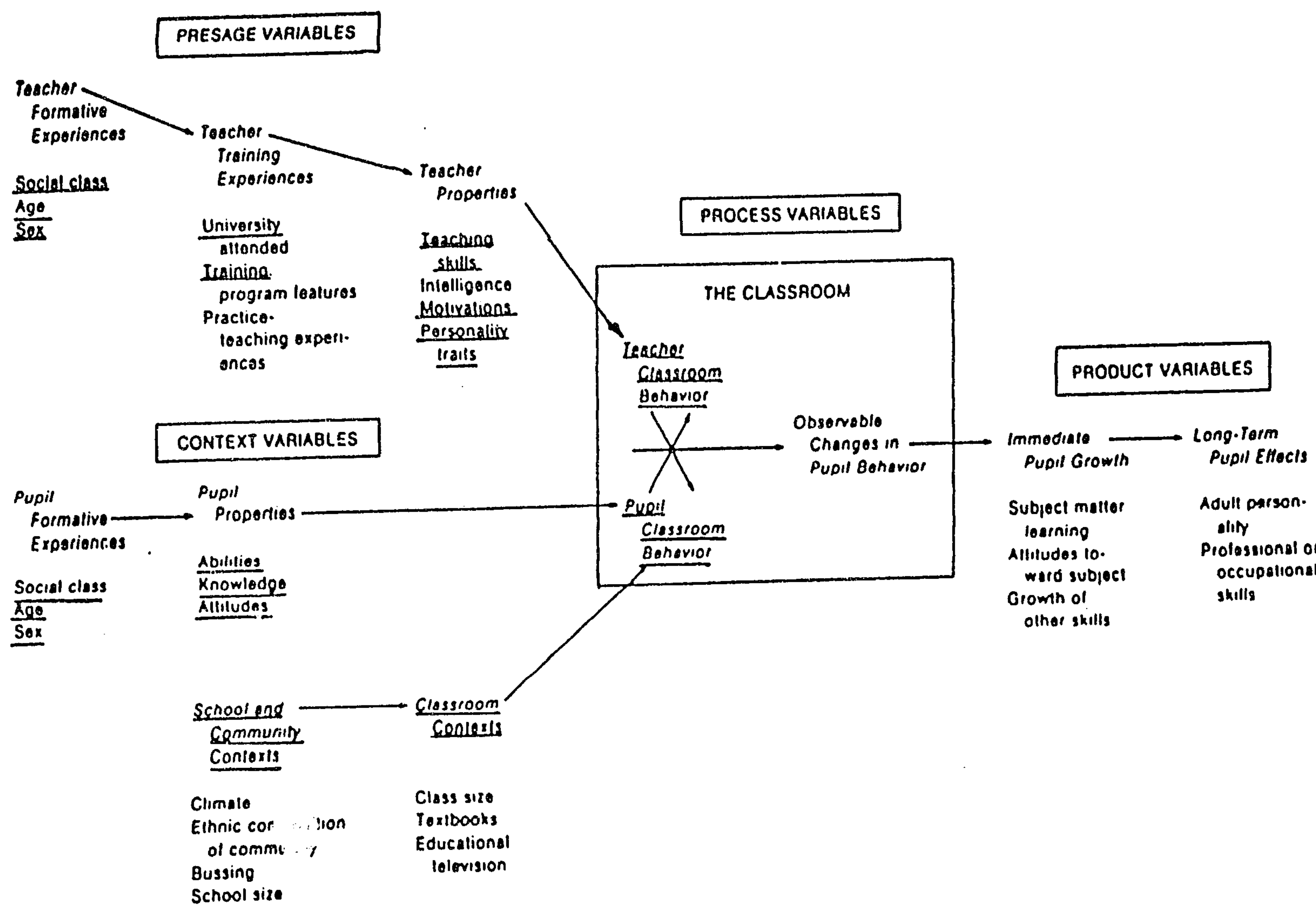
Weiner, Bernard. (1990). History of Motivational Research in Education. Journal of Educational Psychology, 82(4), 616-622.

Weitz, S. (1976). Sex Differences in Nonverbal Communication. Sex Roles, 34, pp.175-84.

Whyte, J. (1986). Girls into Science and Technology: The Story of a Project. Boston: Kegan Paul.

Woolf, V. (1929). A Room of One's Own. New York: Harcourt, Brace & World.

APPENDIX A



A model for the study of classroom teaching. From *The study of teaching* (New York: Holt, Rinehart, and Winston) by J. Dunkin and B. J. Biddle, 1974. Reprinted by permission.

APPENDIX B

September 1991

Dear Parent/Guardian:

We would like to request permission for your child to participate in a research project at school. This project is being conducted by Mrs. Heather Ryan, Department of Educational Psychology, University of Alberta, supervised by Dr. Bruce Bain.

This research is hopefully going to shed some light on the nature of language and other forms of interaction in science classrooms. Heather is the product of a very enjoyable and satisfying education in a rural village in northern Alberta, with subsequent university studies and teaching in Science. This has provided the impetus for her to do rural research for her Master's degree. We are concerned that during the past twelve years, provincial and national studies have shown that Canadian science education must change if our students are to meet the challenges of the next century. From her years as a high school science teacher, she believes there is much to be learned from the interests and knowledge expressed by the dialogue of students and teachers.

This study will involve observations in the classroom, verified by videotaping. Group interactions and teacher-lead discussions will be analyzed according to well established research coding standards. The observation and videotaping will require about 20 days of classroom participation, followed by a one month absence for us to analyze the interactions. A short period of testing for self-concept, self-knowledge and information processing ability, through tests approved by learning specialists in the Department, will take a few moments of the students' time after the first phase of analysis.

The anonymity of students and teachers in the study will be assured by the use of substitute names in all documents. The videotapes will be destroyed after the project is complete.

Students and teachers will have the right to withdraw from the study at any time. This study will in no way deter from academic performance on the part of participants. This study can not be a success without your willing cooperation and support. If you have any questions,regarding this research, please do not hesitate to call Dr. Bruce Bain at the University of Alberta at 492-3693 or Heather at home in the evenings at 662-2442. Thanks for your cooperation and support.

Heather Ryan____________________________

Dr. Bruce Bain____________________________

Parent Signature, granting
permission.____

APPENDIX C

REFLECTIONS FROM A COOPERATING TEACHER'S VIEWPOINT

Please candidly reply to the following questions as your insights are very important to an informed interpretation of videotapes and results from the measures given to your class. Thank you for your support and patience with a watchful stranger. You have made possible a challenging and truly rewarding experience. I will keep you posted as to the results of all the measures and provide a profile for each student.

1) If you were to do this again, what would you recommend be done differently?

2) What can you tell me about this class or individuals that would help me better understand what comes up on video?

3) In this class who do you perceive to be:
   a) the top five students?

   b) the bottom five students?

APPENDIX D:
CLASSROOM VERBAL BEHAVIOUR INVENTORY: Summary for School 1.

Class date:
Summary of Discourse from Videotapes/notes Oct.9-Nov.6,1991.
Note: 2 five minute segments were analyzed per class. Due to timetabling, diversions, and holidays, there are summaries of 13 classes for school 1 and 10 classes for school 2.
5 minute Time Segments Analyzed: 1)
2)

Behaviour: # of Occurences (If by teacher, is entered as a T, boy as B; or girl as G).

1) Assumption of responsibility for mistake or failure.
   3G
2) Assumption of responsibility for success.
   1G
3) Praise given.
   2T to B; 1T to G
4) Criticism given.
   3T to class; 11T to G; 3T to B; 1B to G; 1B to B; 4G to G
5) Correcting other's answers or behaviour.
   2T to class; 12T to girl; 11T to B; 2B to B; 1B to G
6) Advice or direction given to others.
   4T to class; 3T to G; 2T to B; 2G to G
7) Questions asked of individuals rather than whole class.
   11T to B; 6T to G; 2B to T; 1G to T; 1G to B
8) Challenging questions asked.
   4T to class; 2T to B; 2B to T
9) Who is actually manipulating apparatus in labs.
   12G; 22B
10) Talking about science as important to good career or lifestyle.
   0
11) Participate or encourage peer group learning or joint problem solving.
   1T; 4G to G; 2G to B
12) Encouragement for out of class activities related to science.
   0
13) Stereotyping comments.
   3T
14) Relate science curriculum to everyday life/social issues.
   5T

CLASSROOM VERBAL BEHAVIOUR INVENTORY: Summary for School 2.

Class date: Summary of Discourse from Videotapes/notes
Oct.9-Nov.6,1991. Note: 2 five minute segments were analyzed per class. Due to timetabling, diversions, and holidays, there are summaries of 13 classes/labs for school 1 and 10 classes for school 2.
5 minute Time Segments Analyzed: 1)
2)

Behaviour: # of Occurences (If by teacher, is entered as a T, boy as B; or girl as G).

1) Assumption of responsibility for mistake or failure.
   2G; 1B; 2T

2) Assumption of responsibility for success.
   1B; 1T
3) Praise given.
   5T to class; 8T to B; 3T to G; class to G & B after demo's; 1G to G; 1G to T; 1 class to T.

4) Criticism given.
   2B to B; 3G to G.
5) Correcting other's answers or behaviour.
   2T to class; 9T to B; 2B to class; 1T to G; 2G to G; 1B to T

6) Advice or direction given to others.
   5T to class; 1T to G; 6T to B; 2G to G; 1G to T; 3B to B; 2B to T.

7) Questions asked of individuals rather than whole class.
   19T to B; 12T to G; 1B to T; 1G to T; 1B to B
8) Challenging questions asked.
   12T to class; 4B to T
9) Who is actually manipulating apparatus in labs.
   11G; 26B; 2T
10) Talking about science as important to good career or lifestyle.
   0
11) Participate or encourage peer group learning or joint problem solving.
   10T; 4G; 4B
12) Encouragement for out of class activities related to science.
   1T
13) Stereotyping comments.
   1B
14) Relate science curriculum to everyday life/social issues.
   7T; 2B