SCHOOL SIZE AS A FACTOR IN THE SCIENCE ACHIEVEMENT OF GRADE TWELVE STUDENTS

ROBERT LLOYD SIMMS

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by

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Robert Lloyd Simms, B.Sc., B.Ed.

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Department of Curriculum and Instruction
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ABSTRACT

The purpose of this study was to determine whether or not students in schools of different sizes are achieving equally in high school science. The study analyzed, in addition to student achievement, human and material high school science resources as they exist in schools of different sizes. The focus of the study was on the small school.

Student achievement was measured using the Level 18 science test from the battery of tests entitled "Form T - Test of Achievement and Proficiency." The test was completed and scored from 120 Grade 12 students in 120 schools throughout the province of Newfoundland and Labrador. Twelve characteristics associated with each of the schools chosen were collected by means of a teacher questionnaire and compared by school size. These characteristics included courses taken, courses offered, teacher experience, teacher training, teacher workload, school equipment and facilities, and class size.

All data were subjected to analysis by use of programs contained within the Revised Edition of the Statistical Package for the Social Sciences (SPSSX).

No significant difference was found in the science achievement of Grade 12 students in relation to the size of school they attend. A significant difference was found

between science achievement and the number of courses taken by students. A test of interaction between courses completed and school size also indicated that when school size and the number of courses taken interact together the science achievement levels are affected.

In schools of different sizes a lack of balance was found to exist in the types of science courses offered to students and the types of courses taken. Significant differences were found as well in the human and material resources associated with the teaching of science in small, medium and large schools.

The results of the study support the need for a high school program with characteristics designed to address the unique science conditions which exist in small schools.

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CHAPTER 1

THE PROBLEM

Introduction to the Problem

When the Department of Education of the province of Newfoundland and Labrador introduced the Reorganized High School Program in 1981 it was adopted with the premise that it would respond to the needs of schools of varying sizes and diverse characteristics. It is the opinion of the author that it was implemented with the premise that one program would fit schools of all sizes, i.e., "one size fits all."

Berkner (1985), identified a similar problem in the United States after having conducted a needs assessment pertaining to small schools:

> It seems to be assumed that what is good for large and urban schools is also good for small and rural schools. (p. 145)

A recent analysis (Newfoundland and Labrador Department of Education, 1985) of the student population which makes up the 205 schools offering high school courses in this province revealed that there are 84 schools (or 41 percent) which have fewer than 75 senior high school students. There are 40 schools of fewer than 200 students carrying a program from K-12, and 39 schools of fewer than 200 students offering programs from grades 7-12. Of the 205 schools 39 percent have fewer than 200 students and are teaching students other than senior high. The other 61 percent make up the larger schools of the province.

Given the range in the student population of these schools, coupled with a proportional allocation of teacher units to deliver the programs available, a question needing an answer is whether the concept "one size fits all" addresses the high school science needs of the various school sizes of this province.

Gough (1983), states that:

> The reorganized high school is demanding diversification even in small schools to reduce the inequalities that have plagued this province through the years. (p. 13)

The above statement was made to a group of science educators concerned with the future of science education in the schools of this province. It was suggested that the inequalities referred to might have a direct influence on the science achievement of students and the quality of science provided in schools of different sizes.

Considerable research has been conducted on achievement as it relates to school size in other provinces of Canada (Scharf, 1974; Johnson, 1976; Treasure, 1978; and Ryan, 1983). In order to obtain insight into whether or not any significant high school science inequalities exist in this province, the following two questions could be asked:

(1) How does the science achievement of Grade 12 students compare in schools of different sizes?

(2) Are there sufficient human and material resources available in each size of school?

Broader questions which evolve from the comment by Gough are whether or not there is sufficient flexibility in the provincial science program to meet the diverse science needs of students in small schools and whether or not these students have preparation for post-secondary career opportunities equal to that of students in other size schools. This study perceives the diversity of school opportunities in science as a problem needing further examination. If inequalities should be revealed, the science needs of students in all schools, especially the small rural or outport schools, might then be properly addressed.

Need for the Study

The problem just described establishes the need to determine whether or not Grade 12 students in schools of various sizes are achieving equally in science. Fagan (1985), in reporting on the High School Standards Testing Program, reported that there is a very definite relationship between school size and the achievement of students. There is a need for that relationship to be examined from a science perspective. There is also the need to investigate whether or not the material and human resources available for science teaching are adequate in schools of different sizes.

The Reorganized High School Program has eleven science courses available which schools can offer. In order to assess the extent of diversification of the science program, it is important to know what courses are offered to students in each size of school. For example, do students in all schools have an opportunity to do courses in each of biology, chemistry, earth science and physics? Fisher (1985), having studied the chemistry performance of first year students at Memorial University, reported:

> Less than half of the high schools offer chemistry at even the first level (Chemistry 2202), and fewer than 40 percent of eligible students in any particular grade study the subject at all. (p. 2)

Fisher further reported that students from out-of-town rural schools were much more likely than students from out-of-town urban centers to drop the first year university chemistry course (Chemistry 1000). If all courses are not offered in schools of various sizes, then there is a need to determine which courses are not offered and whether this circumstance can be attributed to the lack of human and material resources available to teach them. Future plans designed to improve the quality of science education in all schools would require an assessment of the quality and conditions of high school science as they presently exist. This was done on a national basis in a recent study by the Science Council of Canada (1984). Newfoundland and Labrador were included in the study, which examined the obstacles preventing the achievement of the various aims of K-12 science education. However, at the time of data collection, the province had not implemented the Reorganized High School Program. Also, the study was not conducted according to school size, which pinpoints the need for a study such as this. An investigation into the diversified school characteristics which exist throughout the province is particularly important. It will be useful to know how material and human characteristics relate to science at the high school levels in small schools. These data are essential in order to make recommendations to plan and improve the present curriculum, and to address the high school science needs of students of the rural school.

Purpose of the Study

The purpose of this study was to determine whether students in each size of school are achieving equally in high school science. The study analyzed, in addition to student achievement, the human and material high school science resources that exist in schools of different sizes. This was done to determine whether or not these resources are sufficient to carry out the program in each size of school. The study examines the extent of the differences which exist in the science achievement of students in the small, medium and large schools, the differences in courses made available to students and the differences in human and material resources available to deliver them.

These data could then be the basis for recommendations for adapting the high school science program to further meet the needs of students in each school size, particularly the small school.

Operational Definitions

Grade Twelve students - For the purpose of this study Grade Twelve students are defined as those students that were registered on or before June 1984 and were also registered for the 1986 term.

Large schools - Those with a total senior enrollment greater than 140. The total number of such schools in the province is 69.

Medium schools - Those with a total senior enrollment between 65 and 140. The total number of such schools is 67.

Small schools - Those with a total senior enrollment less than or equal to 65. The total number of such schools is 59. This figure omits the 10 smallest schools which are offering high school courses, but not at the Grade 12 level. The high school population of these 10 schools ranges from 1 - 15 students.

RHSP - The Reorganized High School Program, which will be referred to henceforth as RHSP.

Null Hypothesis

This study was set up to study one research hypothesis which will be evaluated statistically.

Null Hypothesis

> There is no significant difference in the science achievement of Grade 12 students in terms of the size of school they attend.

This will be tested by means of a standardized test which will be described in Chapter 3.

Research Questions

Research questions which this study will attempt to answer using the teacher questionnaire found in Appendix D are:

1. Of the science courses which are part of the high school program, which are being offered in schools of

different sizes? A list of these courses is found in the first question on the teacher questionnaire.

2. How does the number of science courses being taken by high school students compare in schools of different sizes? This question will be answered using the data collected from questions numbered two and three. Each of the science courses listed on the questionnaire is equal to two credits according to the standards established by the Department of Education for the province of Newfoundland and Labrador.

3. Are students in each size of school doing courses in each of the pure sciences? For the purpose of this study the pure sciences consist of biology, chemistry, earth science, geology and physics.

4. How does the teaching experience of science teachers throughout the province compare in schools of different sizes?

5. How do the qualifications of science teachers throughout the province compare in schools of different sizes?

6. How well prepared for the teaching of science do teachers perceive themselves in schools of different sizes?

7. How does the science teaching assignment of teachers compare in schools of different sizes?

8. How does the number of courses that teachers are teaching compare in schools of different sizes?

9. Are all schools equipped to offer each of the science courses within the high school program? If not, which courses are schools not equipped to offer?

10. How does the adequacy of the science reading materials available to students compare in schools of different sizes?

11. How do science teachers in schools of different sizes rate the quality of the facilities and equipment available to teach science?

12. What is the average size of science classes in schools of different sizes?

These questions will be answered by means of a questionnaire which was completed by a high school science teacher randomly selected from each of the one hundred and fifty schools participating in the study.

Each of the questions in the questionnaire relates either directly or indirectly to the kind of science curriculum available to students in various school sizes and the adequacy of human and material resources available to deliver it. Gjelten (1978) suggests:

> ....as long as rural schools emulate an urban model of education, rely on curriculum materials written for urban children, and seek to hire the same kind of teachers as urban schools seek, they probably will be second-rate. But rural schools do not need to fashion themselves after urban schools. They have their own model, with its own wonderful strengths. (p. 24)

This study was set up to provide some of the information needed to develop these strengths in the area of science.

Many references have been made to the growing crisis in science education. Rakow, Welch and Hueftle (1984) suggest some possible underlying factors:

> This crisis has been variously attributed to low class enrollments in science classes, a shortage of qualified teachers, inadequate budgets for science education, and declining scores on measures of student achievement and attitudes in science. (p. 57)

In attempting to answer the questions being posed in this research, the author decided to try to identify the degree to which some of the attributes referred to above are present in schools of various sizes in this province, if indeed they do exist.

If this study can reject the null hypothesis and demonstrate a significant difference in the science achievement of students in schools of different sizes, and also demonstrate by school size differences among the variables included in the teacher questionnaire, then the study will have practical application for the future design of science programs for this province. This will also imply that the "one size fits all" concept cannot work unless it has sufficient built in flexibility to fit the diverse conditions which exist in the various sizes of schools which make up the total number of high schools in the province.

Limitations and Delimitations of the Study

This study had the following restrictions, a number of which were attributable to cost and time.

-- The survey was restricted to a total of one hundred and fifty schools, with one student and one teacher randomly selected from each school. There are a total of 205 high schools offering Grade 12 throughout the province. It is possible that the remaining schools would have different characteristics although there is no reason to believe so.

-- The possible impact of non-science formal instruction within the school was not assessed. It is possible that this could affect the results.

-- The possible impact of different types of instruction by teachers was not assessed. It is possible that this could affect the results, but it is assumed that in practice no consistent bias was present.

-- Differences in the chronological age of students were not controlled.

-- The study was restricted to one grade level (Grade 12). It is possible that the results are not generalizable to other grade levels.

-- The assumption was that the randomness of the study eliminated variables such as IQ. It is always possible that another sample drawn randomly from the same population would exhibit a different pattern of IQ readings.

-- No claim was made that the test being used covered all of the elements of science achievement at the Grade 12 level. Hence, the results are not generalizable beyond the areas investigated.

The samples were unbiased to the extent that:

-- one hundred and fifty schools were randomly selected from the total number of schools offering Grade 12 in the province. These were selected using the table of random samples.

-- each student was randomly selected from within the total number of Grade 12 students in the school. The random sample of students was selected from the student records (1985-86) of the Department of Education, using a computer program developed by Newfoundland and Labrador Computer Services.

-- each teacher was randomly selected from within the total number of high school science teachers in the school. A list of these teachers was supplied by each of the school boards throughout the province. A teacher from each of the 150 schools was then selected by using the table of random samples.

The study was set up with the assumption that the data collected would provide information useful to future curriculum decisions as they relate to science in the small schools of this province. It did not attempt to draw conclusions as to what these decisions should be.

The study was conducted to determine whether the science achievement of Grade 12 students is different in schools of different sizes, and not to determine the reasons for such differences.

Summary and Overview

Chapter 1 has looked at the problem for which this study was developed. It has also discussed the need and purpose of the study and the research questions which it was specifically developed to answer.

Chapter 2 reviews the literature related to the research. Chapter 3 presents the design of the study, the instrumentation, testing procedures and the methods used to analyze the data. Chapter 4 presents the results of the data analysis, interpretations and conclusions. Chapter 5 summarizes the report and presents the implications and recommendations for further research.

CHAPTER 2

RELATED RESEARCH

Introduction

In the various studies that have been carried out in the past involving the science achievement of students, many variables have been identified as influencing the overall achievement scores of students. This chapter will discuss the following factors as they relate to student achievement in science: (a) school size; (b) courses taken by student; (c) pupil-teacher ratio and teacher workload; (d) teacher experience and training and (e) science learning materials and facilities. The last section will present a summary and overview of the literature and general comments on research related to the study.

School Size

One of the problems the author experienced in conducting the study of the related research was the use of words such as rural, urban, small, small town, smaller places, metropolitan and other such words to describe the size of places and schools. Some of the literature defined such terms while others did not. The literature selected for this chapter is that which reflects the definitions of school size presented in Chapter 1.

Past studies have produced conflicting results in comparing the science achievement of students in rural and urban schools and science achievement as measured by school size. However, as stated by Colton (1981):

> It is usually assumed that education in general, and science courses in particular, must be inferior in the small rural high school because of its limited resources, both human and material. (p. 1)

In 1981, an extensive research project was undertaken for the Saskatchewan School Trustees Association on the delivery of educational programs in the small schools of Saskatchewan (Ryan 1983). Much of the past research on student achievement as related to school size was examined through that project and is relevant to this study. The research reported on by Ryan focused mainly on studies completed by Tweenten (1979); Blosser (1984); Johnson (1976); and Treasure (1978).

In an investigation of the number of years of schooling completed, functional illiteracy, grade retardation and the percentage of youth attending college, Tweenten (1979) found that schooling in rural areas did not meet the standard of urban areas. Blosser (1984) also reported similar findings. Johnson (1976) came to the same conclusion for the province of British Columbia. Treasure (1978) in an Alberta study found that, although there was no significant difference in the average science performance of Grade 12 students according to school size, a pattern of differences in the means and standard deviations among the various school sizes indicated an area for further study. Because of the limitations in scope of the questions addressed in that study, Treasure recommended that a study of the effect of variables such as size of school, presence (or absence) of laboratories, and amount of time spent on science be commissioned by the Alberta Department of Education.

Watkins (1982), conducted a study to determine whether significant differences exist in certain demographic characteristics and education factors. The study also determined the relationship between eleventh grade science achievement scores and selected educational factors. The public schools which were studied were stratified into three groups, metropolitan, small town, and rural. Watkins found that the more "metropolitan" a school is, as defined by the study, the higher the students' achievement as measured by the science test.

Scharf (1974), using the Canadian Test of Basic Skills, compared twenty-four urban Saskatchewan schools for achievement differences. He concluded that the composite performance of rural children was not significantly different from that of urban children. As well, Kimble (1976), in a study on rural Montana found that no significant difference existed in the mean test scores of achievement based on school size. Sher (1977), in a review of six such studies, also found no significant differences in achievement between rural and urban students. Fagan (1985), in an analysis of the High School Standards Testing program for the province of Newfoundland and Labrador which is assessed by the Canadian Test of Basic Skills, reported that the larger schools tended to do somewhat better than smaller schools on the average. (See Figure 1).

Figure 1

Average Composite Standard Scores and the National Percentile Ranks by Size of School

School Size Grade XII Enrollment	Composite Standard Score	National Percentile Rank
01 - 39	181.2	29
40 - 74	185.5	37
75 - 129	187.2	41
130 -	189.4	47

In the final report on the high school standards testing program for 1985, Fagan pointed out that there was a very definite relationship shown between the size of school and the achievement of students. Fisher (1985) also supports this relationship in reporting that students in the province of Newfoundland and Labrador from out-of-town rural schools were much more likely to drop out of first year chemistry than students from out-of-town urban centers.

Watkins' (1982), study revealed that a significant difference ($p \leq .05$) existed among the means of metropolitan, small town, and rural schools on the following factors:

1. "Number of courses offered by a school." Metropolitan schools of this study offered more science courses.

2. "Science student to science teacher ratio." Rural schools had smaller science student to science teacher ratios.

3. "Percentage of science equipment available to its science students." Metropolitan schools were found to have a larger percentage of the equipment listed in this study.

In an assessment of the science performance of seventeen year olds according to communities of various sizes, Crane (1978) found that students in schools fringeing around big cities and medium size cities outperformed those in smaller places and big cities. This suggests that not only might students in small schools achieve less in science but also that the larger schools may also approach a size in which student achievement begins to decrease.

Courses Taken by Students

Kanchaturas (1979), found a significant relationship between the number of high school science courses taken by students and biology achievement. Similar findings were reported by Cox (1983) relative to science electives. The number of science courses completed by students in each size of school, and the relationship this has to student achievement, are part of the analysis of this study done in Chapter 4.

Pupil-Teacher Ratio and Teacher Workload

A number of studies have shown that pupil-teacher ratio in science is another variable that appears to influence student achievement (Burton, 1980 and Beditz, 1983). This is supported by Whitworth (1971); Scharf (1974); Edmonds and Bessai (1978); and Palmer (1983). Contrary to the evidence that a lower teacher-pupil ratio provides for an increase in achievement, there exist studies that contradict this, demonstrating that where teacher-pupil ratios are small, teacher courseload is increased. Harrison and Downey (1965), stated that:

> When fewer than four teachers are expected to give a complete academic program for grades ten, eleven, and twelve, the burden becomes onerous. (p. 21)

According to the number of teacher units assigned to schools (Newfoundland and Labrador Directory of Schools, 1985) many cases such as this exist in the small schools of this province, some of which are even more severe than those quoted above.

Ryan (1983), in reporting on the Saskatchewan situation stated that:

> One Saskatchewan teacher, in his first year of high school teaching in a small school, was given the following course load: Grade 9 Science, Grade 10 Science, Grade 11 Physics, Grade 12 Physics, Grade 11 Chemistry, Grade 12 Chemistry, Grade 11 Biology, and Grade 12 Biology. There was no laboratory assistant. Another specialist science teacher in another rural school district carried a comparable load. Instead of the Grade 9 Science course, he taught, in addition to the first teacher's Grade 10, 11, and 12 courses, Grade 9 Social Studies, Grade 10 Geography, and a course for all grades in Computer Literacy! As that teacher wryly commented: "With a load like that, teaching about the nature of science certainly suffers". (p. 14)

The above situation is not uncommon in the province of Newfoundland and Labrador. In a brief presented to the Newfoundland Department of Education by the Newfoundland Teachers' Association (NTA) on the RHSP (1984), this comment was made:

> It should be pointed out here that there are some teachers in our high school systems with absolutely no preparation periods whatsoever. In addition, some teachers are expected to teach up to eleven different courses in our schools. (p. 7)

In some of the more severe multi-grade situations where three and four room schools also offer high school courses, some teachers are actually teaching up to twenty or more courses (Directory of Newfoundland and Labrador Schools 1985-86).

Parsons (1983), in reporting on the Newfoundland and Labrador teacher workload situation, reported:

> It is not uncommon to find teachers trained in physical education or social studies with some background in science who are teaching science in addition to their main area of expertise. Thus teachers end up teaching courses in four or more disciplines plus a full complement of co-curricular activities. Such a workload greatly reduces the amount of time a teacher has to prepare for lab activities as compared to a teacher who is teaching only science, or one science to several classes at the same grade level. (p. 7)

The NTA Brief (1984) presented to the Department of Education pointed out that in large schools other problems exist:

> The teacher-student contact in some schools is of great concern. It appears that some teachers are meeting with 250 to 300 students every weekly cycle. Also, the lack of preparation time is a concern in both large and small schools. It was reported that some teachers were teaching classes as large as forty five in regular class and some of the shop courses and specialist area courses had numbers as high as twenty-five. (p. 7)

From the perspective of the review for this study, teacher-pupil ratio and teacher workload in general were seen as major factors potentially contributing to teacher effectiveness and student achievement and success. As was stated by Davidge (1982):

> Perhaps the overriding assumption that we have to make is that pupil-teacher ratio is an ineffective method of allocation of teachers in small schools. (p. 3)

Presently in the province of Newfoundland and Labrador teachers are allocated to school boards on the basis of the total pupil enrollment for the board. Maybe the time has come where it should be recognized that the teacher units needed in small schools cannot be provided under an allocation formula that treats all school sizes the same. Based upon the earlier research just mentioned, pupil-teacher ratio and teacher workload must be recognized as key variables in attempting to provide for equal student opportunity in all sizes of schools.

Teacher Experience and Training

A number of studies have identified a connection between teacher experience and training and the science achievement of students. Lo (1982), after having studied eight hundred and thirty-two junior secondary classes in Hong Kong, identified teacher experience as a variable which had a significant relationship with the science achievement of students. Few studies have looked at teacher experience and its relationship to student achievement, while also associating it with teacher training. The National Science Teachers' Association (1984) reported that one of the essential components of successful teaching and learning for high school science is a competent science teacher. Ryan (1983), in reference to teacher shortage and teacher qualification, expressed his concern over the number of different areas in which teachers are required to teach subjects for which they are not professionally trained. Griffiths (1983), in reference to the Newfoundland and Labrador situation, stated that:

> Newfoundland teachers are much more generalist than the Canadian average. Even at the senior high level, about one in three Newfoundland science teachers teaches science alone. (p. 2)

This problem is aggravated by the fact that small rural schools are less able to attract and retain well qualified teachers than are urban schools. This is supported by Harrison and Downey (1965) and Parsons (1983). Lack of recognition, fewer professional colleagues, and isolation are a few of the factors that make rural appointments less enticing to well-qualified teachers (Harrison and Downey, 1965). According to Gough (1983), many teachers have acknowledged that their background and experience are major obstacles to the achievement of the objectives of science teaching, most important of which is student achievement. Gough also suggested that a major task for this province would be the development of a co-ordinated plan for teacher re-education, which would be based on a needs assessment. One important question which requires answering is whether the teachers teaching in rural schools are qualified to teach each of the eleven science courses offered by the RHSP, such that small schools are free to select and offer to students any of the courses available under the program. If the teachers that are now teaching in these schools are not generalist science teachers, then the small school cannot offer any of these courses even if they have the other means to do so. The call for improvement in the preservice training of those who will teach in rural settings has been supported by Massey and Crosby (1983); Nachtigal (1982); Gleadow and Bandy (1982); Guenther and Weible (1983); Helge (1983) and Horn (1983). Nelson (1983), found that only 3 out of 41 colleges and universities surveyed offered training programs for rural teaching, and only 17 of 41 offered components in their teacher training programs related to teaching in rural areas. Memorial University, the teacher training facility for Newfoundland and Labrador, does not offer a program designed specifically for teachers who will teach in rural schools.

Another problem in preparing teachers for rural settings reported by Grippen, Sarachan-Deily, Medved, and

Lyon (1985) was that professors do not always know what is unique about rural education. Zetler (1982), also acknowledged this problem in pointing out that the rural teachers are quick to state that their college education did not prepare them for small school assignments. Nachtigal (1981) asked, "Is it not better to have teachers who understand the broad structure of their content areas than narrowly prepared technicians?" Studies conducted by Bear & Lynch, 1983; Guenther & Weible, 1983; and Hegtvedt-Wilson, Hegtvedt, and Bullock, 1982 supported this by reporting that while most teacher education programs are responding to the trend to specialize, rural educators still need to be generalist.

Science Learning Materials and Facilities

One of the essential components prerequisite to successful teaching and learning for high school science as reported by the National Science Teachers Association (1970) is sufficient science learning materials e.g., school library books, magazines, journals, newsletters etc. Smith (1983), in reporting results from the Science Council Canada Report 38, indicated that in the province of Newfoundland and Labrador, over 28 percent of the teachers assessed in the study rated the quality of their facilities and equipment as 'poor' or 'very poor' at the senior level. Further-more, in the same study, 65 percent of the senior teachers in the province rated their physical facilities and equipment as areas in which there were important obstacles to the achievement of their program objectives. Griffiths (1983), made reference to this in speaking to the future needs in science teacher training in Newfoundland and Labrador. Griffiths suggests:

> It seems that most of the teachers in this province work in an environment which is not conducive to the activity based approach to science. (p. 2)

Cummings (1980) and Muse (1983), in associating this concern with the small school, indicated that we sometimes fail to recognize that the smaller schools basically require the same kinds of equipment as larger schools even though their budgets are much smaller.

In the data received in response to the NTA Brief to the Department of Education (1984) it was found that school size was a definite factor in regard to teaching materials and physical facilities. In the survey conducted for the brief, a large percentage of the responses from the smaller schools of the province indicated that physical facilities were 'inadequate' or 'most inadequate'. In its recommendations to the Department of Education it suggested that every effort be made to provide adequate facilities for the RHSP and that special emphasis and accommodation be made for the smaller schools in the province.

Many other variables have been looked at in assessing the science achievement of students at various grade levels. The most common of these tend to be gender and students' attitude towards science.

Summary

In the literature search for this thesis no study similar to this was found to have been carried out in this province. Information gathered from studies such as that conducted by the Science Council of Canada (1983) was analyzed for the province as a whole. The schools from which the information was gathered were not broken down according to size. Even though there is information available on some of the variables defined in this study they have not been looked at in terms of pupil achievement, as this study attempts to do. There is very little literature available on science from a small school perspective, particularly as it relates to school size and achievement. Stephens (1985) gave support to this observation on the quantity and quality of rural educational literature in the following statement:

> ...when viewed as a whole, the literature is meager and much of it lacks sophistication. Moreover, there is not at present a body of research providing a comprehensive and inclusive view of rural education that even begins to approach that on education in an urban setting, one useful benchmark on which

> to judge relative quantity and quality. (p. 167)

Stephens (1985) further stated that:

> The absence of a comprehensive and inclusive research literature on rural schools represents a major obstacle to the furtherance of rural interest at a time when the potential for fundamental change in rural education policy is perhaps the greatest in recent history. (p. 167)

Berkner, (1985) also identified a lack of such research literature in reporting:

> Most research of this nature focuses on urban schools (which tend to be large) and fails to bring out differences between large and small schools. (p. 145)

The writer has had a similar experience in conducting a search of the related literature. Admittedly the references are scarce but are pertinent to the problems that exist.

CHAPTER 3

DESIGN AND PROCEDURES

Significance of the Study

This study is important in that it has the potential for identifying whether or not the reorganized high school program in its present form is providing an equal opportunity for students to achieve in science in each of the various sizes of high schools in this province. If it can be shown that a significant difference exists in the level of science achievement in each of the three school sizes, then the information might initiate some action to modify present curriculum in order to address the science needs of the weakest category of schools. As Colton (1981) suggests, it is usually assumed that any inferiority would be found in the small school, particularly in science.

If this research can produce evidence that the science achievement of students in our small schools is significantly less than in the medium or large size schools, then the study would provide a rationale for posing the following questions to the Department of Education for the province of Newfoundland and Labrador.

1. Should the small rural schools of this province be offering at the high school level courses in science that address the unique conditions in these schools?

2. Should we be training science teachers to teach in rural schools?

3. Is there a need to adapt our science facilities to the needs of science in the small school?

In the province of Newfoundland and Labrador the small schools (those with 65 or less high school students) make up thirty three percent of the total high school student population. The resettlement program is over and small communities are once again beginning to struggle for self reliance and the ability to compete with the larger centers, if not in quantity than certainly in quality.

The importance of this study is that it attempts to identify whether the present quality of science education in these small schools is comparable to that of medium and large size schools of the province. If this research can demonstrate that it is not, then it is most important that the quality of science produced in these schools be upgraded in order that all students graduating from high schools have an equal opportunity in today's society regardless of the size of school from which they graduate.

The Design of the Study

The main purpose of this study was to investigate whether a significant difference exists in the science achievement of Grade 12 students in this province in schools of various sizes. The study also looked at some of the variables which might influence the level of science achievement in each of the categories of schools surveyed. The variables investigated were:

1. Science courses being offered.
2. Number of science credits being completed by students.
3. Years of teaching experience of teachers.
4. Number of science education courses completed by teachers.
5. Extent to which teachers feel prepared to teach science.
6. Teacher course assignment in science.
7. Total courses taught by science teacher.
8. Science courses schools are equipped to offer.
9. Adequacy of science reading materials.
10. Adequacy of science facilities and equipment.
11. Class size.

Population

The population for this study consisted of approximately 8900 senior high school students who were in their third or fourth year during the 1985-86 school year.

School size was determined according to the senior enrollment statistics for 1984-85. The senior high schools throughout the province were divided into three sizes, small, medium and large, according to the classification defined in Chapter I.

Statistics for 1984-85 showed a total of 205 schools offering senior high courses (Newfoundland and Labrador Directory of Schools, 1985). Ten of these schools were offering courses only for students in either their first year or years One and Two (See Appendix A). These students would then have to go to some other school to complete their graduating year. All of the schools in Appendix A come under the small schools category, which makes a total of 69 such schools in the category defined above. This study includes only the 195 schools that are offering the courses required to complete Grade 12.

Sampling Procedure

A total of fifty schools were randomly selected from each of the three school size categories (See Appendix B).

From each selected school, one student was randomly selected to complete the science achievement test chosen for the study. Each student was randomly selected from among the total number of third and fourth year students registered at each of the schools selected for the study. These were students registered with the Department of Education on or before 1984 and also registered for the June 1986 term. These students were classified as Grade 12 students during the 1985-86 school year. In addition to the student achievement test a questionnaire pertaining to the variables identified earlier was completed by one science teacher randomly selected from each of the schools.

Instrumentation

There were two instruments used in this study:

1. A science achievement test for the students.

2. A teacher questionnaire consisting of thirteen questions.

The student achievement test which was used came from a battery of tests entitled "Form T-Test of Achievement and Proficiency", Scannell (1983). A copy of this test, along with the solution key, is contained in Appendix C.

Test Reliability and Validity.

This test was chosen from among twelve such tests designed to measure science achievement or literacy at the Grade 12 Level. This test was chosen because of its correlation with the science courses which make up the senior high school science curriculum. This test was also evaluated as having the best formulated questions, of which a number referred to related graphs and diagrams. It was constructed according to specifications which reflect currently accepted curricular practices, and was then reviewed by curriculum specialists. A K-R 20 formula value of 0.85 was computer calculated as the reliability of the test.

According to Scannell (1983) the basic goal of the developers of the test was:

> to emphasize the use of basic skills and the common knowledge that are marks of a well-educated high school graduate, a person who can function effectively and independently in a complex society. (p. 6)

The test was also developed to reflect the widely used curriculum projects and thus to stress objectives related to content, process, and scientific attitudes. Two of the uses for which this test was developed are:

1. To study individual student and class strengths and weaknesses.

2. To revise courses of study and instructional activities.

The test was piloted in four provincial schools. The content validity of the test was assessed through the opinions of four high school science teachers in these schools. It was looked at in light of the present science curriculum offered to the high schools of Newfoundland and Labrador.

The teachers of the pilot schools were unanimous in their belief that the instrument was valid for assessing science achievement of Grade 12 students in the high schools of this province.

Teacher Questionnaire

The teacher questionnaire was administered to 150 teachers. Each teacher was randomly selected from the total number of high school teachers in each school. The directions given to provide the data suggested that the teacher completing the questionnaire also administer the student achievement test. The questionnaire was designed to cover a number of variables which might affect the student achievement outcome. These variables include: (1) science courses being offered (2) number of science credits completed by students (3) teacher experience (4) number of science education courses completed by teachers (5) extent to which teachers feel prepared to teach science (6) teacher course assignment in science (7) total courses taught by science teacher (8) science courses schools are equipped to offer (9) adequacy of science reading materials (10) adequacy of science facilities and equipment and (11) class size. There are a total of thirteen questions included in this questionnaire. (See Appendix D.) The formulation of these questions was mainly based upon the type and format developed for the British Columbia Science Assessment (Taylor, 1982) and those developed for Report 36 - Science for Every Student by the Science Council of Canada (Orpwood and Alam, 1984). The reliability and validity of the teacher questionnaire are perceived by the author to be consistent with the standards established for the teacher questionnaires of these two studies.

Procedure

The achievement test and the questionnaire were sent to each of the science coordinators of the Districts containing the schools randomly selected for the study (see Appendix E). A covering letter related to the study was sent to each District Superintendent (see Appendix F). The science coordinator was responsible for the distribution and collection of the instruments in his/her district and the return of the instruments to the author. A letter to the teachers, pertaining to both the student achievement test and the teacher questionnaire, is found in Appendix G. Students were given exactly 45 minutes to complete the test. Student directions for completing the achievement test are found in Appendix H. The time assigned for the two instruments to be completed was between the first of March and the middle of April, 1986.

Analysis

The null hypothesis was tested by a two way analysis of variance, with school size as one factor and the number of courses completed by students as the other. The mean scores were compared for students having completed equal numbers of science courses (see Figure 2). The numbers of science courses were categorized as one and two courses; three and four; and five or more. Any science course in which students were enrolled at the time the survey was being completed was also included in the number of courses completed. The scores were grouped as outlined in Figure 2.

Figure 2

Science Achievement

No. of Courses Completed	Small	School Size Medium	Large
1 - 2			
3 - 4			
5 +			

All data were subjected to analysis by use of programs contained within the Revised Edition of the Statistical Package for the Social Sciences (SPSSX) (Statistical Package for the Social Sciences, Inc., 1983).

The Statistical Package (SPSSX) analysis provided descriptive statistics on the responses to the teacher questionnaire. The significance of these results was tested by a chi-square test from the same statistical package.

CHAPTER 4

RESULTS AND DISCUSSION

Introduction

Chapter 4 is devoted to a presentation of relevant descriptive statistics and analysis of the data collected through the use of the instruments and procedure described in Chapter 3. In this chapter, the author will also attempt to discuss the meaning of the data in terms of its statistical and educational significance. Discussion of the twelve questions will focus on the small school. First the data were analyzed to test the null hypothesis and an analysis was then made in response to the twelve questions posed in Chapter 1. The data analysis was carried out using the computer system at Memorial University of Newfoundland and Labrador. The statistical package used was the Revised Edition (SPSSX) (Statistical Package for the Social Sciences, Inc., 1983). Most of the tables in this chapter are reproductions of computer printouts.

Responses

There were a total of 150 schools randomly selected for the study, of which 120 responded or 80 percent. The 150 schools consisted of 50 from each of the three categories, small, medium and large which were defined in

Chapter 1. The 120 responses consisted of 43 small schools, 40 medium and 37 large.

Results

The null hypothesis stated that:

> There is no significant difference in the science achievement of Grade 12 students in terms of the size of school they attend.

The hypothesis was tested using a two way analysis of variance with school size as one factor and the number of courses completed by students as the other. The mean scores were compared for students in each size of school who had completed equal number of courses. The numbers of science courses were categorized as one and two courses, three and four, and five or more (See Table 1).

The level of significance selected for this test was $p < .05$. The F value was calculated to be 0.15 which equals a significance level of 0.86. The null hypothesis cannot be rejected by these values. Therefore, the null hypothesis that there is no significant difference in the science achievement of Grade 12 students in terms of the size of school they attend, must be accepted.

Table 1

Science Achievement by School Size

No. of Courses Completed	Small	School Size Medium	Large
1 - 2	33.84	23.54	32.66
3 - 4	31.44	34.15	30.31
5 +	35.00	37.00	39.20
Mean	33.16	31.88	34.11

Grand Mean - 32.95

School Size F - .147 Significance - .863

Number of Courses F - 5.52 Significance - 0.005

Interactions F - 2.617 Significance - 0.039

In comparing the achievement scores in relation to the number of courses completed, the value of F was found to be 5.52 which results in a significant difference of 0.005. The statement can therefore be made that there is a significant difference ($p \leq .05$) between the levels of achievement and the number of courses taken by Grade 12 students. This suggests that science achievement scores could be expected to increase with an increase in the number of science courses students take.

In a test for interaction between courses completed and school size, the value of F associated with these variables is 2.62 for a probability level of 0.04. Therefore, even though there is no significant difference between school size and student achievement in science, when school size and the number of courses taken interact together the science achievement levels are affected. The achievement scores are distinctly higher among students in medium and large size schools who have completed five or more courses (See Table 1). Further discussion of these results is found in Chapter 5.

Question 1.

Of the courses which are part of the high school program, which ones are being offered in schools of different sizes?

Frequencies and percentages related to question 1 are found in Table 2. Results from the schools surveyed showed that the number of science courses offered in small schools is less than the number offered in medium and large schools. There are two exceptions to that general statement; Biology 2201 is offered in slightly more (0.7 percent) of the small schools surveyed than medium size schools. Also, Geology

3203 is offered 6.2 percent more in the smaller schools surveyed than in the medium size schools. In all cases, the large school category has the greatest percentage of schools offering each course.

In the small schools surveyed, 90.7 percent are offering Biology 2201 and 81.4 percent are offering Biology 3201. Chemistry 2202 is being offered in 79.1 percent of these schools. However, only 7 percent of small schools indicated they were offering Chemistry 3202. Outside of the two biology courses and Chemistry 2202, there is a large decrease in the percentage of small schools offering the other science courses. Only 4.7 percent of the schools surveyed are offering Earth Science 2203 and less than half (34.9 percent and 39.5 percent) of the schools are offering Physics 2204 and Physics 3204. The same is true for Science 1200, Physical Science 2205, and Environmental Science 3205. There is clearly a lack of balance among the science courses being offered in the small schools surveyed.

Table 2

Frequency and Percent

of

Courses Offered by School Size

Course	Size of School Small	Medium	Large
Biology 2201	39(90.7)	36(90.0)	34(91.9)
Biology 3201	35(81.4)	35(87.5)	37(100)
Chemistry 2202	34(79.1)	35(87.5)	37(100)
Chemistry 3202	3(07.0)	19(47.5)	32(86.5)
Earth Sci 2203	2(04.7)	16(40.0)	28(75.7)
Geology 3203	22(51.2)	18(45.0)	19(51.4)
Physics 2204	15(34.9)	15(37.5)	19(51.4)
Physics 3204	17(39.5)	35(87.5)	35(94.6)
Science 1200	13(30.2)	32(80.0)	36(97.3)
Physical Sci 2205	10(23.3)	21(52.5)	25(67.6)
Envir. Sci 3205	13(30.2)	19(47.5)	28(75.7)

Question 2.

How does the number of science courses being taken by high school students compare in schools of different sizes?

The frequencies and percentages related to question 2 are found in Table 3. Results show that of the three sizes of schools surveyed, the small schools had the largest percentage (30.2) of students doing 0 - 2 courses. These schools also had the smallest percentage of students doing 3 - 4 and 5 or more courses in science. However, statistically there is no significant difference in the number of science courses taken by high school students in schools of different sizes. The chi square value was calculated to be 7.6 which results in an insignificant difference ($p = 0.11$) with $p > .05$. (See Table 3).

Table 3

Frequency and Percent

of

Number of Courses Taken by School Size

No. of Courses	Size of School Small	 Medium	 Large
0 - 2	13(30.2)	11(27.5)	3(8.1)
3 - 4	18(41.9)	20(50.0)	19(51.4)
5 +	12(27.9)	9(22.5)	15(40.5)

(chi square = 7.6, df = 4, p > .05)

Question 3.

Are students in each size of school doing courses in each of the pure sciences?

Response to this question indicate that there is a fairly even distribution of students doing courses in biology in each size of school. Thirty three percent of the students surveyed in small schools had taken courses in biology. However, only 4.7 percent of the students indicated that they had taken courses in chemistry. There is a significant difference ($p < .05$) in the number of students doing courses in chemistry in small schools compared to those doing chemistry in medium and large schools. The distribution, even though unstable, shows that the number of students taking chemistry increases with school size. In earth science the reverse is true. The responses indicate that the percentage of students doing courses in earth science decreases as school size increases. Forty two percent of students in small schools indicated having done courses in earth science while only 13.5 percent of those surveyed in large schools indicated having completed courses in that subject area. Statistically, however, these differences are not significant ($p > .05$). In physics 27.9 percent of the students in small schools indicated having completed courses compared to 50 percent of the students in medium size schools and 40.5 percent in large schools. The difference in the number of courses taken by school size in the other subject areas (Science 1200, Physical Science 2205 and Environmental Science 3205) is less than the difference identified in the pure science areas.

The frequencies and percentages related to question 3 are found in Table 4.

Table 4

Frequency and Percent

of

Pure Science Courses Taken by School Size

	Size of School					
Courses	Small	Medium	Large	Chi Sq.	Df.	Sign.
Bio.	33(76.7)	25(62.5)	40(81.1)	6.0	4	.196
Chem.	2(4.7)	8(20.0)	16(43.2)	18.0	4	.001
Earth.	18(41.9)	10(25.0)	5(13.5)	8.3	4	.082
Phy.	12(27.9)	20(50.0)	15(40.5)	7.9	4	.096
Oth.	12(27.9)	16(40.0)	11(29.7)	3.7	4	.450

Notes: Earth Science includes Geology.

Other = Science 1200, Physical Science 2205 and Environmental Science 3205

Question 4.

How does the teaching experience of science teachers throughout the province compare in schools of different sizes?

The frequencies and percentages related to question number 4 are found in Table 5. Results from the teachers surveyed show that small schools have the greatest percentage (26.6) of teachers with less experience (1 - 2 years) and the smallest percentage (11.6) of teachers with 15 or more years. However, statistically there is no significant difference in the number of years of teaching experience among teachers in schools of different sizes. The chi square value was calculated to be 12.2 which resulted in an insignificant difference $(p = 0.14)$ where $p > .05$ (See Table 5).

Table 5

Frequency and Percent

of

Experience of Science Teachers by School Size

	Size of School		
Experience	Small	Medium	Large
1 - 2 yrs	11(25.6)	3(7.5)	3(8.1)
3 - 5 yrs	6(14.0)	6(15.0)	6(16.2)
6 - 10 yrs	13(30.2)	12(30.0)	9(24.3)
11 - 15 yrs	8(18.6)	14(35.0)	9(24.3)
15 +	5(11.6)	5(12.5)	10(27.0)

(chi square = 12.2, df = 8, p > .05)

Question 5.

How do the qualifications of science teachers throughout the province compare in schools of different sizes?

Results showed that of the teachers surveyed, 46.3 percent did not respond to this item on the teacher questionnaire. The frequencies and percentages of teacher training in each of teaching science, biological sciences, earth/space/and general science, chemistry, physics, and other sciences are found in Table 6. The only level of statistical difference ($p < .05$) between school sizes in each of these training areas is in the area of physics ($p = .02$). The low cell distribution of responses decreases the reliability of these statistics related to question 5.

Table 6

Teacher Training by School Size

	School Size									
	Small			Medium			Large			
Training	0-1	2 or 3	4+	0-1	2 or 3	4+	0-1	2 or 3	4+	Sign.
Teaching Science	6(23.1)	15(57.5)	5(19.2)	4(12.5)	17(53.1)	11(34.4)	4(14.3)	16(57.1)	8(28.6)	0.673
Biological Science	2(8.3)	8(33.3)	14(58.3)	1(3.3)	5(16.7)	24(80.0)	3(11.5)	5(19.2)	18(69.2)	0.404
Earth/Space/General Science	7(26.9)	11(42.3)	8(30.8)	4(14.8)	12(44.4)	11(40.7)	3(13.0)	9(39.1)	11(47.8)	0.631
Chemistry	1(6.7)	6(40.0)	8(53.3)	1(3.6)	10(35.7)	17(60.7)	2(7.7)	11(42.3)	13(50.0)	0.929
Physics	6(30.0)	9(45.0)	5(25.0)	2(5.9)	17(50.0)	15(44.1)	1(3.4)	12(41.4)	16(55.2)	0.019
Other Sciences	2(11.8)	5(29.4)	10(58.8)	--	6(35.3)	11(64.7)	--	6(42.9)	8(57.1)	0.389

Question 6.

How well prepared for the teaching of science do teachers perceive themselves in schools of different sizes?

Results show that of the teachers surveyed, in small schools 30.2 percent felt not at all or just somewhat prepared to teach science. None of the teachers in medium size schools felt unprepared while only 2.7 percent of the teachers in large schools felt unprepared. Only 9.3 percent of the teachers surveyed in small schools felt more than adequately prepared to teach science, while 37.5 percent in medium size schools responded this way and 45.9 percent of those in large schools felt more than adequately prepared.

The chi square value of 30.4 resulted in a statistical difference ($p < .05$) among teachers in schools of various sizes in preparedness to teach science. Science teachers in the small schools surveyed feel less prepared to teach science than teachers in medium or large size schools (See Table 7). The reliability of the statistics related to this question is decreased by the low cell distribution of responses.

Table 7

Frequency and Percent

of

Perception of Preparedness to Teach Science by School Size

Prepared	Small	Medium	Large
	Size of School		
Not at all/Somewhat	13(30.2)	-	1 (2.7)
Adequate	26(60.5)	25(62.5)	19(51.4)
More than Adequate	4(9.3)	15(37.5)	17(45.9)

(chi square = 30.4, df. = 4, p < .05)

Question 7.

How do the science teaching assignments of teachers compare in schools of different sizes?

Results showed that of the teachers surveyed in small schools, there were no teachers teaching only science, while 30.2 percent of these teachers were teaching science less than 25 percent of the time. In medium size schools 7.7 percent were teaching science 25 percent of the time while only 2.8 percent were teaching science for this amount of time in large schools.

The chi square value of 31.8 reported a significant statistical difference ($p < .05$) between science teaching assignment and school size. The percentage of science being taught by teachers surveyed can be expected to increase with school size (See Table 8).

Table 8

Frequency and Percent

of

Science Teaching Assignment by School Size

	Size of School		
Assignment	Small	Medium	Large
Only Science	- (0.0)	7(17.9)	14(38.9)
50% of Time	15(34.9)	18(46.2)	15(41.7)
25 - 50%	15(34.9)	11(28.2)	6(16.7)
< 25%	13(30.2)	3(7.7)	1(2.8)

(chi square = 31.8, df. = 6, $p < .05$).

Question 8.

How does the number of courses that teachers are teaching compare in schools of different sizes?

Results show that of the teachers surveyed 30.2 percent of those teaching in small schools are teaching nine or more courses. In the medium size schools 5 percent of the teachers were teaching this number of courses while none of the teachers in the large schools had such a course workload.

The chi square value of 27.6 resulted in a statistical difference of $p < .05$ between the number of courses taught by teachers and the size of school. Teachers in small schools are teaching a significant number of courses more than those teachers in medium and large size schools (See Table 9).

Table 9

Frequency and Percent

of

Number of Courses Taught by School Size

	Size of School		
No. of Courses	Small	Medium	Large
1 - 4	8(18.6)	8(20.0)	18(48.6)
5 - 8	22(51.2)	30(75.0)	19(51.4)
9 +	13(30.2)	2(5.0)	-

(chi square = 27.6, df. = 4, $p < .05$).

Question 9.

Are all schools equipped to offer each of the science courses within the high school program? If not, which courses are schools not equipped to offer?

Results showed that of the responses, 86 percent of the teachers in small schools rated their schools as not equipped to offer all of the high school science courses. In medium size schools, 64.1 percent of the teachers indicated that their school was not equipped to offer all courses while the teachers of large schools indicated 31.4 percent (See Table 10).

Table 10

Frequency and Percent

of

Schools Equipped to Offer All Courses

as Perceived by Teachers Surveyed

	Size of School		
	Small	Medium	Large
Yes	6(14.0)	14(35.9)	24(68.6)
No	37(86.0)	25(64.1)	11(31.4)

(chi square = 24.6, df. = 2, $p < .05$).

The chi square value of 24.6 indicates that there is a significant difference $p < .05$ between the size of school and whether it is equipped to teach all science courses within the high school program. The small schools surveyed are less equipped to offer all courses than medium and large size schools.

Table 11 shows the courses which teachers responding to the study felt schools are not equipped to offer. Of the small schools surveyed, 67.4 percent of the teachers felt that their school was not equipped to offer Chemistry 2202 and 74.4 percent felt that their school was not equipped to offer Chemistry 3202. There were 51.2 percent of the small schools not equipped to offer Physics 3204 and 39.5 percent not equipped to offer Physics 2202. The same percentage was indicated for Geology 3203. There were more small schools equipped to offer biology courses than any of the other pure sciences. The responses from medium size schools indicate that these schools need equipment for chemistry more than any other course, whereas the large schools indicated that 16.2 percent were not equipped to offer Geology 3203 (See Table 11).

Table 11

Frequency and Percent

of

Courses Schools are Not Equipped to Offer

as Perceived by Teachers Surveyed

Course	Small	Medium	Large
		Size of School	
Biology 2201	7(16.3)	3(7.5)	-
Biology 3201	7(16.3)	3(7.5)	1(2.7)
Chemistry 2202	29(67.4)	19(47.5)	4(10.8)
Chemistry 3202	32(74.4)	22(55.0)	4(10.8)
Earth Sci. 2203	9(20.9)	5(12.5)	5(13.5)
Geology 3203	17(39.5)	10(25.0)	6(16.2)
Physics 2204	17(39.5)	2(5.0)	4(10.8)
Physics 3204	22(51.2)	7(17.5)	4(10.8)
Science 1200	5(11.6)	-	-
Physical Sci. 2205	11(25.6)	-	-
Envir. Sci 3205	6(14.0)	-	2(5.4)

Question 10.

How does the adequacy of the science reading materials available to students compare in schools of different sizes?

Teachers responding to this question from small schools indicated that 37.2 percent of these schools have very inadequate reading materials for science, while 48.8 percent indicated that the reading materials are somewhat inadequate.

The chi square value of 27.2 indicate that there is a statistical difference ($p \leq .05$) between the adequacy of science reading materials and size of school. The cross-tabulation in Table 12 gives data demonstrating that the adequacy of reading materials significantly increases with school size. The two empty cells in the more than adequate row decreases the reliability of these statistics related to question 10.

Table 12

Frequency and Percent

of

Adequacy of Science Reading Materials by School Size as Perceived by Teachers Surveyed

	Size of School		
Adequacy	Small	Medium	Large
Very Inadequate	16(37.2)	8(20.0)	2(5.4)
Somewhat Inadequate	21(48.8)	17(42.5)	11(29.7)
Satisfactory	6(14.0)	15(37.5)	22(59.5)
More than Adequate	-	-	2(5.4)

(chi square = 27.2, df. = 6, $p < .05$).

Question 11.

How do science teachers in schools of different sizes rate the quality of the facilities and equipment available to teach science?

Responses to question 11 indicate that 47.6 percent of the teachers surveyed in small schools indicated that the quality of facilities and equipment to teach science in their school was very poor to poor. In the medium schools, 33.3 percent reported the same condition, while 26.5 percent of the teachers of large schools reported very poor to poor quality facilities and equipment.

The chi square value of 7.2 indicate that there is no significant difference between the quality of facilities and equipment to teach science and school size. The percentages however indicate that teachers in small schools rate the quality of facilities for science below that of the teachers surveyed in medium and large schools (See Table 13). The low frequencies in the excellent row in Table 13 decreases the reliability of these statistics related to question 11.

Table 13

Frequency and Percent

of

Quality of Facilities and Equipment to Teach Science

	Size of School		
Quality	Small	Medium	Large
Very Poor - Poor	20(47.6)	13(33.3)	9(26.5)
Good	21(50.0)	25(64.1)	21(661.8)
Excellent	1(2.4)	1(2.6)	4(11.8)

(chi square = 7.2, df. = 4, p > .05).

Question 12.

What is the average size of science classes in schools of different sizes?

Teacher response to this question indicate that 34.9 percent of the small schools surveyed have science classes made up of 10 or < 10 students. The majority, 58.1 percent, of the small schools have a class size of between 11 and 20 students. This was also the class size indicated by the majority (57.5 percent) of responses from medium size schools. In the large schools 67.6 percent of the responses indicated class sizes between 21 and 30 students.

The chi square value of 61.5 indicates that there is a significant difference ($p < .05$) between the average size of science classes in schools of different sizes. The responses indicated that small schools can be expected to have smaller science classes than medium and large schools (See Table 14). The instability in the distribution of the cells in Table 14 decreases the reliability of the statistics related to question 12.

Table 14

Frequency and Percent

of

Average Size of Science Classes by School Size

	Size of School		
Size	Small	Medium	Large
10 or less	15(34.9)	2(5.0)	-
11 - 20	25(58.1)	23(57.5)	6(16.2)
21 - 30	3(7.0)	14(35.0)	25(67.6)
30 +	-	1(2.5)	6(16.2)

(chi square = 61.5, df. = 6, p < .05)

Summary

The results described in this chapter relate to the null hypothesis and the twelve questions posed in Chapter 1. Each was described with a focus on the small school.

It was found that the null hypothesis could not be rejected. There was no significant difference found between the science achievement of Grade 12 students and the size of school they attend. There was however a significant difference between science achievement and the number of courses taken by students. A test for interaction between courses completed and school size also indicates that when school size and the number of courses taken interact together the science achievement levels are affected.

Questions one to twelve responded to the extent of the diversity in the human and material resources related to high school science in schools of different sizes. There is clearly a lack of balance among the sciences in courses being offered in the small schools surveyed, which also relates to the smaller number of science courses being taken by students in small schools. This is also associated with the imbalance of pure science courses being taken by these students.

There was no significant difference found in the teaching experience or science qualifications of teachers except in the area of physics. However, as already stated, the question on teacher qualifications was not frequently answered, and this may be the reason for the lack of a significant difference in these results. Science teachers in the small schools surveyed also felt less prepared to teach science than teachers in medium or large size schools. The percentage of science taught by teachers increased with school size, while the teachers in small schools were also teaching a significant number of courses more than those teachers in medium and large schools. Teachers' responses indicated that small schools are less equipped in facilities, science equipment and science reading materials than other schools.

A discussion of the findings as well as implications and recommendations from these results is presented in Chapter 5.

CHAPTER 5

SUMMARY AND DISCUSSION

Introduction

Chapter 5 presents an overall summary of the study which includes: a summary of the problem, methodology and results; interpretation and implications of the findings; and recommendations from the findings.

Summary of the Problem, Methodology and Results

There are 205 schools in the province of Newfoundland and Labrador offering courses in the high school program. The demographic data indicate that one third of these schools have a high school student population less than or equal to 65. The student population of schools is the governing factor which determines the number of teacher units assigned to schools and the amount of funding. Therefore, school size is a major factor which determines the availability of human and material resources to teach science. The Reorganized High School Program for this province was implemented under the assumption that one program would fit schools of all sizes. Given the range in the student population in the 205 schools, this study was set up to look at the general question of whether or not the concept "one size fits all" addresses the high school science needs of the various school sizes of this province.

More specifically, the study was set up to determine whether or not there is a significant difference in the science achievement of grade twelve students in terms of the size of school they attend. It also looked at whether or not there is a significant difference in the science courses offered by school size and whether or not students in each size of school are doing courses in each of the pure sciences in order to give them a balance in the concepts of science beyond grade nine. In addition to this, the study examined other factors related to the adequacy of human and material resources in schools of different sizes. These include: (1) years of teaching experience of teachers, (2) number of science education courses completed by teachers, (3) extent to which teachers feel prepared to teach science, (4) teacher course assignment in science, (5) total courses taught by science teachers, (6) science courses schools are equipped to offer, (7) adequacy of science reading materials, (8) adequacy of science facilities and equipment, and (9) class size. Most of the related literature indicated that any inferiority in these factors, except for class size, would be found in the small school.

The study divided the total number of schools offering grade twelve into three categories; small, medium and large. A total of fifty schools were randomly selected from each of the three school size categories. From each selected school, one student and one teacher were randomly selected to complete the instruments used to collect the data. A science achievement test was administered to the selected students to test the null hypothesis, while a teacher questionnaire relating to the human and material resources for science was given to the selected teachers. All data were subjected to analysis by use of programs contained within the Revised Edition of the Statistical Package for the Social Sciences (SPSSX) (Statistical Package for the Social Sciences, Inc., 1983).

The results indicated that there was no significant difference between the science achievement of grade twelve students and the size of school they attend. However, a significant difference was found between science achievement and the number of science courses taken by students. It was also found in a test for interaction between courses completed and school size, that when school size and the number of courses taken interact together the science achievement levels are affected.

Questions one to twelve assessed the extent of the diversity in human and material resources related to high school science in schools of different sizes. An analysis of the data indicated the following results relating to the schools surveyed:

1. There is a lack of balance among the science courses being offered in the small schools, for example, more

schools are offering biology than any of the other sciences.

2. Students in small schools had taken fewer science courses than students in medium and large schools.

3. There is an imbalance in the number of pure science courses being taken by students in small schools. Most students had taken courses in biology while fewer had taken courses in chemistry, physics and earth science/geology.

4. There was no significant difference found between years of teaching experience and school size.

5. There was no significant difference found in the science qualifications of teachers in schools of different sizes except in the area of physics.

6. Science teachers in small schools felt less prepared to teach science than teachers in medium and large size schools.

7. The percentage of teacher time devoted to science increased with school size.

8. Teachers in the small schools were teaching a significant number of courses more than those teachers in medium and large schools.

9. Teacher responses indicated that small schools are less equipped in facilities, science equipment and science reading materials than medium and large size schools.

10. Science classes in small schools are smaller than in medium and large size schools.

Interpretation of the Findings

Student Achievement

The overall findings of this study as they pertain to high school science in this province may have been different had the study been set up to include the ten smallest schools that are offering courses in the high school program. However, these schools were not offering a full three year program in which students can graduate and therefore were not included in this study. The high school student population of these schools ranges from one to fifteen and has characteristics both human and material that are different from the other 195 schools because of their smallness. Another important difference is that these schools have the smallest number of teacher units and lowest funding because of the present Department of Education formula for the allocation of teacher units and funds. Consequently, when looking at the overall problems associated with science in the small schools of this Province, these ten smallest schools should be included, since these are the schools which the present system least addresses.

The findings could not reject the null hypothesis that there is no difference in the science achievement of grade twelve students in terms of the size of school they attend. A factor contributing to these results may have been the high dropout rate of students in small schools which might affect the ability level of the students randomly selected in the small school category. In a report entitled "Leaving Early: A Study of Student Retention in Newfoundland and Labrador" (1984) conducted to determine the level of student dropout rate in the province, it was found that the highest percentage of early school leavers was found in predominantly rural districts/communities. If success in school, as was also indicated by the report, is one of the determining factors contributing to dropout, then the implication may be made that the grade twelve students remaining in the small schools should be the "cream of the crop." In other words, the remaining students could be expected to have higher levels of intelligence than if the dropout rate had been comparable to that of larger schools. Therefore, it is the opinion of the author that the higher dropout rate in small schools may have had some influence on the overall comparisons of science achievement by school size. This could have been overcome, had the author controlled the range of IQ in students randomly selected for the study.

Findings pertaining to the twelve questions related to the teacher questionnaire have major implications related to the concept "one size fits all" which was the assumption under which the Reorganized High School Program was implemented. In other words, it was not developed with sufficient flexibility to address the science needs of students in small schools. The results show that the small schools surveyed are not offering a balanced science program from which students may select courses in each of the pure sciences. This is supported by the data showing the percentage of students who have taken courses in each of the science areas. For example, only 4.7 percent of the students in small schools indicated that they had taken courses in chemistry. It is the opinion of the author that the need exists to develop at least one science course for the small school which includes a balanced approach to the four major sciences. This would alleviate the problem of trying to find ways to offer all courses separately as is presently the case.

Human Resources

Characteristics related to human resources did not show the same diversity by school size as did the material resources. There was no significant difference found in the teaching experience of science teachers by school size, nor was there any difference found in the science qualifications of teachers except in the area of physics where teachers in small schools had less training. There were, however, other differences found in teacher training even though they were not significant ($p > .05$). These can be seen in Chapter 4, Table 6. An important factor which must be recognized is that in order for small schools to offer courses to students in each of the pure sciences, it is imperative that science teachers be generalists in training and approach. This was supported in studies conducted by Bear and Lynch, 1983; Guenther and Weible, 1983; and Hegtvedt-Wilson, Hegtvedt, and Bullock, 1982. When asked how generally prepared they felt for the teaching of science, 30.2 percent of those teachers in small schools indicated that they were not at all or just somewhat prepared to teach science. This supports the need for a special training program to prepare teachers to teach in small schools. At present no such program exists in this province.

A significant difference was found to exist between science teaching assignment and school size. Response from the teachers surveyed indicated that none of the teachers in small schools were teaching science alone. Sixty five percent of these teachers were teaching science only 50 percent of the time or less. This demonstrates further the need for generalist teachers in small schools and special programs to train teachers to work in these unique conditions. Thirty percent of the teachers surveyed indicated that they were teaching more than nine courses, which in itself demonstrates the need for generalist training.

Material Resources

Questions relating to the material resources of schools clearly demonstrate a need to upgrade science resources in small schools. Eighty six percent of the teachers surveyed in small schools indicated that their school was not equipped to offer all of the high school science courses. In answering the question related to the quality of facilities and equipment to teach science 47.6 percent indicated that the quality was poor to very poor in small schools. These teachers also indicated that 86 percent of these schools have very inadequate to somewhat inadequate reading materials in science. Each question relating to material resources was asked in the form of attitudinal type questions using a Likert scale. As a result, the reliability of these responses may be questioned. These responses followed a Department of Education subsidy program which was made available to upgrade high school equipment. However, major problems associated with the subsidy program have been that money was provided only if school boards put up 50 percent of the total purchase price per school. Many boards were not in a financial position to do this. Also, the subsidy was made available for non consumable materials only, and did not include such things as science reading materials. Moreover, schools could only avail of the program once per course, which meant that if boards did not utilize 100 percent of the subsidy the first time, no more funding would be provided even though the subsidy continued to exist. A number of boards were not in a financial position to utilize the maximum funds available because of the equalization amount which they had to match. Lastly, orders for equipment could be based only upon the student enrollment during the year of subsidy. This would have left insufficient equipment for any increase in class size for following years. When one considers these weaknesses in the subsidy program, the teacher responses to the questions relating to science resource material appear realistic. These responses suggest the need for further program subsidies with fewer restrictions.

Finally, ninety three percent of the teachers in small schools indicated that their science classes consisted of 20 or < 20 students. Even though these teachers have more courses to teach, the small student-teacher ratio provides an advantage for instruction and individualized student attention over ratios found in medium and large size schools. This is one of many positive features which small schools have over larger schools. However, these features were not the focus of this study.

Recommendations from the Findings

During the time that this study was being completed, the Department of Education for this province had set up a committee to study small schools and to make recommendations for improvements. Having considered the results and insights obtained from conducting this study the author recommends to the Small Schools Committee and the Department of Education, that the following steps be taken towards overall improvement and the quality of science education for students in the small schools of this province:

-- that a different formula be established for the allocation of teacher units to small schools.

-- that a different formula be established for the allocation of funding to small schools.

-- that a committee be set up to recommend design changes to small schools, involving multi-purpose rooms which could allow these schools to accommodate the broadest range of courses.

-- that the Reorganized High School Program establish "built in flexibility" in order to accommodate the diverse characteristics which exist in small schools.

-- that science courses have "built in flexibility" in order to be more adaptable to the unique conditions which exist in small schools.

-- that at least one science course be developed with the small schools in mind, that would consist of a balance of topics relating to each of the pure sciences.

-- that extra teacher and student resources be provided to supplement science courses in the small school. These supplements should include VCR and computer resources.

-- that a different formula be established for the allocation of library funds to small schools.

-- that a plan be specifically designed to utilize government and industrial resource personnel in small schools, in order to enrich and supplement instruction.

-- that a committee be established to look at distance education as an educational supplement to small schools. This should be established to make more courses available to students and to supplement weaknesses in human and material resources.

-- that Memorial University develop a teacher training program to prepare teachers to teach in small schools.

-- that science curriculum guides be revised to include specific sections for teachers in small schools.

-- that a fundamental skills plan be developed for small schools as a framework into which each course would fit. This would enhance skill development while reducing overlapping in content areas.

-- that an equipment subsidy program be provided for small schools with fewer restrictions than those provided earlier.

A significant proportion of the total high school student population of this province will continue to attend small schools. The resettlement program is over and small communities are once again beginning to struggle for self reliance and the ability to compete with larger centers, if not in quantity, then certainly in quality. In order to accomplish this within the educational system and graduate students who have an equal opportunity in today's society, small schools must have adequate human and material resources.

It is the opinion of the author that in order to do this the Department of Education must pursue ways to improve the ability of small schools to serve the needs of the student, rather than having students conform to a system designed on the "one size fits all" concept.

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APPENDIX A

SMALL SCHOOLS OFFERING ONLY LEVEL ONE, LEVEL TWO OR BOTH

BOARD AND SCHOOL	GRADES OFFERED	HIGH SCHOOL ENROLMENT
VINLAND		
Port Hope Simpson	K-11	4
BAIE VERTE		
West Port Acad.	K-11	15
TERRA NOVA		
Glenwood Acad.	K-10	10
PORT AUX BASQUES		
LaPoile Acad.	K-10	3
Petites Elem.	K-10	1
ST. BARBE SOUTH		
River of Ponds A.G.	K-10	1
RAMEA		
Grey River Elem.	K-10	6
GANDER-BONAVISTA-CONNAIGRE		
Glenwood Prim.	K-10	10
BAY D'ESPOIR		
McCallum A.G.	K-11	14
PENTECOSTAL ASSEMB.		
Postville A.G.	K-10	3

APPENDIX B

SCHOOLS RANDOMLY SELECTED FOR THE STUDY

Schools with senior enrollment less than or equal to 65

BOARD AND SCHOOL	HIGH SCHOOL ENROLMENT
VINLAND	
Cook's Hr. A.G.	26
Griquet A.G.	33
Mary's Hr. A.G.	33
St. Lewis A.G.	16
STRAITS OF BELLE ISLE	
Main Brook C.H.	21
DEER LAKE	
Hampton C.G.	55
GREEN BAY	
Beaumont Acad.	28
King's Point A.G.	60
EXPLOIT'S VALLEY	
Badger Acad.	15
Cottrell's Cove A.G.	29
NOTRE DAME	
Change Island's Integ.	36
CAPE FREELS	
Greenspond Acad.	13
Lumsden C.H.	47
BONAVISTA - TRINITY - PLACENTIA	
Sunnyside A.G.	56
Swift Current A.G.	64
AVALON NORTH	
Dunville C.H.	34

BAY D'ESPOIR	
Francois A.G.	11
Gaultois A.G.	31
Hermitage C.H.	44
Rencontre East A.G.	14
Seal Cove A.G.	39
BAY OF ISLANDS - ST. GEORGES	
McKay's High	45
ST. BARBE SOUTH	
Trout River C.H.	25
Woody Point C.H.	46
LABRADOR EAST	
Hopedale Memorial	24
Nain Memorial	27
North West River A.G.	22
Rigolet Acad.	8
BURIN PENINSULA	
St. Bernard's C.H.	62
Terrenceville C.H.	60
CONCEPTION BAY NORTH	
Bay de Verde C.H.	55
Northern Bay C.H.	42
EXPLOIT'S - WHITE BAY	
Badger Collegiate	58
Brent's Cove C.H.	51
Buchan's A.C.	31
GANDER - BONAVISTA - CONNAIGRE	
Conne River A.G.	30
Hr. Breton A.G.	46
St. Brendan's A.G.	27
HUMBER - ST. BARBE	
Conche A.G.	22
Croque A.G.	19
Deer Lake C.H.	61
LABRADOR	
West St. Modeste A.G.	41
PLACENTIA - ST. MARY'S	
Southern Hr. C. H.	61

PENTECOSTAL ASSEMBLIES	
Charlottetown Acad.	17
Hawkes Bay A.G.	30
Middle Arm A.G.	43
Port Hope Simpson A.G.	26
Roddickton Colleg.	43
Stephenville Colleg.	39
SEVENTH DAY ADVENTIST	
St. John's Acad.	35

High school enrollment between 65 - 140

BOARD AND SCHOOL	HIGH SCHOOL ENROLMENT
STRAITS OF BELLE ISLE	
Forteau C.H.	74
DEER LAKE	
Sop's Arm C.H.	99
GREEN BAY	
LaScie Colleg.	86
Pilley's Island Colleg.	117
EXPLOIT'S VALLEY	
Bishop's Falls High	95
Buchans High	106
Point Leamington C.H.	106
NOTRE DAME	
Campbellton C.H.	129
TERRA NOVA	
Dover Acad.	132
Eastport C.H.	106
Musgrave Harbour A.C.	80
Victoria Cove C.H.	100
CAPE FREELS	
Trinity C.H.	112
BONAVISTA - TRINITY - PLACENTIA	
Hickman's Har. Integ.	70
Arnold's Cove A.C.	69
Port Rexton A.G.	90
AVALON NORTH	
Norman's Cove C.H.	139
Victoria C.H.	140
BURIN PENINSULA	
Jacques Fontaine High	87
BAY D'ESPOIR	
Harbour Breton C.H.	74
Milltown C.H.	102

PORT AUX BASQUES	
Isle Aux Morts A.G.	68
Burnt Islands Colle.	81
BAY OF ISLANDS - ST. GEORGES	
Lark Hr. A.G.	66
ST. BARBE SOUTH	
Daniels Hr. A.G.	67
Cow Head C.H.	94
Norris Point C.H.	131
BURGEO	
Burgeo C.H.	129
RAMEA	
Ramea C.H.	81
BURIN PENINSULA	
Burin C.H.	108
St. Lawrence C.H.	138
Lawn High	80
Rushoon A.G.	68
CONCEPTION BAY NORTH	
Carbonear C.H.	121
EXPLOIT'S - WHITE BAY	
Baie Verte High	122
FERRYLAND	
Mobile C.H.	140
Trepassey High	117
GANDER - BONAVISTA - CONNAIGRE	
King's Cove, C.H.	79
HUMBER - ST. BARBE	
Benoit's Cove Acad.	115
Curling C.H.	125
Port Saunders C.H.	115
LABRADOR	
Happy Valley A.G.	72
Wabush Collegiate	108
PLACENTIA - ST. MARY'S	
Mount Carmel C.H.	74
St. Joseph's A.G.	70
Dunville Acad.	125

PORT AU PORT	
DeGrau High	92
PENTECOSTAL ASSEMBLIES	
Robert's Arm Colleg.	66
St. Lunaire Colleg.	66
Springdale Colleg.	108

High school enrolment greater than 140

BOARD AND SCHOOL	HIGH SCHOOL ENROLMENT
VINLAND	
St. Anthony Colleg.	240
DEER LAKE	
Deer Lake R.H.	325
Pasadena Acad.	142
EXPLOIT'S VALLEY	
Botwood Sr. High	268
Windsor High	142
NOTRE DAME	
Lewisporte R.H.	253
Twillingate Collegiate	209
Virgin Arm Acad.	202
TERRA NOVA	
Gander Colleg.	445
Carmanville A.G.	164
Dark Cove High	182
Glovertown R.H.	180
BONAVISTA - TRINITY - PLACENTIA	
Clarenville High	394
Musgravetown C.H.	236
Bonavista Colleg.	199
Catalina R.H.	155
AVALON NORTH	
Bay Robert's Colleg.	722
New Harbour R.H.	241
Carbonear C.H.	157
Heart's Content R.H.	167
AVALON CONSOLIDATED	
Mount Pearl C.H.	490
Bishop's Colleg.	763
Booth Memorial	607
Prince of Wales Colleg.	717
PORT AUX BASQUES	
Channel R.H.	351

BAY OF ISLANDS - ST. GEORGE'S	
Herdman Colleg.	837
Gillams Colleg.	169
LABRADOR EAST	
Goose Bay High	345
LABRADOR WEST	
Labrador City High	247
BURIN PENINSULA	
Salt Pond R.H.	350
Fortune Colleg.	169
Grand Bank High	196
LABRADOR	
Labrador City Colleg.	233
ST. JOHN'S	
Manuels A.G.	258
Beaconsfield High	551
Brother Rice High	641
Gonzaga R.H.	501
Holy Heart of Mary R.H.	1120
Bell Island High	146
Goulds C.H.	199
GREEN BAY	
Springdale Collegiate	157
BAY ST. GEORGE	
Stephenville Crossing C.H.	177
CONCEPTION BAY CENTRE	
Roncalli Central High	299
FERRYLAND	
Ferryland R.H.	162
GANDER - BONAVISTA - CONNAIGRE	
St. Alban's C.H.	152
HUMBER ST. BARBE	
Regina High	208
PLACENTIA - ST. MARY'S	
St. Mary's Acad.	159
Placentia R.H.	291

PORT AU PORT	
Port au Port West High	195
PENTECOSTAL ASSEMBLIES	
Lewisporte Colleg.	170

Level 48 Begin Here

61. **What is characteristic of communities of social animals?**

A. Individuals have specific functions.
B. All the animals do the same kind of work.
C. The society takes over dens of other animals.
D. The communities are always a nuisance to people.

62. **Which of the following is not a characteristic of a biological system?**

A. Many separate components form a more complex network.
B. Each component in a system has a unique function.
C. Components function independently of each other.
D. Other components are affected by the performance of one component.

63. **Algae which thrive on oxygen may feed on fertilizer that gets into streams. When the amount of algae in the stream gets too high, which of the following may result?**

A. The algae can be taken out of the water and used as fertilizer.
B. The algae can be "harvested" to provide a source of vitamins for people.
C. Fish may die from suffocation.
D. Fish grow rapidly because they feed on algae.

64. **Which of the following best supports a theory that life on earth began in the oceans?**

A. The oldest fossils are of marine life.
B. Salt is found in the blood of all mammals.
C. Protoplasm contains water.
D. Marine fossils are found where oceans once existed.

DIRECTIONS: *Use this information for items 65 and 66.*

A student hypothesized that mice cannot live in a carbon dioxide atmosphere. One mouse was placed in a large container of carbon dioxide with food, water, and shelter. In less than 15 minutes the mouse died.

65. **Select the most scientific interpretation of this "experiment."**

A. The mouse could not have died from anything except carbon dioxide.
B. In terms of this experiment, the hypothesis must be accepted.
C. The mouse probably got indigestion from the food and then died.
D. This was a cruel and useless experiment.

66. **Which of the following changes, if any, would improve the research design?**

1. **Use more mice.**
2. **Use a control with an air atmosphere.**

A. Both 1 and 2
B. Only 1
C. Only 2
D. Neither 1 nor 2

Make no marks in this booklet.

67. **The chemical composition of moon rocks is quite different from that of earth rocks. This fact has helped to**

A. show that the moon was formed outside our galaxy.
B. disprove the hypothesis that the moon was formed from part of the earth.
C. encourage plans to mine the moon in the future.
D. explain noticeable features observed when the moon is full.

68. **Which controls or catalyzes chemical reactions within cells?**

A. Bile
B. Enzymes
C. Hormones
D. Vitamins

69. **The rate at which soil is eroded from land surfaces depends least on the**

A. slope of the surface.
B. amount of water flowing.
C. grass or surface cover.
D. temperature of the water.

70. The best way to find out if pulse rate changes after swimming twice around a pool is to

A. check the pulse rate of a number of people before and after they have swum twice around the pool.
B. ask friends whether their pulse rates change when they swim twice around the pool.
C. check the pulse rates of all the people in the pool who have swum at least twice around the pool.
D. check a person's pulse rate before swimming and compare it to the pulse rate after swimming twice around the pool.

71. To compare the effect of rain water and tap water on growth rate, plants of the same kind and height are selected. For a month one plant is watered with tap water, the other with rain water. Which of these considerations is <u>least</u> important to the conclusion reached in the study?

A. Are equal amounts of water used?
B. Is the same soil used?
C. Do the plants receive equal amounts of sunshine?
D. What kind of plants are used?

72. The increase in life expectancy from 21 years in 1500 A.D. to 70 years in 1975 can <u>best</u> be explained by

A. the benefits derived from scientific knowledge.
B. improvement in the human diet.
C. the genetic improvement in humans.
D. a less hostile world environment.

73. Human lungs frequently have inactive air sacs, hardened surfaces, or infections resulting from disease, chemicals, smoking, or aging. The most serious consequence of such damage is

A. chronic cough.
B. shortness of breath.
C. inadequate oxygen–carbon dioxide exchange.
D. inability to exercise vigorously.

74. Where does the exchange of cell nutrients and waste products occur?

A. Arteries
B. Capillaries
C. Plasma
D. Veins

75. Involuntary reaction to a loud noise is an example of

A. a conditioned response.
B. an instinct.
C. a learned behavior.
D. a reflex.

Four mice of the same age are given a daily injection of vitamin B_{12}. Four other mice of the same age and weight as the first group are not given any injections of vitamin B_{12}. After two months all the mice are weighed with the following results:

Weight of mice given B_{12}	Weight of mice not given B_{12}
22 g	18 g
33 g	13 g
27 g	21 g
30 g	19 g

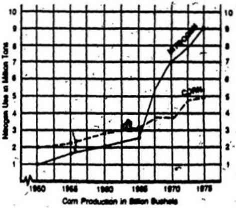
76. Which one of the following hypotheses is supported by these data?

A. Mice injected with vitamin B_{12} are healthier than mice that are not given vitamin B_{12}.
B. People would grow larger if they were given injections of vitamin B_{12}.
C. Most mice suffer from insufficient vitamin B_{12}.
D. Vitamin B_{12} affects the growth of mice.

77. Which of the following conclusions is warranted by the accompanying graph of nitrogen use and corn production?

A. Corn production and use of fertilizer are linearly related.
B. No evidence of relationship between fertilizer use and corn production exists.
C. Corn production increases with fertilizer use only to certain limits.
D. Corn production depends more on other factors than on nitrogen fertilizer.

CORN PRODUCTION AND NITROGEN USE
1950-1975



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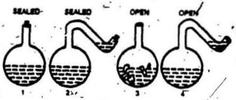
DIRECTIONS: Items 78 through 80 are based on the information given here and the diagrams presented below.

Because some scientists of his time maintained that air was necessary for spontaneous generation, Pasteur conducted the experiment pictured below to show that only unsterilized air supported their contention. Flasks 1, 2, 3, and 4 were partially filled with a nutrient and then sterilized by boiling. Flasks 1 and 2 were sealed and flasks 3 and 4 left open.



78. In this experiment, which flask(s) served as control(s)?

- **A.** 1 and 2
- **B.** 1 and 3
- **C.** 2 and 4
- **D.** 3 only

79. If the hypothesis being tested is that unsterilized air contains micro-organisms which will grow in the nutrient, in which flask(s) should growth occur?

- **A.** 2 only
- **B.** 2 and 3
- **C.** 3 and the tip of 4
- **D.** All flasks

80. If micro-organisms should generate spontaneously with any form of air, in which flask(s) should growth appear?

- **A.** 3 only
- **B.** 1 and 2
- **C.** 3 and 4
- **D.** All flasks

81. Amino acids are a necessary constituent of what substances?

- **A.** Carbohydrates
- **B.** Fats
- **C.** Proteins
- **D.** Vitamins

The following amounts of water and methyl alcohol are combined:

	Water	Methyl alcohol
Mass	50 grams	79 grams
Volume	50 ml	100 ml

82. Which of the following will be a characteristic of the mixture?

- **A.** A volume of 150 ml
- **B.** A mass of 129 grams
- **C.** A volume of more than 150 ml
- **D.** A mass of less than 129 grams

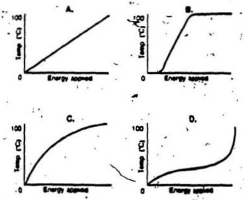
83. Which of the following methods would be most useful in recovering a dissolved salt from solution?

- **A.** Evaporation
- **B.** Filtration
- **C.** Flotation
- **D.** Fractional distillation

84. Why is a control group important in experimental research?

- **A.** To complete the experiment
- **B.** To provide a comparison without the experimental factor
- **C.** To provide a way to control the procedures
- **D.** To provide replacement subjects if they are needed

85. Which graph shows the energy required to change ice into steam?



86. **Two homing pigeons were taken in separate boxes that were not light-proof to an isolated area and released. Two other pigeons were transported in individual light-proof boxes to the same approximate area and released. Times of release and arrival at the home lofts were recorded. Which of these hypotheses is being tested?**

A. Light is related to pigeons' ability to find home.
B. Resting in dark will improve flight time.
C. Isolation will affect the birds' time of flight.
D. Flight time is inversely related to order of release.

87. **In questioning a person's claims about a scientific matter, the most scientific attitude is to say,**

A. "I don't believe it."
B. "Describe the evidence for your position."
C. "What authority supports your position?"
D. "How do your results compare with those of other investigators?"

88. **Which of the following is the least effective and economic means of conserving energy?**

A. Thorough insulation of housing and industrial buildings
B. Developing public transportation in areas of dense population
C. Returning to horse-powered agriculture
D. Developing alternative energy sources (solar, oil shale, nuclear)

89. **What is the major purpose of laboratory work in scientific research?**

A. To verify previous work
B. To demonstrate known facts
C. To investigate questions
D. To reach final conclusions

90. **Water reaches its maximum density at 4°C. This characteristic means that in lakes**

A. water temperature is uniform.
B. water temperature rarely exceeds 4°C.
C. ice forms on the surface, not the bottom.
D. in summertime surface water will be colder than water near the bottom.

91. **When an insecticide to kill aphids is sprayed on an orchard, all bees in the orchard are killed. Which of the following is most likely to result?**

A. The apples will be infested with an increased number of borers.
B. There will be fewer apples this year.
C. The apples will not be as sweet since the blossoms were not injected with honey by the bees.
D. There will be a larger crop of apples this year.

Make no marks in this booklet.

To measure the amount of energy in food, the food is burned, and the heat is used to raise the temperature of water. The following information was obtained from one trial:

Volume of water: 25 ml
Beginning temperature: 31°C
Final temperature: 35°C

92. **How many calories are produced from this trial?**

A. 25
B. 50
C. 70
D. 100

93. **What is the advantage of the transistor over the vacuum tube?**

A. Less space is required.
B. Less power is consumed.
C. Less heat is produced.
D. All of the above

94. **Which of the following is not an action promoted by bacteria?**

A. Causing disease
B. Aiding digestion in cattle
C. Controlling breathing in certain animals
D. Providing usable nitrogen to certain plants

95. **A laboratory assistant accidentally poured 250 cc of ethyl alcohol into a bottle containing a water solution of some salt. Which of the following could be used to recover the alcohol?**

A. Filtering
B. Precipitation
C. Electrolysis
D. Fractional distillation

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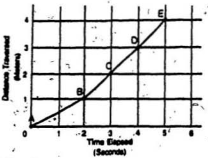
***DIRECTIONS:** Use this graph of distance traversed by an object and the time elapsed to answer items 96 and 97.*



96. How many meters has the object traveled between points A and B?

A. 1
B. 2
C. $\sqrt{5}$
D. 5

97. What is the average velocity in meters per second between B and D?

A. 0
B. 1
C. 2
D. 2.82

Make no marks in this booklet.

98. When solar energy evaporates water, what change does it cause?

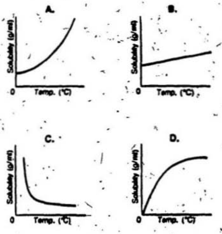
A. It increases the speed of water molecules.
B. It raises the temperature of the air.
C. It decreases temperature and increases speed of water molecules.
D. It decreases the speed of water molecules.

99. A series of earthquakes occurred near a city during a time when a government facility was forcing waste water underground through deep holes. The hypothesis was submitted that the water served as a lubricant that caused slippage between rock surfaces, resulting in frequent earth tremors. The best scientific test of that hypothesis would be to

A. stop all disposal of water into the holes.
B. increase the amount of water forced underground near the city and see if stronger quakes occur.
C. confer with earthquake experts for their opinion.
D. force water under unpopulated, potential earthquake regions and note changes in quake occurrences.

100. The solubility of a salt in water at various Celsius temperatures is reported below. Which graph best represents the data in the table?

Temperature (°C)	Mass dissolved (g/ml)
0	.15
20	.32
40	.62
60	1.10
80	1.58



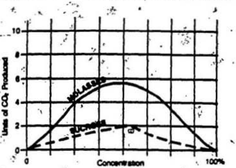
101. A Geiger counter is activated when it

A. is close to a heated object.
B. touches any magnetic material.
C. is entered by radioactive particles.
D. is near an electrostatically charged body.

DIRECTIONS: Refer to the formula and graph in answering items 102 and 103.

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{yeast} 4C_2H_5OH + 4CO_2 + energy$$

Below is a graph reporting the CO_2 production from sucrose and molasses using a number of concentrations of each. The values graphed are class averages.



102. **Which would be the best approach to investigate why the molasses produced more alcohol than the sucrose?**

- **A.** Test to see if sucrose is an impure form of molasses.
- **B.** Repeat the experiment with honey instead of molasses.
- **C.** Investigate the composition of molasses to see what substances it contains that are not present in sucrose.
- **D.** Repeat the experiment increasing the time for fermentation before collecting alcohol and CO_2.

103. **Which of these questions generate testable hypotheses for further study?**

1. **Why isn't the relationship between CO_2 production and solution concentrations shown by a straight line?**
2. **Why was molasses more effective in producing CO_2 and C_2H_5OH than sucrose?**
3. **Did the students prepare the correct concentration of sucrose?**

- **A.** 1 and 2
- **B.** 1 and 3
- **C.** 2 and 3
- **D.** 1, 2, and 3

104. **Ten grams of sugar are dissolved in 100 milliliters of water. What will happen if the solution is left standing in an open container?**

- **A.** The water will evaporate and leave less than 10 grams of sugar.
- **B.** The water will evaporate and leave 10 grams of sugar.
- **C.** The water will evaporate and leave more than 10 grams of sugar.
- **D.** All of the sugar and water will evaporate.

DIRECTIONS: Below is a table of data gathered in a study of the smoking habits of adult heart patients at a hospital. Use this table for items 105 and 106.

	Number of cigarettes smoked per day				
	None	1-10	11-20	21-40	Over 40
Percentage of adult heart patients	8	19	22	24	27

105. **What is the fairest interpretation of the table?**

- **A.** Nonsmokers seldom suffer heart disease.
- **B.** Smoking definitely causes heart disease.
- **C.** There is a relationship between amount of smoking and heart disease.
- **D.** There is no trend shown by these statistics.

106. **If only 48 percent of adults smoke, which of the following statements can be supported by these data?**

- **A.** Nonsmokers rarely contract heart disease.
- **B.** Smoking is a definite cause of heart trouble.
- **C.** Smokers are more likely to have heart problems than nonsmokers.
- **D.** Smokers work at occupations that promote heart disease.

107. **What has been a major consequence of the expansion of scientific knowledge during the last century?**

- **A.** All worthwhile scientific knowledge has been discovered.
- **B.** Over half of the U.S. work force is employed in scientific or technological work.
- **C.** Specialization has become necessary.
- **D.** Careers in science and technology are not profitable.

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108. What condition on the moon would cause a space explorer's body to explode if the explorer took off the protective space suit?

A. Strong gravitational field
B. Extremely low temperature
C. Thin atmosphere
D. Radiation from the sun and stars

109. What characteristic of applied science most clearly distinguishes it from pure or basic science?

A. Concern for the environment
B. Emphasis on usefulness of findings
C. Lack of scientific procedure
D. Absence of investigators' curiosity

110. Of the following, the least desirable action for a scientist is —

A. basing conclusions on impulse and intuition.
B. referring to findings of earlier investigators.
C. repeating experiments that have been done before.
D. using non-experimental work in developing theories.

111. The primary purpose of the Viking space probe to Mars (1975-76) was to

A. demonstrate U.S. superiority in space.
B. look for a place to go if our resources fail.
C. check for signs of present or past life.
D. search for the source of unidentified flying objects.

112. Given: The atomic weight of calcium is 40; nitrogen, 14; and oxygen, 16. What is the molecular weight of $Ca(NO_3)_2$?

A. 70
B. 102
C. 164
D. 204

113. Which of the following would be the most definite way to determine whether a solution is an acid?

A. Determine the pH.
B. See if it mixes with water.
C. Determine whether it burns the skin.
D. Measure its specific gravity.

114. What is the principal reason why more marine life is found near the ocean surface than near the ocean floor?

A. There is more air in surface water.
B. There is less pressure near the surface.
C. There is more light near the surface.
D. There is more water movement near the floor.

115. A sample of radioactive material gives a reading of 100 counts per minute. One hour later the reading is 50 counts per minute. What count rate should be expected one hour after the second reading?

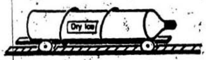
A. 0
B. 25
C. 37
D. 50

116. Which of the following factors affect(s) the density of a material?

1. Mass of the material
2. Shape of the material
3. Volume of the material

A. 1 only
B. 1 and 2 only
C. 1 and 3 only
D. All three factors

The diagram below shows a loosely stoppered cylinder attached to a toy train car on toy railroad tracks. The dry ice in the cylinder is changing into a gas.



117. When the stopper pops out of the cylinder opening, what will happen to the train car?

A. It will move to the left.
B. It will move to the right.
C. It will lift off the tracks into the air.
D. It will remain motionless.

118. In which type of location would water boil at the lowest temperature?

A. In a dry desert
B. In a humid forest
C. In a mine shaft below sea level
D. On a mountain top

119. A tablet placed in a bottle of water produces a gas which is collected in a balloon attached to the top of the bottle. What change in mass, if any, has occurred after the tablet stops fizzing?

A. The mass of the balloon has increased.
B. The mass of the water has increased.
C. The mass of the total system has increased.
D. The mass of the total system has remained the same.

120. A person wishes to build a heat storage system for a solar greenhouse. This requires a cheap, abundant material that would absorb and retain large quantities of heat and store it in a relatively small space. Which of the following approaches is scientifically the most logical?

A. Visit a number of other such greenhouses and copy what they have done.
B. Buy a set of plans from a company that advertises in a popular magazine.
C. Visit a building materials store; ask for recommendations; obtain cost of materials.
D. Look up specific heats and heats of fusion in a technical handbook; check availability and cost of materials; then make a selection for trial.

121. To test a theory that alcoholism results from an unhappy childhood, arrangements were made for police to gather pertinent data from alcoholics who were arrested. The major weakness of the study was that

A. nonalcoholics were not studied.
B. arrested alcoholics are not a good sample.
C. police do not provide good data.
D. the hypothesis was unreasonable.

122. The nature of science as a means of acquiring knowledge emphasizes

A. reading the recorded scientific information
B. reasoning about observations, planning experiments, and studying prior information
C. measurement accuracy and related skills
D. organizing and assembling knowledge

123. Geologists have theorized that continents, mountain ranges, and oceans float on a semi-plastic mantle inside the earth. According to current scientific thought, which best accounts for lateral earth forces that produced faults and mountains?

A. Unequal heating of the mantle by geothermal sources
B. Magnetic forces of the earth
C. Unequal precipitation on the earth
D. Weight of eroded materials

SOLUTION KEY

61. A
62. C
63. C
64. A
65. B
66. A
67. B
68. B
69. D
70. A
71. D
72. A
73. C
74. B
75. D
76. D
77. C
78. A
79. C
80. D
81. C
82. B
83. A
84. B
85. B
86. A
87. B
88. C
89. C
90. C
91. B
92. D
93. D
94. -C
95. -D
96. -A
97. -B
98. -A
99. -D
100. -A
101. -C
102. -C
103. -A
104. -B
105. -C
106. -C
107. -C
108. -C
109. -B
110. -A
111. -C
112. -C
113. -A
114. -C
115. -B
116. -C
117. -A
118. -D
119. -D
120. -D
121. -A
122. -B
123. -A

APPENDIX D

TEACHER QUESTIONNAIRE

1. Circle the science courses which the student completing the science achievement test could have taken at your school over the span of his/her high school program.

Biology 2201 1
Biology 3201 2
Chemistry 2202 3
Chemistry 3202 4
Earth Science 2203 5
Geology 3203 6
Physics 2204 7
Physics 3204 8
Science 1200 9
Science 2205 10
Environmental Science 3205 11

2. Circle all of the science courses which have been taken by the student being surveyed over his/her high school program.

Biology 2201 1
Biology 3201 2
Chemistry 2202 3
Chemistry 3202 4
Earth Science 2203 5
Geology 3203 6
Physics 2204 7
Physics 3204 8
Science 1200 9
Science 2205 10
Environmental Science 3205 11

3. Circle all of the science courses which the student is presently taking.

Biology 2201	1
Biology 3201	2
Chemistry 2202	3
Chemistry 3202	4
Earth Science 2203	5
Geology 3203	6
Physics 2204	7
Physics 3204	8
Science 1200	9
Science 2205	10
Environmental Science 3205	11

4. How many years of overall teaching experience do you have, including the present year?

(circle one)

a. 1 - 2 years	1
b. 3 - 5 years	2
c. 6 - 10 years	3
d. 11 - 15 years	4
e. more than 15 years	5

5. How many university college courses have you successfully completed in each of the following areas?

	none	1	2-3	4+
a. The teaching of science	____	____	____	____
b. Biological sciences	____	____	____	____
c. Earth/space/general science	____	____	____	____
d. Chemistry	____	____	____	____
e. Physics	____	____	____	____
f. Other science or engineering courses	____	____	____	____

6. In general how well prepared do you feel for the teaching of science?

(circle one)

not at all	1
somewhat	2
adequately	3
more than adequately	4

7. Which of the following best describes your current teaching assignment?

(circle one)

a. I teach only science 1
b. I teach science 50% or more of the time 2
c. I teach science between 25% and 50% of the time 3
d. I teach science less than 25% of the time .. 4

8. How many courses are you currently teaching?

(circle one)

a. 1 - 4 1
b. 5 - 8 2
c. 9 - 12 3
d. more than 12 4

9. Is your school equipped to offer each of the high school science courses offered through the reorganized high school program of this province

yes __________ no __________

10. If your answer to question number nine was no, circle the courses listed below which you feel that your school is <u>not</u> adequately equipped to offer.

Biology 2201 1
Biology 3201 2
Chemistry 2202 3
Chemistry 3202 4
Earth Science 2203 5
Geology 3203 6
Physics 2204 7
Physics 3204 8
Science 1200 9
Physical Science 2205 10
Environmental Science 3205 11

11. In your opinion, how adequate are the science reading materials in your school? i.e., science library books magazines, journals, newsletters etc.

(circle one)

a. very inadequate 1
b. somewhat inadequate 2
c. satisfactory 3
d. more than adequate 4

12. Overall, how do you rate the quality of the facilities and equipment available to you for teaching science?

(circle one)

a. very poor 1
b. poor 2
c. good 3
d. excellent 4

13. What is the average number of students in your classes?

(circle one)

a. 10 or less 1
b. 11 - 20 2
c. 21 - 30 3
d. over 30 4

APPENDIX E

Letter to Co-ordinators

March 1, 1986
P.O. Box 261, Stn. "C"
Goose Bay, Labrador
AOP 1C0

Dear

As follow-up from my earlier correspondence with you related to my thesis study, I have enclosed the package to be used in order to collect the data needed from the selected schools in your district.

Enclosed you will find the following: (1) copies and directions for a grade 12 (level 18 in booklet page 86) student achievement test in science; (2) copies of a teacher questionnaire and (3) a covering letter to your superintendent.

The achievement test and teacher questionnaire are to be completed by the student and teacher whose name appears on each school package. Each student's name has been randomly selected from the computer data at the Department of Education. Each teachers name has been randomly selected from the information you provided me earlier. If for some reason the teacher is no longer on staff, please randomly select another high school science teacher from the same school. The names of students and teachers involved in this study will only be used to monitor the distribution and return of the study instruments. A total of 150 schools throughout the province have been randomly selected for the study. These schools have been divided into three categories small, medium and large. The focus of this study however will be on the small school. It is hoped that the data accumulated will provide some useful information to better adapt our present science program to fit the science needs of students in these schools.

The timeframe in which the student achievement test and teacher questionnaire are to be completed is between March 3 and April 11. Your cooperation in enabling me to receive the necessary data from your district within the specified time would be most appreciated, if you would like feedback on the results as it pertains to your board please let me know.

Thanking you in advance.

Sincerely

Bob Simms

APPENDIX F

Letter to Superintendents

March 1, 1986
P.O. Box 261, Stn. "C"
Goose Bay, Labrador
A0P 1C0

Dear

I am in the process of completing a Master's degree in science curriculum at Memorial University. The title of my thesis is "School size as a factor in the science achievement of grade twelve students in the province of Newfoundland and Labrador". The study will focus on science in the small school and hopefully provide some useful data to indicate whether or not there is a need for some adaptation to be made to the present high school program in order to better address the science needs of students in these schools.

The study involves two instruments (1) a Grade Twelve science achievement test and (2) a teacher questionnaire consisting of thirteen questions related to nine variables i.e., science courses available to students in schools of different sizes. The achievement test will be administered to one student randomly selected from each of the schools involved within your district. One science teacher has also been randomly selected from each of the same schools to complete the questionnaire part of the study.

I am a science program coordinator with the Labrador East Integrated School Board and have therefore asked my counterpart with each of the boards involved to deliver and return the survey instruments to me. With a few boards this will be done by the Assistant Superintendent.

This letter is to inform you of the study and to ask for your support in obtaining the necessary data from the schools selected within your district.

Thanking you in advance.

Respectfully,

Robert L. Simms

APPENDIX G

Letter to Science Teachers

March 1, 1986
P.O. Box 261, Stn. "C"
Goose Bay, Labrador
AOP 1CO

Dear

I am in the process of completing a Master's degree in science curriculum. The title of my thesis is "School size as a factor in the science achievement of grade twelve students in the province of Newfoundland and Labrador". The study will hopefully provide some useful data to indicate whether or not there is a need for some adaptation to be made to the present high school program in order to better address the science needs of students in various school sizes.

You and the student identified to take the science achievement test have been randomly selected with teachers and students in 150 other schools throughout the province. If for some reason this student is no longer at your school, please randomly select another grade 12 student.

It would be most appreciated if you would complete the teacher questionnaire and make the necessary arrangements in conjunction with your principal to have the student achievement test completed. The time assigned to complete the achievement test is forty five minutes. Please go over the enclosed directions with the student before he/she begins to answer the questions.

The first three questions on the teacher questionnaire pertain to the student taking the achievement test.

I am most grateful for your assistance in helping me carry out this study.

Sincerely

Bob Simms

APPENDIX H

Student Directions

The test you are about to complete is part of a test booklet entitled "Test of Achievement and Proficiency". The test is indicated as level 18 which in this province is equal to science at the grade 12 level.

All of your answers are to be marked on the answer sheet, which contains begin and stop directions for the level 18 science (see bottom of answer sheet marked "6. Science").

For each item a corresponding number roll of lettered answer spaces is on the answer sheet. You should read an item and decide which answer is correct or clearly better than the others. Then, blacken the space on the answer sheet which corresponds to the answer you have chosen.

As you mark your answers, remember these points:

1. Be careful to mark your answers in the section of the answer sheet for the test you are taking. Be careful that your mark is placed in the row numbered the same as the item you are answering.

2. Make the mark large enough to fill the answer space and make it dark.

3. Mark only one answer space in each row. If you change your mind about an answer, thoroughly erase your first mark and blacken the space of your new choice.

EARNING YOUR BEST SCORE

As you take the test, remember these points:

1. If you are not absolutely sure about the answer to an item, but think you know the correct answer, mark your choice. You will earn your best score if you attempt all of the items for which you think you may know the answers.

2. There are some items on the test which you may not be able to answer. Do not linger over difficult items; omit these and go to the easier ones. You may return to omitted items at the end of the test if there is time remaining.

If you have questions about how to take the test, your test administrator can help you.

DO NOT START TO WORK ON THE TEST UNTIL YOU ARE TOLD TO DO SO.

It is hoped that this study which you have been part of will help to improve the science program being offered to high school students within our province.

Thank you

Bob Simms