C.1

GENDER DIFFERENCES IN SCIENCE ACHIEVEMENT TESTS

by

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ABSTRACT

The primary intent of this study was to examine the possible role of early learning experiences in contributing to sex-related differences in selected science achievement items.

The science achievement items were drawn from the 1982 BC Science Assessment on the basis of a difference in P value (percent correct) of 10% or greater between males and females. The items were administered to a group of 238 high school students randomly selected from three schools in the Vancouver School District. The major data base for this study was obtained through interviewing 15 students with the basic question, "Can you tell me what you were thinking when you chose your answer for question 1.. 2.. ?" The interviews were audio-taped, transcribed, and condensed into five major categories which provided the main analytical framework for the study.

Among the significant findings of this study were:

1. Boys' explanations for their responses to the test items referred to considerably more informal learning experiences than girls.
2. Girls' explanations for their responses to the test items referred to considerably more formal learning experiences than boys.

3. Even though girls used more formal experiences than boys to justify their answers, their performance was still substantially lower than boys for the majority of test items.
4. Girls expressed some negative reactions to a number of test items, particularly items in the physical sciences.
5. A substantial number of girls expressed uncertainty in their responses for a number of items.None of this uncertainty appeared among the boys.

The findings of this study suggest that prior experiences appear to contribute to some of the sex-related differences observed in the science achievement items. It appears from this study that informal experiences reinforce and enhance school learning and could possibly result in superior performance levels.

TABLE OF CONTENTS

LIST OF TABLES

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CHAPTER I

INTRODUCTION TO THE STUDY

In Canada by the year 2000 it is estimated that two out of every three women over the age of 20 will be in the labour force. In a world where the impact of science and technology is becoming increasingly important, over 62% of Canadian women are employed in the clerical, sales, and service sector of the economy. (Philips and Philips,1983). A study completed by the Science Council of Canada revealed that more women than men lack not only the skills to do jobs in the technological areas, but also the qualifications required for admission to required training programs (Who Turns the Wheel?, 1982).Research indicates that fewer girls than boys enroll in science and math courses in senior high and that girls have consistently lower scores on standarized achievement examinations in the physical sciences (Comber and Keeves 1973; Erickson and Erickson 1984; NAEP 1978). As a consequence, few girls enroll in university science classes and even fewer women become scientific professionals.

Explanations which attempt to rationalize the discrepancy between males over females on achievement tests and enrollment patterns in the physical sciences have been based on hypothesized sociological and biological factors. While many authors argue that the biological basis is weak (Kimball, 1981; McGee, 1979;

Sherman, 1978) some social factors seem to be working to give boys an early learning advantage in science. Numerous studies have examined such sociological factors as culture, attitude of boys and girls to science, classroom instruction, peers, counsellors, and parental influence (Erickson and Erickson, 1984; Kelly, 1981; 1978; Sherman, 1978).

Several authors (Dwyer, 1979; Erickson and Erickson, 1984; Johnson and Murphy, 1984; Kelly, 1981; Wheeler and Harris, 1981) have examined the nature of the actual test items for possible explanations of the discrepancy between male and female achievement in selected content areas. Wheeler and Harris (1981) hypothesized that tests which emphasize items requiring spatial visualization as opposed to items stressing verbal and algebraic content might mitigate against good test performance in girls.

Erickson and Erickson (1984) examined test results from a BC Science Assessment and discovered that boys tended to outscore girls on items which tested the understanding of scientific knowledge and application of scientific knowledge in the physical science areas. However, in the broad goal area of process skills, which was defined by the assessment team as a measure of the ability to understand the logic of science and to reason in a scientific context, no differences were found at any grade level. In another study Dwyer (1979) suggested

that males achieve higher scores than females when the items are set in contexts that are primarily scientific, mechanical, business, practical affairs or mathematics. Females achieve higher scores than males when item context is drawn from the arts and humanities and is based on an understanding of human relationships.

Explanations accounting for these differences in achievement on multiple choice tests have alluded to the possible role of early experience in providing males with a learning advantage in the sciences. For example, Erickson and Erickson (1984) argue that socio-cultural factors are working to give males an early experiential advantage in many science areas. They determined from the 1978 BC Science Assessment data that there were relatively large sex differences in individual items which tested knowledge more typically encountered in a boy's sphere of experience.

The National Assessment study completed by NAEP (1978) revealed marked differences in extracurricular activities between boys and girls. Secondary science girls participated less often than boys in all the extracurricular science activities studied.

Kelly (1981) reported that males may have different types of early learning experiences which might help them in their science studies. She suggests that boys are taught to play with cars, trucks, and mechanical items while girls generally play with dolls, animals, and so forth. These sorts of activities for boys could

lead to a better understanding of science concepts later on. In spite of these conjectures, actual research studies examining the role played by experience has been scarce with little firm evidence documented in this area.

Clearly, the role of experience in explaining some of the above issues related to the women in science is an area that should be examined in closer detail. The primary intent of this study was to carry out such an examination.

PROBLEM STATEMENT

This thesis addressed the following general question:

> Can the sex-related differences, which have been observed in selected science achievement items, be attributed in part to differences in the everyday experiences of males and females?
>
> This broad question was broken down into more specific questions which are as follows:

1. Can the everyday experiences of boys and girls be identified and categorized by the explanations provided by students to explain their choices on a set of science achievement items?
2. Are there sex-related differences in terms of these explanatory categories?

3. Are there any relationships between sex-related differences in these categories and test item contexts?
4. Is there any evidence that the context of the item influences the students' affective response to that item?

LIMITATIONS OF THE STUDY

This study was designed largely as an exploratory study to examine the possible role of experience in contributing to sex-related differences in selected science test items.

The interview sample which consisted of 15 volunteers from a larger group of 238 students, cannot be considered to be a totally random sampling of the population. However, the performance of the students from Table 2 suggest that their performance is representative of the larger population. Validity can increase only if similiar research with larger more representative groups of students be conducted.

CHAPTER II

REVIEW OF THE LITERATURE

INTRODUCTION

The underachievement of girls in the physical sciences is now a well documented phenomna in the literature. Interest sparked in this area stems in part from the increasing awareness of technology and job changes and the results of two major surveys: the International Associations for the Evaluation of Educational Achievement (IEA) and the National Assessment of Educational Progress (NAEP). The IEA survey conducted in the early 70's in over 19 countries discovered that boys scored higher than girls in the physical sciences and this trend increased throughout the years of secondary schooling. A number of other assessment programs have confirmed these findings. (BC Science Assessment, 1978; 1982; NAEP, 1978).

Not only was it established that females had lower scores on a range of items from the physical sciences, but they had considerably lower enrolments in the physical sciences. Scott (1982) has gathered data on enrolment and achievement patterns among girls in high school in Canada.

Her study revealed that fewer girls than boys are studying senior math and physics. She found that the percentage of girls in each grade who were enrolled in

physics varied from a low of 8.6% in Newfoundland to a high of 25.2% in New Brunswick. In each province the number of boys enrolled in physics were two to three times greater than girls. This observation was in accordance with the patterns of science enrolment in the United Kingdom reported by Kelly. She summarizes the immensity of this problem:

> Half the population of the country-the female half is missing out on science education. Most girls are receiving only a rudimentary education in physical science (Kelly 1978, p 18).

This divergence between boys and girls achievement and enrolment patterns has prompted studies aimed at offering some remedies or at best some possible explanations for these differences. Although it has been generally accepted that these differences exist, the proposed underlying causes of this situation are varied. Some researches argue that society is at fault, while other argue that females are destined by their sex to be distinct from males. It is this complexity of underlying causes that offer no simple solutions to the problem. Research can suggest and offer strategies both in and out of the classroom.

This chapter briefly reviews some of the current factors which have been offered as potential explanations for the variation in science achievement between males and females. These factors can be discussed in terms of

three broad categories: biological, socio-cultural, and experiential.

BIOLOGICAL FACTORS

Until recently, the literature has placed a heavy emphasis on biological theories as possible explanations for the variation in science achievement between boys and girls. Additionally, explanations of metabolic and hormonal origin have been postulated to account for the differences in achievement between boys and girls. Of these explanations and theories, including the X-linked theory and the brain lateralization theory, the brain laterization theory emerges as the most empirically sound. The major focus of the research involving this theory has centered on variations in spatial abilities between the sexes. It has been shown through various studies that spatial visualization (ability to manipulate an object or pattern in the mind) is higher for males than females, (Gray, 1982; Maccoby and Jacklin, 1974; Skolnick et al, 1982). Why spatial ability is higher for males than females is accounted for by the brain lateralization theory. Briefly this theory refers to the notion that the left and right sides of the brain are specialized to some degree to perform different functions. The left side of the brain controls speech while spatial functions are controlled principally by the right side. Research studies have revealed that females rely more on the left hemisphere

than the right for spatial functions. Additionally, left hemisphere dominance for verbal functions is established earlier in females while right hemisphere dominance is established earlier for males. (Vandenberg and Kuse, 1979).

Sherman (1978) cautions that although there is a difference in the use of the right and left hemisphere for boys and girls it should not be considered as the major explanations for variations in spatial ability. She argues that although differences exist between the sexes on spatial tasks, the actual differences are quite small and are insufficient to account for the large differences observed in many achievement items. She suggests that the types of toys and games that boys play with might lead to the differential development of spatial skills.

Kimball (1982) had disputed the position that biological factors of any type contribute to sex differences on science achievement tests. She suggests that evidence for the X-linked theory and the brain lateralization theory are weak and highly inferential at best. She suggests that environment may affect the nature and size that genetic and biological factors have on an individual's ability. She argues that girls with tendencies towards excellent math skills and abilities may become weak in this area if opportunities aren't available. Conversely, if girls are weak in the basic math skills and abilities, this weakness could be

addressed by increasing the opporunities available. She summarizes her position by arguing:

> We must focus on the important question of why is is that the differences in participation of men and women in scientific fields is so large, when sex differences in intelluctual abilities are so small (Kimball 1982, p 59).

SOCIO-CULTURAL FACTORS

The more recent literature has focused on social-cultural factors as possible explanations of why males display superior achievement in items in the physical sciences. It has been hypothesized that the superior performance of males on physics items is based on social, cultural, attitudinal and experiential factors acting separately or in combination. Several authors suggest that pressure through cultural and educational influences work together to create different social situations for males and females and communicate what is considered role appropriate behaviour. As a case in point Johnson and Murphy emphasize:

> Society's role expectations for men and women result in the kinds of differences in the early socialization experiences of boys and girls... and are reinforced by appropriate role models in real life, in the media, and in textbooks, and by the subtle influence of the hidden curriculum throughout their schooling (Johnson and Murphy 1984, p 407).

There is a wide body of literature encompassing the negative influences of peers, traditional parents,

influential teachers and counsellors, single sex schools, biased texts and testing formats. The majority of authors agree that parents, counsellors, and teachers may have a negative effect on how a girl perceives the physical sciences and how these perceptions influence subsequent actions and decisions. Some counsellors and parents steer girls away from a subject because they feel it is too masculine or not necesary for a girls future role as a homemaker. A teacher's influences can affect how well students do in science. Fox et al (1979) suggest that teachers subconsciously interect more with males than females. Spear (1984) conducted a study to test three basic hypotheses: a) Whether science teachers award higher marks to boys than girls for identical written work b) Based on the written work do science teachers have higher expectations for boys than girls? and c) Are attributes relevant to the study of science more likely ascribed to boys than girls?

The experimental procedure required teachers in various schools to evaluate work based on the writeup of an experiment and an essay on science and scientists. Spear discovered that written work attributed to a girl was often given lower marks than boys and boys were give higher ratings in terms of the attitudes and interests expressed in the essay questions.

The recent literature involving single sex schools and girls success in the physical sciences suggest that girls achieve better in single sex schools

(Kahle 1983). Kelly (1981) suggested that girls are at a disadvantage in a mixed school because science is dominated by boys and science is labelled as a boy's subject whereas this doesn't occur in a girl's school. The literature suggests that the sex of a teacher has little influence on a girls desire to study the physical sciences. One study initiated by Vockell and Cobonc (1981) explored whether the presence or absence of female science teachers would influence enrollment and achievement in a coeducational public school and a girls school. They found no significant difference between the sex of the teacher and enrollment and achievement in the schools. Kelly (1981) states that although there is little real evidence to support this view, a exclusively male staff will do little to dispel the idea that science is a masculine subject no matter how sympathetic the teachers may be.

Fischer (1982) has argued that in all societies, there is a general concept of masculinity and feminity and particular characteristic traits that go with them. He goes on to suggest that in North America, science is viewed as masculine and stereotypes of male and female behaviour are reinforced in many ways by parental expectations and behaviours, peer pressure, TV, literature, teachers, and other social agents.

All of these factors mentioned in the above paragraphs influence in turn, the wide spectrum of

experiences that boys and girls encounter. From an early age boys and girls play with different types of toys and games. Mechanical and electrical toys would be more instrumental in developing physics related skills and spatial abilities than the kinds of toys that girls play with. Girls that like to play with boys games and toys are often considered 'tomboys' by their parents and peers and maybe discouraged from pursuing these activities. It is this type of pervasive attitude continuing throughout a girls schooling that creates negative feelings towards science or anything considered masculine.

Several authors have discussed the relevance of early experiences on attitudes and achievement of females in science (Erickson and Erickson, 1984; Johnson and Murphy, 1984; Kahle, Matyas, and Cho, 1985). As Johnson and Murphy stress:

> A great deal of discussion about the under-achievement of girls in physics has centered around the subject polarization issue in the secondary school, but it should be clear from the evidence in this paper and elsewhere that the root of the problem lies rather in differences in early socialization experiences (Johnson and Murphy 1984, p 407).

It is this role of experience which will be discussed in in greater detail below.

EXPERIENTAL FACTORS

Differences in science experiences has been documented as early as age three. In an early study

completed by Bridges (1927) on the interests of three year olds, it was demonstrated that boys preferred activities calling for invention, one allowing for freedom of expression (building bricks) while girls follow instructions and engage in routine activities such as pairing colours. Hutt (1972) discovered that there were variations in the behaviour of two to four year old boys and girls at play. Girls were more willing to follow instructions and were more hesitant than boys to try out a number of activities. Kelly (1978) suggests that from the time of birth boys and girls are treated differently and that adults are usually unaware of the means by which they are transmitting messages. These messages may be the tone of voice and particular body postures.

Both the national surveys and the BC survey indicate inequities in the types of science experiences that girls and boys had both in and out of the science classroom. When responding to items such as have you ever used a magnet? compass? etc. fewer girls than boys reported that they had. In an attitudinal survey completed by the BC Science Assessment fewer girls reported participating in laboratory experiments than boys. In a current study completed by Kahle et al (1985) it was revealed that fewer girls participated in science related activities outside of the classroom (such activities would include reading books, magazines, or

working with hobbies). Over twice as many boys mentioned that they were involved in some type of science related activity than girls. Additionally, a study by Lie and Bryhni (1983) indicated that not only do boys participate more in science activities than girls but this seems to affect science performance as well. Lie and Bryhni discovered a striking correspondence between experience and test scores in science with girls performing less well in areas where they had less experience.

Howe and Shayer (1981) completed an experient to find out whether a period of classroom instruction given to 10 and 11 year olds on a task of volume and density would improve test performance. It was discovered that performance improved for males and females but there was still the sex-related difference apparent between boys and girls. They concluded that when appropriate experiences are available, both boys and girls assimilate the new ideas starting from wherever their level is. They speculated that there might be sex differences in early experiences that influence cognitive development.

Graybill (1975) based his study on whether differences in social milieu, aspiration and reward for males and females in society should have an effect on the development of Piaget's stages from concrete to formal operations. He discovered that test scores varied for boys and girls and that different experiences during the concrete period may account for this widening gap.

He suggested that the types of experience that the boys obtain outside of school might be helpful in the transition from concrete to formal operations. These types of experiences might include the types of sport boys play and the hobbies and games they pursue. (baseball, hockey, train sets etc.).

Several authors have tested the possibility that females experiences may differ from males and in doing so will affect test results (Castore and Stafford, 1971; Graf and Riddell, 1972; Milton, 1959). Since achievement test results are one of the main indicators of success they are an important variable to consider.

Milton (1959) and Graf and Riddell (1972) found that when altering a problem to make it less appropriate to the masculine sex role, sex differences in problem solving were reduced. In Milton's study two parallel sets of problems were constructed; one in a male role and the other in a female role. They are as follows:

Snuffy, the tramp, rolls his own cigarettes from butts he collects in his travels. The tobacco from six butts produces one new cigarette. One day he collected a total of 72 butts. He smoked a cigarette every half hour, yet this supply lasted him seven hours. How did he manage this?

Sally, the cook, cuts cookies from batter she makes each morning. She rolls out six cups of batter to cut one dozen round cookies. One day she made a total of 72 cups

of batter. She sold a dozen cookies every half hour, yet this supply lasted her seven hours. How did she manage this?

These problems were given to a group of males and females to solve. From the results Milton concluded that men on the average solved more problems than the women regardless of the role appropriateness of the problem while women solved more problems when they were presented in a feminine role.

Hoffman and Maier (1966) completed a series of experiments to determine whether women were less able than men in problem solving. They selected eight problems in which they tested three main variables: sex of the experimenter, added motivation (extra work with similiar type problems) and masculine and feminine versions of the problems. They concluded from the results that each variable influences the results on some of the problems. In some instances the sex of the experimenter influenced the subjects to do better on some problems. The feminine vs masculine versions of the problems showed marked differences between males and females on some of the problems and not on others. Hoffman and Maier suggested that a complex interaction between the variables must be taking place and should be examined in greater detail.

Erickson and Erickson (1984) discovered when examining the results of the BC Science Assessment that

no difference at any grade level was found for the goal of understanding science processes. This goal included items which involved graphing, reading tables, interpreting data and observations. Additionally it was inferred that boys do better than girls on items dealing with events drawn from their sphere of experience. This was found in the physics area where sex related differences were the greatest. One of these items referred to the motion of rubber balls. They suggested that boys have much more extensive experience in the throwing of balls than girls and may use this experience to provide explanations for their answers.

If boys perform better than girls on items dealing with events drawn from their sphere of experience then it can be argued that this lack of experience should be taken into consideration when instructing boys and girls in the sciences, especially the physical sciences.

Erickson and Erickson (1984) stress that the early years of science instruction are particularly important as girls might lack the background knowledge to formulate more sophsicated concepts. Acknowledging this potential difference and providing adequate instruction to compensate for the lack of background knowledge is essential in the early years.

Exactly what types of experience girls and boys have or bring into their school based work has not been extensively researched in the literature. This study is

an attempt to explore whether differences in everyday experiences of males and females contribute to some of the differences that have been observed in performance on selected science test items.

CHAPTER III

METHODOLOGY

INTRODUCTION

The primary aim of this study was to examine the possible role played by the prior experiences which males and females bring to science achievement test situations. To investigate this basic problem a 23 item test was administered to a group of 238 grade twelve students. From this group 15 students volunteered to be interviewed for the purpose of explaining their responses to these test items. The 23 item test was extracted from the 1982 BC Science Assessment and the selection criteria was based upon those items displaying the greatest sex-related differences. The unstructured interview format was chosen as the investigator felt that it was the most appropriate tool for the major question being addressed in this study.

This chapter will identify and discuss the design of the research study, the sample, data collection (which includes test adminstration and interview procedures), and data analysis.

DESIGN OF THE STUDY

A. The Test

The multiple choice test items were taken from the 1982 Science Assessment. Twenty-three items were selected on

the basis of a difference in P-value of ten percent or greater between males and females. P value (main statistic used in interpreting the survey) refers to the percentage of students attempting the item who chose the correct response.

Each of the test items fell into one of three domains established by the 1982 Assessment: Science Processes; Knowledge, Recall and Understanding; and Higher Level Thinking. Science Processes consisted of processes such as observing, classifying, and intepreting information for the purpose of solving problems. Knowledge, Recall, and Understanding involved the ability to recall and understand various science facts, concepts, and principles, including safety procedures. Higher Level Thinking involved the ability to solve problems by transfering prior knowledge and/or learning behaviour.

In addition, each item was classified into one of four groups by the 1982 assessment team: physics, chemistry, biology, and earth/space science. The classification of these items is displayed in Table 1, while the actual items and student instructions are reproduced in Appendix A.

Out of these 23 items four items (20,21,22,and 23) were altered to see if changes in the context of an item would make any difference in the boys and girls test performance. Item 22 was altered to determine whether a

TABLE 1

CLASSIFICATION OF TEST ITEMS BY DOMAIN AND CONTENT AREA

Domain	Content Area			
	Biology	Chemistry	Physics	Earth/Space
1. Science Processes				
a) interpret data	20,21*		1,2	
b) identify and control variables		11		
II. Knowledge, Recall				
a) understanding	9	18	6	5,16
b) safety procedures		7,8,17,22	13	
III. Higher Level Thinking				
a) evaluate evidence for conclusions			15,23	12
b) solve abstract problems		10	14,19	3,4

* Item number. See Appendix A for a full description of the items.

subtle change from a laboratory setting to a kitchen setting would have any difference on test performance. Item 23 was altered to see if a small change in the diagram from laboratory bottles to saucepans would affect performance. Items 20 and 21, based upon interpretation of graphical data, were altered in an attempt to observe whether the use of variables familiar to all students would create any differences in test scores. It was not expected that this would differentially affect the girls' test performance.

These four items were selected for alterations because changes to each of these items were relatively simple and did not change the conceptual content of the items.

The alteration of the four items subsequently resulted in a two form test being printed. One form, printed on white paper, contained the original 23 items; the second form, printed on green paper, contained the revised items . The coloured paper was used by the investigator as a simple means to quickly identify the two forms. Approximately half of the students tested were given the alternate version of the test.

B. The Interviews

Each interview ranged from approximately 20-30 minutes in length. The structure and type of questions used in the interviews were developed during a series of pilot interviews. The format of the interviews were non-structured but centered on students responses to the

basic question "Could you tell me what you were thinking or explain why you chose your answer for question 1...2...?" Using this basic question as a guide for each item further elaboration of their responses were requested if necessary. See Appendix B for a complete transcript of one of these interviews.

This style of interview is fairly common in educational research and has been utilized and justified as a research tool for students by a number of researchers(Aguirre, 1978; Erickson, 1979; Kuhn, 1978; Posner and Gertzog,1982). This method was judged by the investigator to be necessary to obtain the type of data required to address the problem of interest in this study.

C. The Sample

The test was adminstered to a group of 238 students randomly selected from three schools in the Vancouver School District. The three schools were selected by officials in the Research Services Division of the VSB as being roughly representative of the Vancouver school population.

An empirical check on the representativeness of the sample was obtained by comparing the p-values obtained from this sample of students with the population of BC students obtained from the 1982 Science Assessment . As Table 2 indicates the match in performance between this

TABLE 2

MALE/FEMALE RESPONSES FOR SELECTED SCIENCE ACHIEVEMENT ITEMS FOR RESULTS FROM CURRENT STUDY AND 1982 B.C. SCIENCE ASSESSMENT

	1982 Results (N-22,110) Percent Correct		Current Results (N-238) Percent Correct	
Item No.	Male	Female	Male	Female
1	46	38	49	32
2	43	26	42	27
3	48	26	60	31
4	41	19	42	26
5	36	25	54	36
6	60	34	65	38
7	53	38	55	36
8	27	17	20	22
9	71	57	72	48
10	50	32	57	32
11	57	46	68	52
12	52	38	52	45
13	74	44	66	35
14	76	55	72	51
15	69	44	54	47
16	58	39	57	39
17	80	67	67	51
18	72	62	73	61
19	69	46	70	50
20	47	37	*38 41	*30 32
21	66	58	*57 58	*41 40
22	70	46	*48 60	*30 51
23	60	45	*49 63	*30 51

*Male/Female Responses for the altered items.

sample and the 1982 sample was very high.

The tests were administered by a classroom teacher to English 12 and Consumer Education 12 classes. Because these classes are compulsory, it was felt that this would result in a more representative sample of students.

From the 238 students, 15 students (8 males, 7 females) volunteered to take part in the interview study. When asked to volunteer, the investigator stressed to the student that the interview would not take longer than 30 minutes, that they could choose their own time to be interviewed, and most importantly that they were not being evaluated.

DATA COLLECTION

A. Test Adminstration

The adminstration of the test took approximately 25 minutes. The directions for administering the science test was explained to each of the classroom teachers. A deliberate point was made not to refer to these questions as a test to avoid initial negative reactions set up when the word test is mentioned. The only explanation offered by the investigator to inquisitive teachers was that the questions were designed to see how well students were doing in science. Since the classes being assessed were English and Consumer Education there should have been no pressure put on the teachers for the

students to perform well. The tests were collected by the teacher and the investigator scored all the tests.

B. Interview Procedure

Each of the 15 students that volunteered to be interviewed had their choice of the time of day and date to be interviewed (within investigators guidelines). All of the 15 students chose to be interviewed after school hours.

Each student was interviewed in the back of an empty classroom. In this setting it was felt that the students were relatively comfortable and away from other school distractions.

Because of time restrictions and teacher scheduling the time span between testing and interviewing was approximately one week. This wasn't perceived as a major obstacle as each student was given time to examine their unmarked test paper during the interview.

Before starting any of the interviews a few minutes of small talk was engaged in to reduce any anxiety or tension. In addition, it was explained to the students that the investigator wasn't interested in whether they got the answer right or wrong but in why they chose the answer they did. They were able to reread the questions and their own response to each question during the interview. Each interview was audio-taped so as to have an accurate record of the students' responses for subsequent analysis.

DATA ANALYSIS

The explanations given by the students to explain their answers comprise the main source of data for the study. The interview data was analyzed using the following steps:

1. Each one of the 15 tapes was listened to once to get a general overview of boys and girls explanations for the 23 items.

2. Each of the tapes was listened to a second time and a list alluding to a wide variety of both classroom and out-of-classroom experiences was prepared. These experiences were noted on index cards for further analysis.

3. From listening to the student's explanations on the tapes a number of common factors began to emerge. These common factors were described in terms of the following categories: formal experience, informal experience, common sense, knowledge, guessing, and a group of idiosyncratic responses which were simply categorized as miscellanous. For example, the miscellaneous category included responses where the students weren't sure how they got their answer or when they forgot how they arrived at their answer.

The descriptions of these explanatory categories are given below:

a) FORMAL EXPERIENCE- This category consisted of school based experience. This included textbooks, reading material, media resources, and school instruction.

b) INFORMAL EXPERIENCE - This category consisted of out of school experience. This included such events as hobbies, TV, reading (magazines, books, newspapers,) listening to the radio, playing games, and so forth.

c) COMMON SENSE - This category included practical knowledge that students had without naming any particular event.

d) GUESSING- This category included students responses where they simply stated that they dervived their answer by guessing.

e) MISCELLANEOUS - This category included all the responses where students couldn't remember how they obtained their answers, or they simply stated that it looked like the right answer or they found their answer by the process of elimination.

4. Using the categories illustrated above, each tape was listened to again, item by item. Each student's explanation for an item was categorized and written onto a file card. This procedure was followed for all 15 students. For each student there

was only one category assigned per item.

5. Using the information on the file cards a frequency response for boys and girls was tabulated for each category. This procedure yielded the primary data base for subsequent analysis and interpretation as described in the following chapter.

CHAPTER IV

RESULTS AND DISCUSSION

The basic research question being addressed in this study was to explore whether the prior experiences of secondary school boys and girls contribute in part, to some sex-related differences in selected science test items.

This question was examined through testing a random selection of students on specific test items taken from the BC Science Assessment and interviewing 15 of these students with the specific question "Can you explain why you chose the answer you did for question 1...2.. etc?" Each student's response to the 23 item test was audio-taped and their responses analyzed and categorized as discussed in Chapter III. These analytic procedures yielded a frequency table of responses for boys and girls for each item broken down by explanatory categories. Table 3 provides these response frequencies.

Using the data presented in Table 3, this chapter is organized around the discussion of the general questions presented in Chapter 1. Whenever possible, excerpts from student interviews have been quoted and used to exemplify some points raised by this study. In parentheses, besides each quote, the subjects sex and level of science education have been noted.

TABLE 3

NUMBER OF RESPONSES BY CATEGORY FOR MALES AND FEMALES
(N=8 males, 7 females)

Item No.	P. Values		Experience Formal		Experience Informal		Common Sense		Guessing		Miscel-laneous	
	M	F	M	F	M	F	M	F	M	F	M	F
1	49	32	4	4	2	2	1			1	1	
2	42	27	3	6	2	1	1		1		1	
3	60	31	3	2			2	2	2	2	1	1
4	42	26	1	1	5	2	2	3		1		
5	54	36	1	1	3	4	3	1			1	1
6	65	38	4	4	2	2			1	1	1	
7	55	36	4	6	1		1		2	1		
8	20	22	3	7			1		3		1	
9	72	48	4	5	1		3	2				
10	57	32	1	2	2	2	3				2	3
11	68	52	1	4			3	1	1		3	2
12	52	45			2		4	6		1	2	
13	66	35	3	6	3		1		1	1		
14	72	51	1	2	4	4	1	1	1		1	
15	54	47	3	4	4	3			1			
16	57	39					6	5	1	2	1	
17	67	51	1	4	3	3	3		1			
18	73	61	7	6			1	1				
19	60	50	6	6			2			1		
			O A	O A	O A	O A	O A		O A	O A	O A	O A*
20	41	32	3 3	3 4	1 0				0 1			
21	58	40	3 3	3 3	1 0				0 1	1 0		
22	60	51	2 0	3 0	0 2	0 3	2 0				0 2	1 1
23	63	51	0 3	0 1			0 1		2 0		2	3 3

*The O/A split refers to responses to the two forms of questions 20-23. There were 3 girls and 4 boys responding to the original items (0) and 4 girls and 4 boys responding to the altered items (A).

The First Research Question:

> Can the everyday experiences of boys and girls be identified and categorized by explanations provided by students to explain their choices on a set of science achievement items?

Five categories were established as a result of an analysis of the interview data. The interview data consisted of explanations given by the students to explain their choice of answers to the 23 science test items. From listening to these explanations on tape a number of common factors were established. These common factors which were subsequently referred to as explanatory categories were: formal experience, informal experience, common sense, guessing, and miscellaneous. Descriptions of these categories along with excerpts from a number of interviews are illustrated below.

Formal Experience

This category consisted of school based experiences. These included textbooks, reading material, media resources, and school instruction.

For example:

> Well, it's something I remember my teacher telling me to do (female, science 11).

> You always mix the water with the acid. (female, science 11).

> We learned that from a biology course that I had taken (male, science 12).

Informal Experience

This category consisted of out of school experience. This included reference to such events as hobbies, TV, reading (magazines, books, newspapers) listening to the radio, playing games and so forth. For example:

> I chose number two because in driver training school, that's how long it takes you to stop. (male, science 11).

> I guess I've always been interested in submarines and stuff and I used that to choose my answer (male, science 12).

Common Sense

This category included practical knowledge that the students had without naming any particular event. For example:

> Well, that's just basic knowledge. Something I learned a time ago. (female, science 12).

Guessing

This category included student responses where they simply stated that they derived their answers by

guessing. For example:

> Oh, I had no idea for this question so I guessed. (female, science 11).

> Oh boy, I don't know what would happen. I have too much pride to put I don't know so I guessed. (female, science 12).

Miscellaneous

This category included all the responses where students couldn't remember how they obtained their answers or they simply stated that it looked like the right answer, or they found their answer by the process of elimination. For example:

> At the time I knew the answer, but it seems too long and complicated to remember what I was thinking (male, science 11).

> Well, I sort of eliminated the ones I knew were wrong (female, science 11).

These explanatory categories provided a means of condensing the large amount of data presented by the student interviews. From a thorough review of the interview tapes the investigator discovered it was fairly easy to categorize each of the student's responses according to one of the five categories. This categorization scheme allowed for comparisons to be made between boys and girls responses to various science test

items and permitted some insights into the differential response patterns between the sexes. Once this categorization was complete a total number of responses by sex was established for each category (Table 3). This comprehensive table comprising all of the students responses to each item, provided the source of data upon which the remainder of the research questions could be addressed.

The Second Research Question:

> Are there sex-related differences in terms of these explanatory categories?

From the results displayed in Table 3 the explanatory categories that accounted for the greatest number of boys and girls responses to the 23 items were the categories of formal experience, informal experience, and common sense, respectively. For the categories of guessing and miscellaneous, the number of boys and girls responses were measurably smaller. All of these categories will be examined in greater detail below.

A) FORMAL EXPERIENCE

This category accounted for the largest variation in the percentage of responses for boys and girls (Table 4). In the types of responses cited both boys and girls mentioned teachers, something that they had remembered

TABLE 4

PERCENTAGE OF BOYS AND GIRLS RESPONSES BY CATEGORY

	Formal	Informal	Common Sense	Guessing	Miscellaneous
Boys	36*	21	22	10	12
Girls	54	16	14	7	9

* Rounded to the nearest hundreds

doing in class, and textbook learning as their main reasons for their choice of answers.

> I remember learning about circuit breakers in physics 11 (female, science 11).
>
> I've heard the term before. I think I heard it in my science class (female, science 12).
>
> I learned about this from Chemistry 11 (male, science 12).
>
> I don't have much background on earth rotation. In geography in grade 10 we studied mainly seismographs (female,science 11).

In this category there were substantial differences in the responses between the sexes for a number of selected science test items (2,8,11,13, and 17).

Item 2 was a physics question which involved the interpretation of information displayed on a bar graph. The setting of the question centered around the time and distance needed for a car to stop. For this item the majority of girls used formal experiences to explain their choice of answers. Virtually all of the girls mentioned that they utilized the graph to find their answers.

> I chose that answer because the reaction time in the graph under one second (female, science 11).
>
> I chose the middle graph because it appeared to be the average time (female, science 11).

It is interesting to observe that although a substantial number of girls attempted to interpret the graph, the P values of the girls is lower than the boys. A study by Johnson and Murphy (1984) of data collected from science surveys conducted in England, Wales, and Northern Ireland, showed significant performance differences in favour of boys for using graphs, tables, and charts. Johnson and Murphy suggest that work with graphs is more common in the physical sciences and since many more girls than boys discontinue physics after age 13, boys will have benefited from a continued familiarity with graphical representation.

Responses from boys for this item reflected not only formal experience, but informal experience and common sense as well.

> I took a drivers test which gave me practically the same question as this (male, science 12).

> I based my answer on how long it takes me to stop in a car (male, science 11).

Item 8 was a chemistry item which involved the dilution of an acidwith water. Seven out of 7 girls cited formal experience as explanations compared to 3 out of 8 boys.

> I asked my teacher and he said that whenever you dilute something you add water (female, science 11).

> I took chemistry last year and we sort of put one solution into another (female, science 12).

It is interesting to notice that while all of the girls referred to formal experience to justify their answers, the type of knowledge being tested by the question pertained to performing laboratory work. Kahle (1983) states that girls have fewer opportunities to participate in common laboratory experiences than boys and therefore lack the skills and knowledge needed in this area.

Item 11 was a chemistry item involving the concepts of shape, weight, and density using an egg as the example. Four out of 7 girls used formal experience to answer this item compared to 1 out of 8 boys.

> We learned a little about that in science 10 although I never did anything with it (female, science 11).

> I remember the terms in my chemistry 11 class (female, science 11).

Responses from the boys seemed to focus around the common sense and miscellaneous categories.

> The other responses didn't sound right so I put down volume as my answer (male, science 11).

> I assumed that most eggs have equal density just by looking them (male, science 11).

Item 13 was a physics item involving the purpose of a fuse or circuit breaker. For this item 6 out of 7 girls used formal experience to explain their answers compared to 3 out of 8 boys. The P values from Table 3 illustrate that only 35% of girls compared to 66% of boys selected the correct answer. Discrepancies in the performance of girls and boys on questions involving electricity seems to be a fairly established phenomna (Johnson and Murphy, 1984). Additionally, Lie and Bryhni (1983) have reported that students who are interested in electricity and have some related experience in this domain score higher than students who do not have the same interests or experiences. As the following excerpt reveals, the female subject had very little interest in the electrical area.

Interviewer: Why did you chose that particular answer?

Subject: I know what a circuit breaker is. It makes things go in two directions. We did it in grade 10. I wasn't into it. I didn't put it in my long term memory. It was a little tedious and hard for me to understand. It wasn't something that I would use all the time. I wouldn't put wires up in my house. I think in other areas that aren't as technical as that.

Interviewer: Such as...

Subject: Well, I like making things and drawing pictures.

Boys responses generally tended to focus on experiences that they had been involved with at one time or another.

> I built a basement suite downstairs and I took stagecraft as well (male, science 11).

> That I know from stuff around the house. Fuses blow in our house all the time. I usually go downstairs and switch the breakers (male, science 12).

Item 17 was a chemistry item involving keeping substances (including HCl and sulfuric acid, sodium hydroxide and potassium hydroxide, tin and lead, and alcohol and ether) away from open sparks and flames. Responses for this item indicated that 4 out of 7 girls used formal experience compared to 1 out of 8 boys. Boys tended to prefer to use informal experience and common sense to explain their answers.

> I chose this one because when we worked with bunsen burners and chemical substances the teacher would say be careful when you light it (female, science 11).

> Oh, I know this one from chemistry. The OH group would be snatched up (female, science 12).

> I know that alcohol is flammable. I burnt it. Ether is a gas and to my knowledge gases are explosive (male, science 11).

Findings in this explanatory category strongly suggest that girls tend to use more formal experiences

than boys and this is especially evident for items which could be considered to be within the realm of a boys sphere of experience. All of the items discussed above could be regarded as items in which boys are more familiar with than girls (electricity, cars, chemistry labs). Studies completed by Lie and Bryhni (1983) and Kahle et al (1985) illustrated that boys and girls activities are quite different and that boys tended to dominate in tinkering activities such as taking items apart, while girls were relatively weak in these areas (Table 5). Moreover, Lie and Bryhni postulated that achievement is related to experience and girls underachieve in fields where they have less experience. Perhaps because of a more limited experience base in the physical sciences, girls draw upon formal knowledge that they have learned at one time or another.

This is not to say as reflected in Table 3 findings, that boys don't use formal experiences, but girls use it to a much greater extent to justify their answers.An intrepretation of the International Science Assessment data by Kelly (1981) indicated that instruction in physics was considered by girls to be more important than it was for boys. It was suggested by Kelly (1981) that boys acquire knowledge of physics in informal situations whereby girls are more dependent upon instruction in school, even though as can be seen from the data in this study, the girls have not thoroughly understood the

TABLE 5

PERCENTAGES OF 1983 SAMPLE RESPONDING POSITIVELY TO ITEMS CONCERNING SCIENCE ACTIVITIES, BY GENDER

Item	Percentage Responding Positively			
	Total	(Std. Error)	Male	Female
	%	%	%	%
Have you ever worked or experimented with/used/see/visited:				
electricity?	74.1	(3.0)	84.2	69.5
erosion?	39.2	(3.1)	41.1	36.9
telescope?	78.4	(2.6)	83.2	73.1
electricity meter?	40.5	(3.1)	54.2	32.8
animal skeleton?	86.8	(2.1)	93.0	82.3
solar heat collector?	44.9	(3.2)	53.2	37.0
North Star?	68.9	(2.9)	98.1	59.5
moon through a telescope?	51.6	(3.2)	60.4	47.3
skyscraper?	66.9	(3.0)	82.3	57.2
electricity plant?	34.3	(3.0)	44.8	25.4
rock quarry/mine?	59.5	(3.1)	65.6	57.2
Have you ever:				
wired together an electric circuit?	64.5	(3.8)	77.1	55.4
touched a snake/lizard	82.0	(2.4)	94.8	70.0
taken something apart to see how it works?	72.9	(2.8)	90.0	59.2
made a magnet with electricity and wire?	40.9	(3.1)	52.1	32.8
fixed something electrical?	46.6	(3.2)	68.4	27.5
fixed something mechanical?	54.2	(3.1)	77.1	37.4
taken care of an unhealthy animal?	46.8	(3.1)	38.5	49.6

Source: Kahle, Matyas, and Cho (1985) p. 391

concepts and ideas that were discussed in the science classroom.

B) Informal Experience

In this explanatory category a greater percentage of boys explained their answers using informal experience than did girls (Table 4). There were only 7 items where informal experience was not used by any of the boys to justify their answers. In contrast, there were 13 items where girls didn't use any informal experiences to explain their choice of answers. Some of the explanations cited by the boys ranged from something they had done at home to reading books or magazines or simply pursuing a hobby or interest.

> Everytime a fuse blows, I usually go downstairs to check the circuit breaker (male, science 11).

> I learned about this when I was in stagecraft where I was responsible for the lighting (male, science 11).

> I remember something about this because I had a job as a surveyor (male, science 11).

> I'm interested in nuclear power. I read books and stuff on it (male, science 12).

Some of the explanations cited by the girls were hobbies they pursued or something they had read in the newspaper or watched on TV.

> Well, I know from diving that the deeper you go the greater the pressure (female, science 11).

> What I thought about steam is that it moves about a room. When you put a kettle on a stove and close the kitchen door the windows fog up (female, science 11).

> I saw something like this on a show Quincy- where they were all burned up from radiation (female, science 11).

Findings from this category suggest that boys and girls use different types of experiences in answering questions tested. Depending upon the nature of the test item these informal experiences for boys include hobbies such as computers and model making, reading scientific magazines or listening to science programs. It could be postulated that items where boys used more informal experiences to answer the questions than girls were items that were within a boy's sphere of experience. These items, which included a chemistry lab and a electricity item, are considered items that many more boys are familiar with than girls (Kahle et al, 1985). Moreover, Erickson and Erickson (1984) suggest that boys do better than girls on items which deal with objects and events drawn from their sphere of experience. They mention that items involving electricity or physics are more likely to be encountered in a boys everyday life than girls.

For the girls, informal experiences included something they had observed on TV or read in a magazine, listening to friends, and hobbies such as swimming. It seems that for some items where girls cited informal experiences for their answers are items familiar enough to girls that they can recall informal experiences. Item 5, which involved diving into the ocean near the equator and explaining why the water got colder the deeper you went, was an item where several girls used their swimming and diving experiences to formulate their answers.

> Well, I know from diving that the deeper you go the colder the water gets (female, science 11).
>
> I know from taking swimming lessons that this is true (female, science 11).

C) Common Sense

In this category boys responded to 19 items using common sense compared to 9 items for the girls. Common sense responses included experiences that the students seemed to draw upon without naming any particular event. Boys responses for many of the items involved something that they had learned at some time or another.

> Well, that just basic knowledge. Something I learned a long time ago (male, science 11).
>
> This sort of made sense to me. It was logical (male, science 11).

Because common sense knowledge incorporates all the experiences that an individual has and is dependent on the social environment then boys should have an advantage over girls in the science area. The whole range of sociological and cultural factors as discussed in Chapter II no doubt influences how boys and girls perceive and react to their environment. Because boys are conditioned by society to play with toys and games which may enhance spatial abilities and encourage scientific endeavors, they have greater opportunities than girls to accumulate experience that is necessary for the understanding of relevant science concepts.

D) Guessing

The category of guessing comprised only a small percentage of the total responses for boys and girls (Table 4). The interesting fact to observe is that even though a limited sample was studied, the results illustrate that the difference in guessing between boys and girls is not that large. It doesn't appear as if boys are more willing than girls to guess for any particular item.

In summary, from an examination of the above categories it appears that sex-related differences in responses do exist particularly in the categories of formal experience, informal experience, and common sense.

It is suggested that the experience that boys bring to a science question may well influence how well they will do on a item. Girls with their more limited experiental base rely more on formal learning. The higher percentage of responses for boys for the common sense category reflect the influences of early societal and cultural factors.

Finally, the explanatory category of guessing showed little substantial differences between boys and girls.

The Third Research Question:

> Is there any relationship between sex-related differences in these categories and test item context?

From the responses illustrated in Table 3 and Table 4 it appears that some of the items elicited quite different responses from boys and girls. Items 2,8,11,13,and 17 as discussed under formal experience, elicited a greater number of formal responses from girls than boys. These items which involved electricity, physics and chemistry lab work, could be considered items in which boys are more familiar with and relate to by using more informal experiences. Responses from the boys show that they utilize informal experiences to derive their answers.

> Well, I know from driving that is how long it takes me to stop (male, science 12).

> I'm interested in electronics so I know about circuit breakers (male, science 11).

To probe further into the question of whether test item context would result in different responses for boys and girls , an attempt was made to alter several of the test items. Approximately half of the interviewed students were given the altered version and the other half received the original version of the test.

Item 22 was a chemistry item whose original setting was a laboratory where a tightly stoppered test tube was left to boil under the flame of a bunsen burner. In the altered version the setting was changed to a kitchen where a tightly sealed casserole dish was left to boil under the direct flame of a gas stove. For the original version 3 out of 4 girls used formal experience compared to 2 out of 4 boys.

> Well, I remember my science teacher telling me that you should never leave a stoppered test tube boiling (female, science 11).

> I think I remember doing something like this in a lab but my partner was doing most of the work (female, science 11).

However, in the altered version of the test all three girls explained their answers in terms of informal experience compared to 2 out of 4 boys. The majority of

girls responses centered around cooking or something they had done in the kitchen.

> I would turn it down to low heat. If steam built up it would blow the lid off if it was sealed tightly (female, science 11).

> Whenever I have anything boiling on the stove I turn it down to low heat and take the lid off (female, science 11).

> I know that a casserole dish is pretty deadly because it can explode on you if you don't turn down the heat (female, science 11).

It appears from the above findings that the setting of a question does influence how a boy or girl answers a question. A more familiar setting to a girl such as a kitchen, seems to result in a higher percentage of informal responses although it did not significantly improve the girls performance on the item. This failure should be examined in the light of the changed item where the more standard practice is when a saucepan of water is boiling (even with the lid on) to turn down the heat to low. The correct response for the original item however, was to turn off the heat completely.

Items 20 and 21 were altered to see if a change in the distractors would result in different explanations for both boysand girls. The original distractors which contained such unfamiliar terms as ball mill abrasion, were changed to more common terms such as moisture and temperature. When examining the responses given by boys

and girls, both sexes relied on formal experience.

> For this question I looked at the graph and figured out the correct answer (male, science 11).
>
> By looking at the graph I figured that the time would be six hours (female, science 11).

These explanations provided by the students are similiar regardless of whether or not the items distractors had been altered. From the interview data it appears that the students are reading from the graphs and were not mislead by either set of distractors. As the following excerpt between interviewer and subject reveal, the actual distractor had little to do with obtaining an answer.

> Subject: Because of this (pointing to a line on the graph) I chose my answer which is ball mill abrasion.
>
> Interviewer: Do you know what ball mill abrasion is?
>
> Subject: No idea!

Item 23 , a chemistry question was diagramically altered to show saucepans instead of laboratory flasks. Regardless of the alterations , this item was considered confusing by a large number of students and this confusion is reflected in the responses cited.

> Well, for this one I was confused about the diagram. I didn't know what they meant (female, science 11).

> I don't really remember what I was thinking when I answered this question. It would take too much effort to go over it (male, science 12).

A calculation of P values for the altered items showed that there was little variation between the original items and the revised ones (Table 2). More of the boys answered more of the items correctly regardless of whether or not they had been altered.

In summary it appears that items whose context is primarily concerned with electricity, chemistry labs or physics seem to evoke different responses from boys and girls. Boys use more informal responses while girls rely strictly on formal responses. When an attempt was made to alter the context of an item into one in which girls might be more familiar (kitchen setting) more of the girls used informal experiences to justify their answers.

The Fourth Research Question:

> Is there any evidence that the context of an item influences the students affective responses to that item?

There were a number of items that elicited immediate negative responses from the girls when they

were asked to explain the reasoning for their choice of answers. For the majority of boys this wasn't the case. In fact, only one boy mentioned that he disliked an item. This negativity in responses by girls was especially apparent for items 7 and 13.

Item 7 was a physics item which involved the operation of a bunsen burner. Many of the girls expressed concern over the operation of a bunsen burner.

> I never want to light another bunsen burner again. They scare me (female, science 11).

> Well, I got my partner to do it. I went and did the other stuff. Maybe I was afraid of bunsen burners (female, science 11).

> Bunsen burners scare me. I never did learn how to use them (female, science 12).

Item 13 was a physics item which involved the purpose of a fuse or circuit breaker.

> Oh no, not another physics item! (female, science 11).

> I remember doing a thing on this but most of this comes from talking to the guys. I'm not into technical stuff (female, science 11).

There was one boy who expressed strong negative reactions to any earth/space science question.

> I haven't taken earth science. I hate anything to do with earth science, the stars etc. I find it

> extremely boring. I found this item very boring. It took too much effort to eliminate the distractors so I guessed (male, science 12)

The general negativity on the part of the girls precipitated by bad experience and lack of confidence might mitigate against good test performance for girls. Erickson and Erickson (1984) suggest that in any teaching situation which involves input (teaching materials), the current state of the system (mind) and the output (students behaviour) it is often the current state of the system which is ignored or minimized in instructional planning. They argue that this system is influenced by prerequisite knowledge and skills which might include prior experience and of course the motivational state of the student at that point in time.

Aside from the immediate negativity that the girls displayed for a number of items, there was an underlying unsureness in many of the girls explanations for their answers. This appeared to be fairly pervasive throughout the 23 items. Some of the following exerpt taken from several of the interviews stress this point.

> Oh, I don't know why I put that one. I guess the answer is density, isn't it? (female, science 11).

> I wasn't sure about this one. I believe that density had to do with water. We did an experiment on it once. Mercury has a high density and water has a so so density (female, science 11).

> Oh, this I think I remembered doing in the physics

> lab. I sort of looked at the diagrams (female, science 11).

This uncertainty was definitely not present when the boys explained their choice of answers. Boys appeared to be much more self assured and this was reflected in their responses for a number of test items.

In summary there were certain items which evoked negative reactions from the girls. Additionally, throughout the 23 items there was a general lack of self confidence displayed on the part of the girls. Many of the girls expressed uncertaintly or hesitation when responding to items especially in the physics and space science area. It could be plausible that girls have been conditioned by a broad series of sociological factors ranging from society to peers to feel that science is a masculine subject and therefore they shouldn't be expected to do as well as boys.

CHAPTER V

CONCLUSIONS AND IMPLICATIONS

The purpose of this final chapter is to present a discussion of the major findings followed by conclusions of the study. Educational implications and recommendations for future research will conclude this chapter.

Discussion of the Major Findings

This section examines the major findings as reported in Chapter lV. These findings are organized around the general questions presented in Chapter 1 and they are discussed under the headings corresponding to each of the major research questions.

The First Research Question:

> Can the everyday experiences of boys and girls be identified and categorized by the explanations provided by students to explain their responses to a set of written science achievement items?

The original intent of this thesis was to examine whether sex-related differences in science achievement items could be attributed in part, to the early learning experiences of boys and girls. These early learning experiences were explored through interviewing 15 students on 23 selected test items and asking them what

they were thinking when they chose an answer to a particular test item. The explanations given by the students to explain their choice of answers ranged from hobbies and activities that they pursued, something they had learned in class, to not remembering why they chose a particular answer. All of the explanations were grouped into one of the five categories which were developed from the students explanations for their choice of answers. These five categories included: formal experience, informal experience, common sense, guessing, and miscellaneous. These categories provided a systematic means of categorizing the data and were used to address the remaining major research questions of this study.

The Second Research Question:

> Are there sex-related differences in terms of these explanatory categories?

There were a number of major findings resulting from this research question. They are as follows:

a. A greater number of girls explained their answers to test items using formal experience than did boys.

b. Although a greater number of girls used formal experiences as explanations for their answers, the P values of girls over the 23 items was consistently lower than boys, especially for items dealing with electricity and chemistry.

c. A greater number of boys explained their answers to the test items using informal experiences than did girls.

d. A greater number of boys explained their answers to the test items using common sense than did girls.

e. There weren't any measurable differences in the responses between boys and girls for the categories of guessing and miscellaneous.

These findings suggest that the different experiences that boys and girls have are reflected in their responses to the test items. Boys seemed much more willing to draw upon informal experiences than girls, who preferred to use formal experience to justify their answers-- whether or not the knowledge being assessed by the test item was more directly applicable to informal experiences. Moreover, even when girls used formal experiences to justify their answers, their performance was still substantially lower than the boys for the majority of test items. It has been suggested by Johnson and Murphy (1984) that boys reinforce their practical experience with theoretical study much more effectively than do girls. It appears that boys as young as seven have been found to be more interested than girls in reading information books and magazines. From the explanations given by the 15 students to account for their choice of answers, it appears that more boys than girls

related answers to something they had read about or been involved with at one time or another.

It is plausible that the informal experiences that many boys bring to the achievement item questions might provide them with a distinct advantage over girls when it comes to selecting a correct response, especially in the areas involving physics, electricity, and laboratory work. Numerous authors (Erickson and Erickson, 1984; Johnson and Murphy, 1984; Kahle, 1983; Kelly, 1981; and Lie and Bryhni, 1983) suggest that boys show greater enthusiasm for informal activities dealing with how things work than girls and this sort of 'tinkering experience' strengthens their science background. Furthermore Lie and Bryhni (1983) postulated that the type of activities and interests that boys and girls have are related to achievement and girls underachieve in fields where they have less experience.

The findings presented by the common sense category seem to support Johnson and Murphy (1984) arguments that society's role expectations for men and women result from early socialization experiences which are different for boys and girls. These early sociological factors, as discussed in Chapter II may lead to differences in experiences which favour boys and could be reflected in the responses given to the test items. Findings in the category of guessing suggest that there really isn't much difference between boys and girls responses over the 23 items.

The Third Research Question:

Is there any relationship between sex-related differences in these categories and test item content?

The major findings emerging from this research question are as follows:

a. The items which displayed the largest differences in responses between boys and girls appeared to be items which required a knowledge of physics and chemistry laboratory work. In all these items the boys had substantially higher P values than the girls. Moreover, girls relied much more on formal experiences than boys to justify their answers to these items.

b. The altered items exhibited little variation from the original items in terms of student responses. In the item where a kitchen setting was used, girls responded using more informal experiences to justify their answers.

These findings support claims made by such authors as Erickson and Erickson (1984) who suggest that boys do better in events and activities that are drawn from their sphere of experience. It is conceivable that when boys are responding to items dealing with physics and chemistry they incorporate not only formal based

learning but informal experiences they have had at one time or another. It is safe to assume from the responses cited by the girls, that they lack these informal experiences and rely instead on formal classroom based knowledge. In spite of relying more heavily than boys on classroom based learning , boys performance is still superior to girls which suggests that prior experiences coupled with formal learning provides boys with an edge in test performance.

The Fourth Research Question:

Is there any evidence that the context of an item influences the students affective responses to that item?

The major findings in this area were as follows:

a. There were a number of test items in which girls exhibited immediate negative reactions. Those items in which this response was most pronounced dealt with electrcity and the operation of a bunsen burner.

b. There was only one boy who expressed a generalized negative response towards a test item. This item dealt with space science.

c. Many girls expresssed uncertainty in their responses. This general lack of confidence was not

limited to one time but appeared to be fairly pervasive throughout the 23 items.

These findings suggest that girls tend to respond negatively to subject areas where they either lack the interest or the experience in comparison to boys. This is supported by the findings reported by Kahle, Matyas, and Chos (1985) which revealed that boys have more positive science attitudes than girls for science activities involving the more technical aspects of science. In addition, boys participated in a greater number of extracurricular science activities than girls. Furthermore, Lie and Bryhni (1983) and Kelly (1981) emphasize that girls are more interested in the humanistic aspect of science, the human body, the home, and society whereas boys are particularly interested in the technical aspects of science.

The tone of uncertainty which is fairly consistent throughout the 23 items illustrates that girls aren't as comfortable with science as boys and perhaps view it as a male domain. Typical responses were often permeated with words such as:

" I think", " I'm not really sure but "....

According to a study completed by Kelly, White, and Smail (1983) boys have certain stereotypic views of girls in science. Boys tended to view girls that did science activities as weird and peculiar, and at an age

where girls have a growing interest in boys they don't want to appear different or strange. It is possible that the girls general tone of uncertainty over the 23 items is a result of not wanting to appear too knowledgeable in science or perhaps feeling, through the transmittance of boys attitudes, that science is a male domain.

CONCLUSION

The overarching intent of this thesis was to address the following general question: Can the sex-related differences, which have been observed in selected science achievement items, be attributed in part to differences in the everyday experiences of males and females? Based on the results of this study the conclusions are as follows:

a. Prior experiences from non-school activities (as exemplified by the categories of informal learning and common sense) appear to contribute to some of the sex-related differences observed in the 23 test items. Boys used these non-school based learning experiences to explain their answers to a much larger extent than girls, who based the majority of their answers on formal based learning. Boys overall performance over the 23 items was consistently higher than girls which might indicate that this superior performance is linked to the ability to draw upon a wide range of informal

experiences.

b. Formal school based experiences (as exemplified by the category of formal experience) didn't appear to be particularly helpful in contributing to the overall performance of girls over the 23 items. Although a substantial number of girls used formal school based experiences to respond to test items, their performance was still lower than boys. Moreover, the type of formal responses cited were vague and simply eluded to some course or something the teacher had discussed in class. This suggests that informal experiences, as exemplified by the boys responses, may be strong contributors to boys superior performance on the 23 test items. Perhaps informal experiences lead to the development of skills and knowledge relevant to science and in turn, reinforce and strengthen the formal learning situation.

c. Prior experiences from non-school activities might contribute to a feeling of confidence and positiveness when responding to a number of test items. Throughout the 23 test items there was a general tone of uncertainty among the girls when responding to items which was not present among the boys. Boys seemed more confident and positive when explaining how they derived an answer. Perhaps because girls lack the informal

experiences which appear to be important for the development of basic science skills, they feel inadequate or unsure of themselves, which in turn, is reflected in the types of responses given in the test items.

IMPLICATIONS

Based on the types of responses given by the girls in this study it appears that many of them do not have the same extent or range of experience with every-day phenomna which illustrate some of the basic concepts in the physical science. Additionally many of the girls are lacking in confidence when they explain their answers to the 23 items. Coupled with this lack of confidence some of the girls displayed an immediate negative reaction to such items as the function a a circuit breaker and the operation of a bunsen burner. To increase girls confidence and understanding of these areas mentioned above the following strategies are recommended.

1. When teaching a unit in the physical sciences, teachers should assume that girls will not have the same background knowledge as boys and may have negative reactions towards these subjects. Teachers should plan introductory activities which emphasizes the humanistic aspects of science and use examples which could be drawn from a females sphere of experience. For example, one way to interest both

girls and boys in the principles of levers in physics would be to approach it using the human body, thus emphasizing the relevance to ourselves.

2. From the findings of this study it appears that girls play a passive role in physics and chemistry laboratory work. Instructors in a laboratory setting should attempt to involve all students in "hands on" work. If necessary, this might involve pairing girls with girls so they won't feel as intimidated as in a mixed group situation.

3. Girls should be encouraged to participate in science related activities. This might include activities emphasizing the humanistic aspects of science such as field trips to various institutions including hospitals, and research stations. Additionally, teachers should attempt to examine such traditional physical science topics as electricity, mechanics, and chemistry and discuss their applications to societal issues. A study in electricity, mechanics, and chemistry might examine how a kidney dialysis machine works thus stressing the social aspects of technology. An effort has been made by the new junior secondary science curriculum in B.C. to at least incorporate some societal issues. The unit on nuclear power studies not only includes the physics of nuclear energy but also the societal implications involved in using

nuclear energy.

4. Starting at the elementary level, girls should be encouraged to pursue science activities for fun. This would involve encouraging girls to experiment and explore various materials which could help girls gain some intuitive understanding of the basic concepts of science. For example, playing with various building materials or putting together a model might lead to the development of spatial skills .

RECOMMENDATIONS FOR FUTURE RESEARCH

On the basis of the research conducted in this study it is apparent that additional research into boys and girls everyday and school experiences are warranted. The following are recommendations for further research:

a. Develop science curriculum materials that emphasis the humanistic context of science. These materials should be developed especially in the physical science areas where girls may see this area as being too technical. Any material that attempts to explore the interactions between technology and societal issues would be extremely beneficial.

b. A refinement of the major analytical categories used in this study. This would involve trying to distinguish situations where the reference to earlier experiences was indeed warranted and useful

to the student and those situations where they were simply 'inventing' or just making a passing reference to some vague experience from the past (eg; "Oh, I think I remember doing something like that in Grade 10). While these 'weak' associations do reveal something of how students try to make sense of problem situations, however, they clearly are not of much assistance to them in sorting out an appropriate response as we see from the girls poorer performance on many of the items. If one were to make this distinction, then it might be possible to do a more detailed analysis of the way in which experience can be translated into a better understanding of science concepts.

c. Develop more indepth studies to understand how some of the experiences cited by students relate to school science. How does the ability to change a tire or read a compass relate to a student's ability in science? This could be conducted through case studies involving one or two students where indepth interviews are initiated.

APPENDIX A

SCIENCE QUESTIONS AND BACKGROUND INFORMATION

1. What is your date of birth?

   Year: 1962 or earlier ____
   1963 ____
   1964 ____
   1965 ____
   1966 ____
   1967 or later ____

2. Sex: Male ____
   Female ____

3. What language did you use when you first learned to speak?

   English ____
   Another language ____

4. What language do you now speak most often at home?

   English ____
   Another language ____

5. Check ALL of the following which you have successfully completed.

   Science 8 ____
   Science 9 ____
   Science 10 ____
   Biology 11 ____
   Biology 12 ____
   Chemistry 11 ____
   Chemistry 12 ____
   Physics 11 ____
   Physics 12 ____
   Earth Science 11 ____
   Geology 12 ____
   Other science ____

6. Check ALL science courses you are taking now.

   Not taking any now ____
   Science 8 ____
   Science 9 ____
   Science 10 ____

Biology 11 ____
Biology 12 ____
Chemistry 11 ____
Chemistry 12 ____
Physics 11 ____
Physics 12 ____
Earth Science 11 ____
Earth Science 12 ____
Geology 12 ____
Other science ____

7. At this time, what do you plan to do immediately after leaving secondary school?

Attend a business school ____
Attend vocational, art, or trade training school ____
Attend a technical institute ____
Attend community college: university transfer program ____
Attend community college: career program ____
other plans ____
undecided ____

SCIENCE QUESTIONS

INSTRUCTIONS

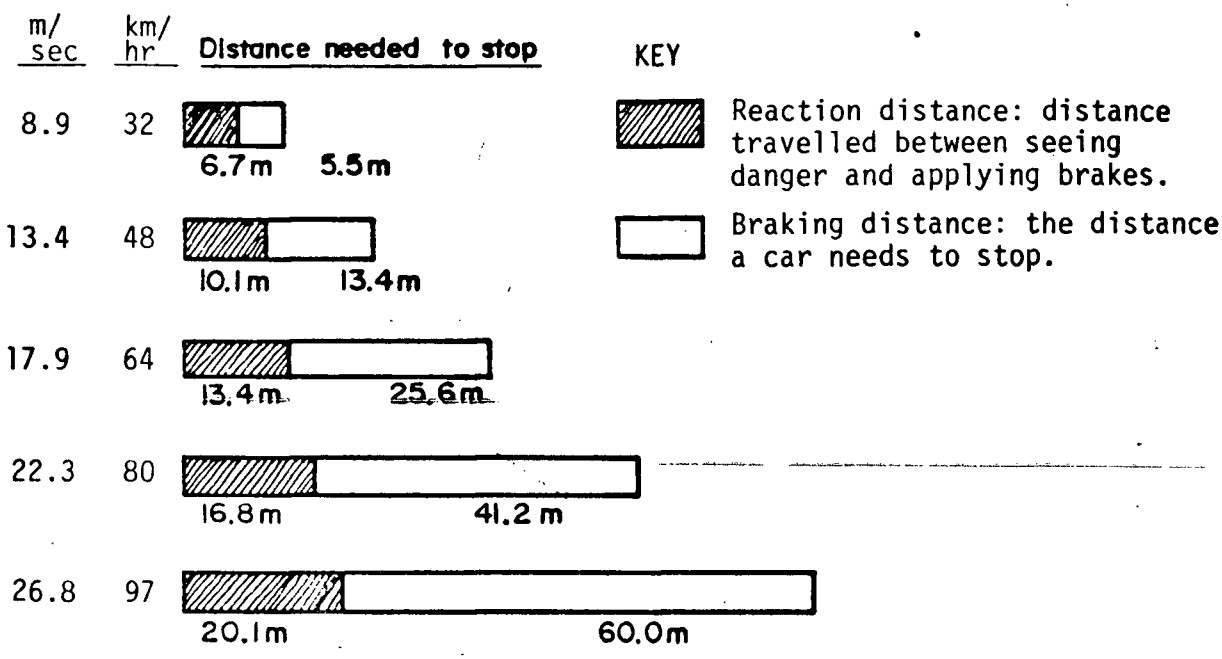
The questions in this handout have a single best answer. A number of choices is available for each question, including "I don't know." After reading all the possible answers, make an x on the line next to the one best answer to each question. If you have no idea of the correct answer, make an x on the line next to "I don't know."

EXAMPLE: How many days are there in December?

28	____
29	____
30	____
31	____
I don't know	____

The answer should be 31.

Use the following graph when answering questions 1 and 2



1. Which of the following conclusions is most justified?
   - The higher one's speed, the longer it takes to react ____
   - As one doubles the speed, the total distance necessary for stopping becomes twice as great ____
   - For the speeds given, the greater the speed- the greater the reaction distance ____
   - The braking distance is always greater than the distance travelled in reacting to the danger signal ____
   - I don't know ____
2. From the chart you could conclude that the reaction time of the average driver is
   - less than one second ____
   - one second ____
   - a little more than one second ____
   - much more than one second ____
   - I don't know ____

3. If the earth's axis were to be tipped at an angle of 10° instead of 23^{0} which of the following would be true?

   The year would be longer than at present ____
   There would be only half as many hours of daylight in a year as at present ____
   We would be able to see both sides of the moon ____
   The moon would appear to be motionless rather than appearing to move in the sky ____
   None of the above would be true ____
   I don't know ____

4. Scientists are skeptical that earth has been visited by beings from outside the solar system because

   there is no life anywhere in the universe except on earth ____
   the distances between stars are enormous ____
   only crackpots believe in such nonsense ____
   few places outside the solar system can support life ____
   I don't know ____

5. Think of diving into the ocean near the equator. As you go deeper, the water gets colder because

   the saltiest water is always coldest and sinks to the bottom ____
   warm water is lighter than cold and stays on top ____
   the deeper water is not in contact with the air ____
   I don't know ____

6. Which of these concepts can be used to explain why a driver who is wearing a seat belt may be thrown through the windshield if his car stops suddenly?

   Buoyancy ____
   Friction ____
   Potential energy ____
   Inertia ____
   Mechanical advantage ____
   I don't know ____

7. You are going to light a bunsen burner. What should you do just before you turn on the gas?

   Guess at the position at which the air control should be open for proper burning ____
   Close the air control completely ____
   Leave the air control as you found it, since it probably is in the correct position ____
   Open the air control completely ____
   I don't know ____

8. When diluting an acid, which is the correct procedure?

   Add water to acid ____
   Add acid to water ____
   Add water to one-half of the acid and then add the remainder of the acid ____
   Pour acid and water together into an empty beaker ____
   I don't know ____

9. Green plants are important to animals because the plants

   consume both food and oxygen ____
   consume food and give off oxygen ____
   consume food and give off carbon dioxide ____
   produce food and give off oxygen ____
   produce food and give off carbon dioxide ____
   I don't know ____

10. Atmospheric carbon dioxide is believed to be increasing due to

    increased carbon dioxide fixation by green plants ____
    increased release from volcanoes ____
    increased burning of fossil fuels ____
    cutting down of too many trees ____
    I don't know ____

11. Salt may be added to a solution until it will float an egg. This statement is based on the assumption that all eggs have

    equal weight ____
    equal volume ____
    equal density ____
    about the same shape ____
    I don't know ____

12. A poem entitled "The Ancient Mariner" contains the lines:

The sun now rose upon the right
Out of the sea came he,
Still hid in mist, and on the left
Went down into the sea.

In which direction was the Ancient Mariner sailing?

north ____
south ____
east ____
west ____
I don't know ____

13. The purpose of a fuse or circuit breaker is to

turn the lights on and off ____
protect circuits from carrying too much electricity ____
protects people from getting electric shocks ____
saves electricity from being wasted ____
regulate the number of volts in the circuit ____
I don't know ____

14. What is the main problem associated with the disposal of waste products from a nuclear reactor? Some of the products

remain radioactive for thousands of years ____
are likely to explode at any time ____
can destroy the ozone layer ____
give off dangerous levels of microwaves ____
I don't know ____

15. Look at the figure below

This figure demonstrates that

the deeper the liquid, the greater the liquid pressure ____

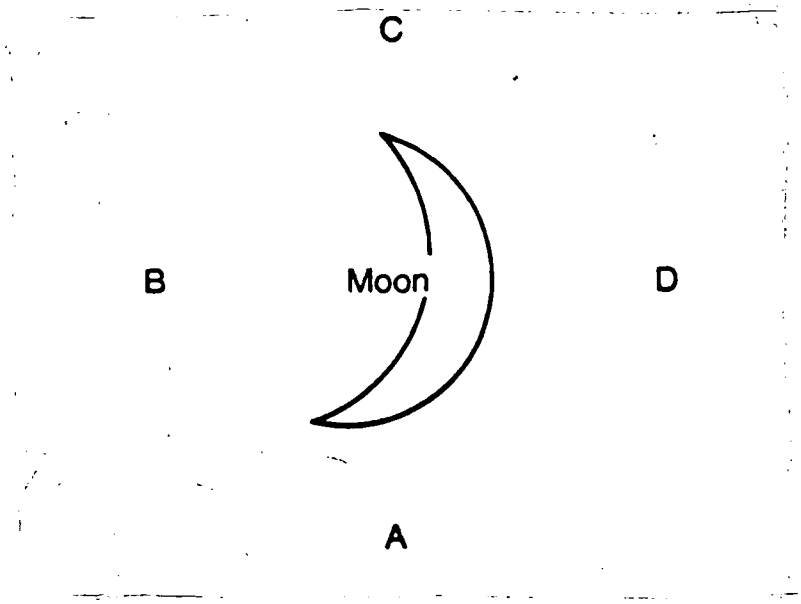
liquid moves at different speeds ____

air pressure causes the liquid to shoot out ____

the deeper the liquid, the greater the air pressure ____

I don't know ____

16. Look at the diagram below



The sun would be located at position

A ____

B ____

C ____

D ____

I don't know ____

17. Which of the following substances must be kept away from sparks or open flames?

Hydrochloric and sulfuric acid ____

Sodium hydroxide and potassium hydroxide ____

Alcohol and ether ____

Tin and lead ____

I don't know ____

18. In which of the following ways does a sample of steam differ from a sample of ice? The molecules of steam

move more slowly ____

are smaller ____

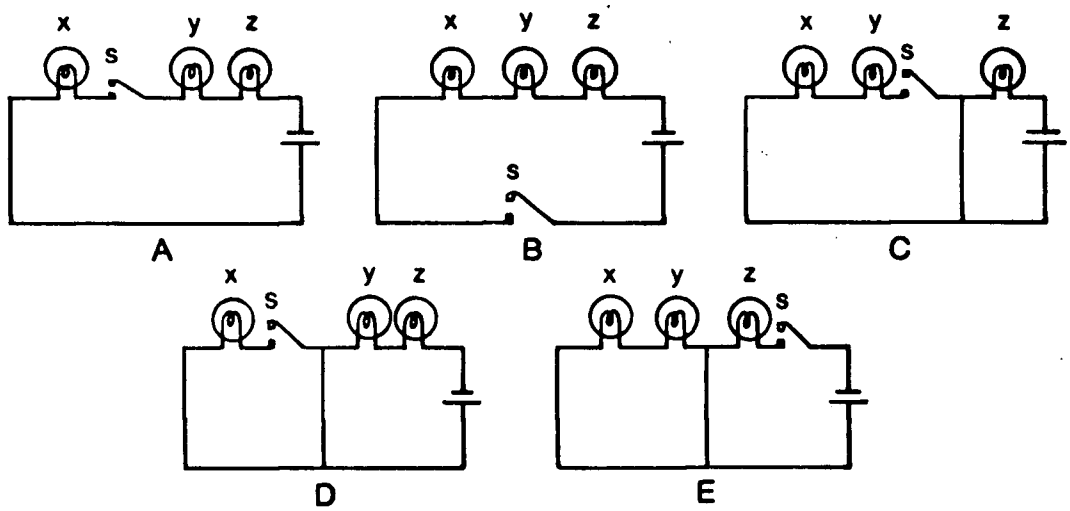
contain less energy ____

are closer together ____

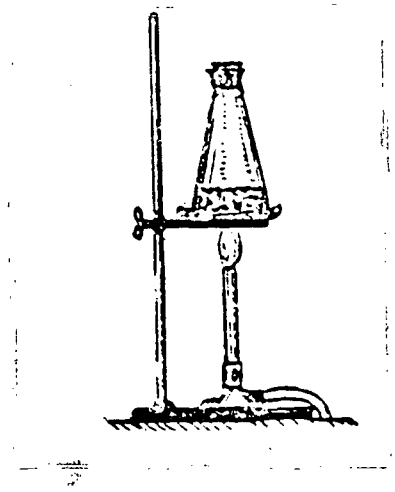
are farther apart ____

I don't know ____

19. In the diagrams below, X, Y, and Z represent three lamps in a circuit, which also includes a battery and a switch S.



22. A student is boiling water in a stoppered glass jar or flask as shown. What precaution would you take if you saw this?

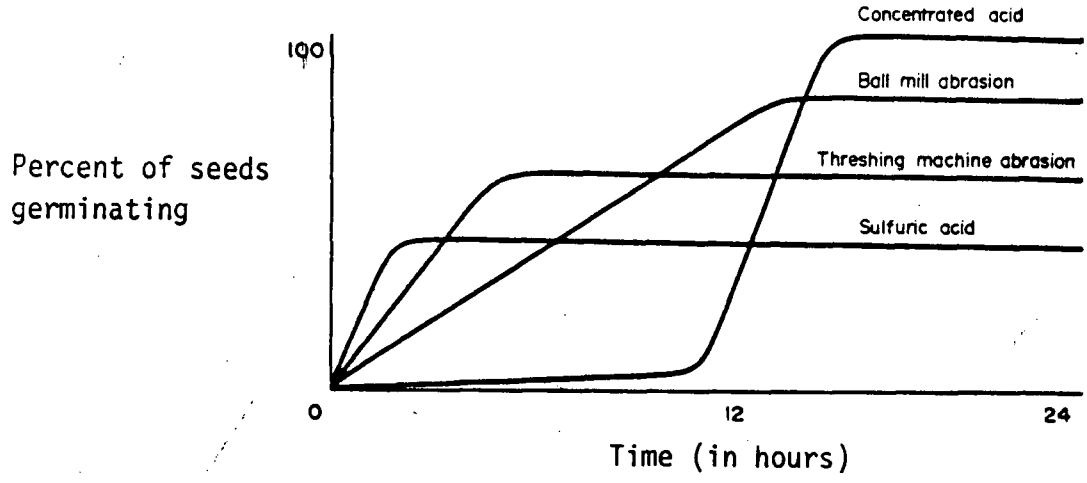


Immediately turn off the gas to the burner ____
Make sure the stopper is in tightly so the steam cannot escape ____
Make sure the gas line does not become disconnected ____
Keep the burner turned down to low heat ____
I don't know ____

When the switch is open, X fails to light while Y and Z do light. Which one of the following circuits is it?

A ____
B ____
C ____
D ____
E ____
I don't know ____

20. Use the graph below when answering questions 20 and 21



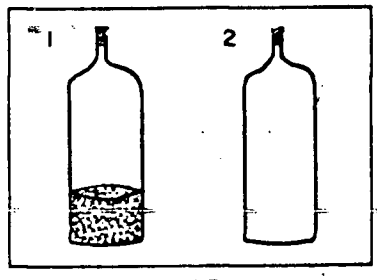
Which ONE treatment of seeds seems to be MOST effective for starting germination in a maximum number of seeds (i.e; for breaking dormancy)?

Concentrated acid ____
Ball mill abrasion ____
Threshing machine abrasion ____
Sulfuric acid ____
I don't know ____

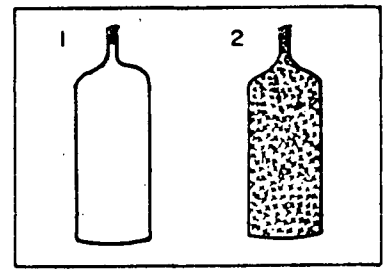
21. If the treatment were given for only six hours, which ONE would be MOST effective for starting germination in a maximum number of seeds (i.e; for breaking dormancy)?

Concentrated acid ____
Ball mill abrasion ____
Threshing machine abrasion ____
Sulfuric acid ____
I don't know ____

23. In the diagrams below, bottles 1 and 2 are exactly alike. HOWEVER, THEY MAY BE AT DIFFERENT TEMPERATURES. Bottle 1 contains a substance which is transferred to bottle 2 without any loss.



BEFORE



AFTER

Which one of the following is the best explanation of what you see in the diagrams?

In bottle 1, the substance is a gas and in bottle 2 the substance is a liquid ____

In bottle 1, the substance is a liquid and in bottle 2 the substance is a gas ____

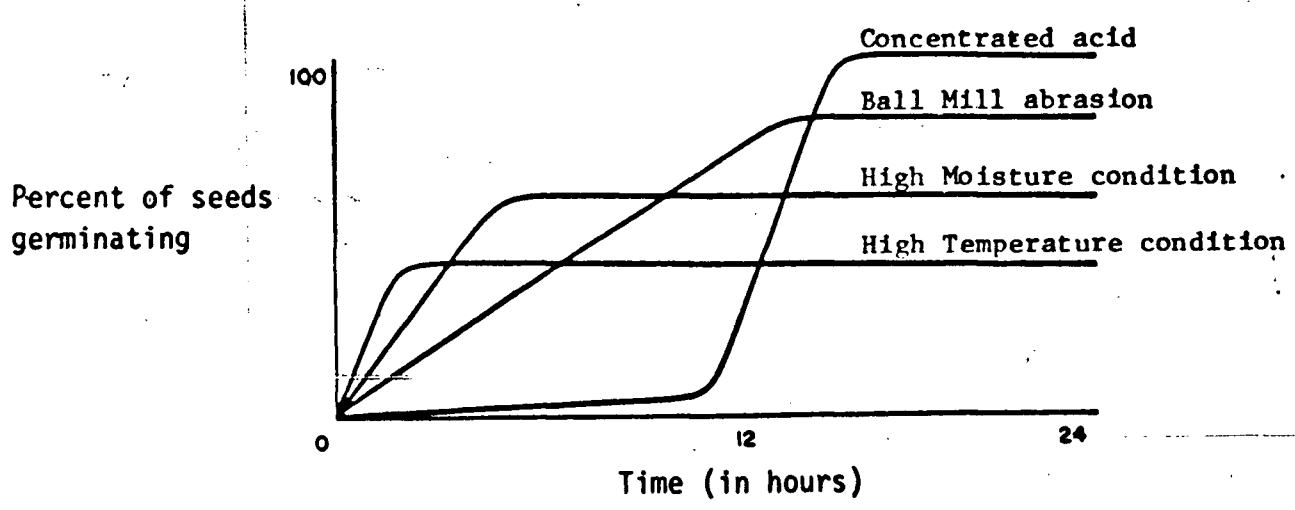
In bottle 1, the substance is a solid and in bottle 2 the substance is a liquid ____

In bottle 1, the substance has less mass than in bottle 2

I don't know ____

ALTERED VERSIONS OF ITEMS 20 and 21

20. Use the graph below when answering questions 20 and 21



Which ONE treatment of seeds seems to be MOST effective for starting germination in a maximum number of seeds (i.e; for breaking dormancy)?

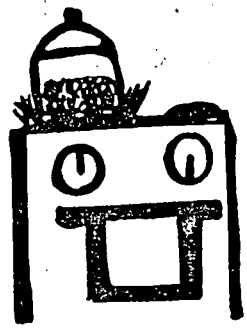
Concentrated acid ____
Ball mill abrasion ____
High moisture condition ____
High temperature condition ____
I don't know ____

21. If treatment were given for only six hours, which ONE would be MOST effective for starting germination in a maximum number of seeds (i.e; for breaking dormancy)?

Concentrated acid ____
Ball mill abrasion ____
High moisture condition ____
High temperature condition ____
I don't know ____

ALTERED VERSION OF ITEM 22

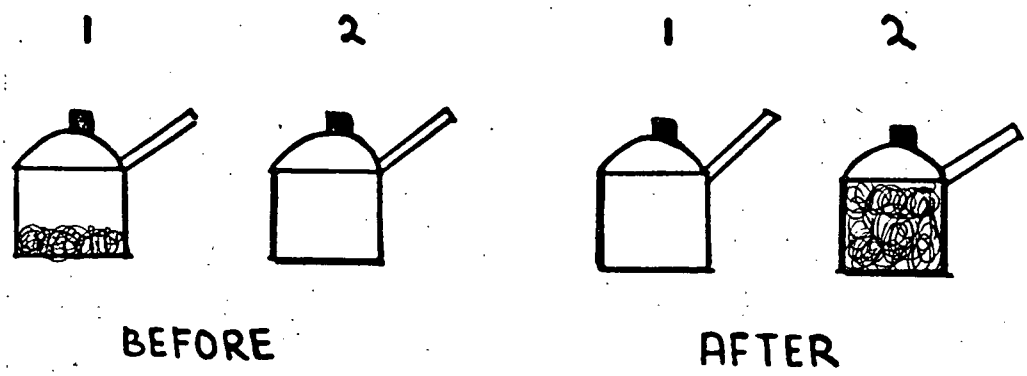
22. A cook is boiling water in a casserole dish with a tight fitting lid, as shown. What precaution would you take if you saw this?



Immediately turn off the gas to the stove _____
Make sure the lid fits tightly so the steam cannot escape _____
Make sure there is gas getting to the stove _____
Keep the stove turned down to low heat _____
I don't know _____

ALTERED VERSION OF ITEM 23

23. In the diagram below, saucepan 1 and 2 are exactly alike. HOWEVER THEY MAY BE AT DIFFERENT TEMPERATURES. Saucepan 1 contains a substance which is transferred to saucepan 2 without any loss.



Which one of the following is the best explanation of what you can see in the diagram?

In saucepan 1, the substance is a gas, and in saucepan 2 the substance is a liquid _____

In saucepan 1, the substance is a liquid and in saucepan 2, the substance is a gas _____

In saucepan 1, the substance is a solid, and in saucepan 2 the substance is a liquid _____

In saucepan 1, the substance has less mass than in saucepan 2 _____

I don't know _____

APPENDIX B

TRANSCRIPT

SUBJECT: MELANIE
GRADE 12
AGE: 17
FEMALE
I- INTERVIEWER
S- SUBJECT

IN PARENTHESES, BESIDES EACH SUBJECT'S EXCERPT, IS THE CATEGORY ASSIGNED FOR EACH ITEM.

I: Tell me what you were thinking when you chose the answer you did for question 1?

S: I chose No. 3 because I've done something like this before. Somebody has explained to me that if you go at a higher speed it takes a longer distance to stop. So that was other knowledge besides basic science knowledge.

I: What was this other knowledge?

S: Oh.. It was through drivers school. That helped me a lot (informal experience).

I: Question 2?

S: Umm.. I chose No. 1. That was more or less the same reasons as Question 1. They showed a film on reaction time. I looked at the graph a bit and tried to figure it out also (formal experience).

I: Now for question 3. Take your time.

S: Okay. For this one I didn't really know what it was. I haven't had much background on earth rotation (miscellaneous).

I: What about other background?

S: The only geography I had was in Grade 10 which was studying semismographs, earthquakes etc. That's it.

I: Question 4?

S: Okay. For that one I chose No.1 because its a theory you know. That there is no life anywhere on earth.

I: How did you find this information out?

S: Through TV, the media, and the movies. Some movies think there are creatures out there. To me there is not enough proof (informal experience).

I: Question 5?

S: This one I didn't really know. For No. 1 I was thinking when its frosty outside you throw salt on the road so the ice melts. I was thinking about that because of our past experience of a couple of weeks. I didn't know about the other answers (common sense).

I: Moving on to question 6

S: Okay. The answer I chose was interia. I learnt this

through driving and seat belt commercials (informal experience).

I: Question 7?

S: Okay. When I was in grade 9 I had a bad experience with a bunsen burner. I don't know whether my answer is right or not. When I lit the bunsen burner it kind of shocked me. My science teacher gave me a sheet and said that you should read it and study it and know where the air control should be. Well, I'm never going to light another bunsen burner , I'm going to get someone else to do it so I never read it.So what I put for my answer was No. 4 because air allows a flame to burn. I didn't want to put I don't know because I kind of had a bit of knowledge about it (formal experience).

I: Why didn't you want to light a bunsen burner again?

S: Past experience I quess. It scared me a bit.

I: Question No. 8?

S: This one I chose adding the acid to water. I took chemistry last year and we sort of put one solution into another. To me No. 1 and No. 2 are interchangeable. No. 3 is getting really technical. I don't have that background knowledge (formal experience).

I: Question No. 9?

S: Well I know that green plants give off oxygen and they do produce food for human consumption.

I: How do you know that they produce food?

S: Well, what I perceived from this question is that green plants themselves are food to us,so thats how I interpretated food. Basic knowledge (Common sense).

I: Now moving on to question 10.

S: I chose No. 3 because I listen on the news and they have a lot of information on the fact that theres so much CØ2 in the air because of fossil fuels burning, too many cars on the road, and too much congestion. During the Olympics there was too much traffic. All the carbon monoxide would be bad for the runners plus the heat etc (informal experience)

I: Question No. 11?

S: I chose No. 4. I wasn't sure about this one, but I put down an answer anyway. Okay, I know that, I believe that density has something to do with water. I did an experiment on it. Mercury has a higher density and water has a so so density. That's how I interpretated my answer (formal experience).

I: Question 12?

S: For this one I thought that the sun sets in the west and rises in the east. I guess the way I perceived it is my bedroom faces south. I was picturing myself looking at the globe. How would the sun look? (common sense).

I: Question 13?

S: For question 13 I chose No. 2 because of my past experience in physics. We talked about circuit breakers a bit and to me a breaker is to prevent overloading of an outlet so I chose No. 2 (formal experience).

I: Have you done anything else with circuit breakers besides physics?

S: Well, that's pretty much it. I don't take electronics or anything like that.

I: Okay. Moving on to question No. 14

S: This one I didn't really know. All of them seemed like good answers to me. I chose No. 4 because in the news you hear these things so I just chose this one (informal experience).

I: Question No. 15?

S: This one was a bit confusing. I was getting to the end so I was getting restless. I chose No. 1 because

I perceived the answer to be that. When you go down into water there's more pressure on you.

I: How do you know that?

S: I take swimming lessons that's why. My ears kind of go 'wonko' when I go to a deeper depth (informal experience).

I: Question 16?

S: I wasn't quite sure about this one. I thought (pointing to diagram) if it was an eclipse it would cover the moon. I was trying to use some of the basic knowledge I had (common sense).

I: Moving on to question 17?

S: Okay. With this one I wasn't really sure. I knew that No. 4 wasn't the answer. The first three I had to think about. HCL and sulfuric acid are not flammable because I remember doing something in chemistry class. Then there's alcohol. Alcohol is flammable. So I chose that one (formal experience).

I: What about ether?

S: I wasn't sure about that because I didn't pay much attention to the end of the year in chemistry. We did talk about ether. I have come across the word but I haven't paid much attention to that word.

I: Question 18?

S: Okay. What I thought about this is that steam moves

about in the room. You can tell when you put a kettle on the stove and you close the door (like in a kitchen) and the windows fog up. When I think of ice I think of the sea forming around the ice. It doesn't move around much (informal experience).

I: Question 19?

S: More physics stuff! I chose No. 4 because the circuit would stay lit because of the circuit involved in the diagram. Physics information (formal experience).

I: Question 20?

S: I wasn't sure about the word dormancy so what I thought dormancy was when it reaches a level and then evens out or then changes speed. So the answer I chose was No. 2. It increases pretty normally (from the graph) so that's how I got my answer (formal experience).

I: Question 21?

S: This is related to 20 in a way by the graph. Because (theres that word again dormancy) of this (pointing to a line on the graph) I chose my answer which was ball mill abrasion (formal experience).

I: Do you know what ball mill abrasion is?

I: No idea!

I: Moving on to question No.22

S: This one was a bit confusing. I haven't really done anything in experiments where I had to use a stopper.

I: Really? Nothing at all with a stopper?

S: Well, I've done it, but not with water.

I: With other things?

S: Yeah.. Acids etc.

S: I chose No. 2 . I wasn't really sure. If its really tight and pressure grows it will explode. I didn't want to put down I don't know because I sort of knew the answer (formal experience).

I: Question 23

S: I was kind of confused about bottle one and bottle two.I thought this one (pointing to diagram) was bottle one and bottle two so I chose No. 2

I: Have you done anything like this before?

S: No, but through reading and common knowledge I derived my answer (common sense).

I: Okay Melanie we have finished. Thank you very much.

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