THE UNIVERSITY OF MANITOBA

CHANGING ENROLMENT PATTERNS IN SCIENCE EDUCATION

by

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Chapter I

INTRODUCTION TO THE STUDY

For some time now it has been apparent that the enrolment patterns in High School Science have been undergoing change. Data collected in the Province of Alberta[1] by G.F. Caron for the years 1951 to 1969 show that Physics enrolments in public secondary schools in Alberta were not keeping up with total enrolments in High School. In comparison, Chemistry maintained a relatively constant enrolment pattern until 1968 and then suffered a sudden severe drop. On the other hand, Biology registrations expanded, apparently at the expense of the other major science options.

This trend described by Caron in Alberta is similar to a trend identified earlier in the United States. Data compiled by the American Institute of Physics[2] confirmed the declining enrolment pattern of Physics in that Country.

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1 G.F. Caron, "Students' Reasons for Electing or Rejecting Enrolment in Grade 12 Physics", Unpublished Master of Education Thesis, University of Manitoba, 1972.

2 The American Institute of Physics, "Why is High School Physics Enrolment Not Keeping Up With The School Population", The Physics Teacher, (November, 1964), p. 389.

NEED FOR THE STUDY

These surveys raise several questions:

1) Is there evidence of a pattern of declining enrolment in Physics in Manitoba?

2) If a changing pattern exists, what are the factors that contribute to it?

3) Can a problem of declining enrolment be solved within the framework of education? Should any of the three major science courses now offered become a pre-requisite course of study rather than remain as an option? Is there need to change the content of science curriculum, methods of instruction, or teacher preparation? Have teachers attempted to halt the downward trend?

No study has been made in Manitoba to confirm or deny such a trend, or to identify the contributing factors. Until now, the problem has been left to speculation. Only by collection and analysis of data can the nature of the problem be determined.

SCOPE AND DEFINITION OF THE PROBLEM

The purpose of this study is to determine the nature and extent of the changing enrolment patterns in High School Science and to identify possible causal factors contributing to them.

Since Manitoba High School students at the grade 12 level may elect one or more of the major science options, Physics, Chemistry and Biology, the study will focus on enrolment in grade 12 science.

The study will seek answers to the following questions:

Question 1: What is the nature and extent of the changing enrolment patterns in grade 12 Physics, Chemistry and Biology in Manitoba?

Question 2: What characteristics distinguish a grade 12 student who: (a) is enrolled in science from one who is not enrolled in science; (b) is enrolled in Physics from one who is not enrolled in Physics?

The characteristics or variables to be tested are: sex, I.Q., academic achievement, aptitudes, general interests and subject attitudes.

Question 3: What are the reasons offered by students for electing not to enroll in Physics?

STUDY POPULATION

The study involved the total grade 12 population within Manitoba for each of the years 1962 to 1972. The Manitoba records of enrolment were consulted to determine the number of students enrolled in each of the major science options, namely; Physics, Chemistry and Biology, in each year in question. Brandon School Division records were examined to determine grade 12 student enrolment in the Division and within Brandon Collegiate Institute.

For the purposes of questions 2 and 3, a sample was taken from the population, comprising 76 students enrolled in grade 12 at the Brandon Collegiate Institute during the academic year 1972-73. Out of this sample of 76 students, 21 were enrolled in Physics. While the sample from Brandon Collegiate was taken in the year following the decade that was used to determine Provincial and Divisional trends, it is assumed that the student sample is not different from the total population under study.

STUDY DESIGN

To answer question 1, a historical survey was taken of total student enrolment in grade 12. The survey was carried out at three different levels: (1) for the Province of Manitoba as a whole; (2) for Brandon School Division #40; and (3) for a school within the Division, Brandon Collegiate Institute.

The data for question 2 were obtained from a survey of existing school records and from a battery of objective tests. Kuder's General Interest Survey and the Purdue Masters Attitude Scale Toward Any School Subject were administered to obtain data regarding students general interests and attitudes toward school subjects.

For the purposes of question 3, a "Student Questionnaire" was used to determine what students' gave as reasons for electing not to enroll in Physics.

STATISTICAL TREATMENT OF DATA

The data for each of the questions investigated were treated in a different manner. With respect to question 1, the enrolment records were consulted to determine the percentage of students enrolled in each of the major science options, Physics, Chemistry and Biology, for each of the years 1962-72. The percentage of students enrolled was plotted against time and slopes of the curves obtained were used to determine the nature and extent of enrolment trends within each major science option.

Data derived from the investigation related to question 2 were treated by computer using Pearson's Chi-Square Test of "Association". The test statistic (X^2) was calculated using the formula;

$$(X^2) = \frac{(E - 0)^2}{0}$$

where: E denotes the expected frequency of the parameter classification under question, and 0 is the corresponding observed frequency. A critical value for Chi-square at the 5% level of confidence was used as a criterion for rejection of the null hypothesis.

An item analysis of student responses to the "Student

Questionnaire" was made with respect to question 3 which categorized the responses into four main areas: (1) academic, (2) pedagogical, (3) cultural-social, and (4) vocational. Data resulting from the item analysis were presented as a histogram.

Chapter II

REVIEW OF THE RELATED LITERATURE

Although modern educators recognize that the knowledge of Physics is fundamental to understanding and coping with such vital issues as space exploration, environmental pollution, nuclear weaponry, as well as the mechanics of everyday living, an increasing number of students are avoiding the study of Physics.

A review of the literature relating to the changing enrolment patterns in High School Science reveals a widespread concern with respect to Physics only. Since Chemistry enrolments have been somewhat more constant and Biology enrolments have been increasing, little mention has been made of these two areas. Secondly, the concern appears to be primarily American. All the studies, except one in the Province of Alberta, were made in the United States.

HISTORICAL BACKGROUND

The percentage of high school students in the United States enrolling in Physics has been declining for more than half a century. The phenomenon was recognized for some time before educators began to voice concern about it during the Fifties in the United States. However, nothing was done about it until the Sixties, when new science courses were beginning to be introduced.

For decades, the American enrolment pattern[3] (see Figure 2.1, page 9) in the three major science options has been undergoing drastic changes. Total school enrolment at the grade 12 level has risen sharply but only Biology has kept pace with the rising enrolment pattern. In terms of percentage enrolments, Physics shows an almost steady rate of decline. In Canada, the data from Alberta[4], indicate a similar pattern during the past two decades.

SURVEY OF CASE STUDIES

Factors suggested as responsible in publications appearing during the past ten years may be clustered under three general categories: (1) the school curriculum; (2) the Physics teacher; and (3) the student. Literature relating to some of the variables tested in question 2 of the investigation appeared to be unavailable.

The School Curriculum. Course content and philosophy of Physics courses was one of the first concerns cited for decreasing enrolment patterns in Physics. For this reason, experimentation with different text books began, as well as

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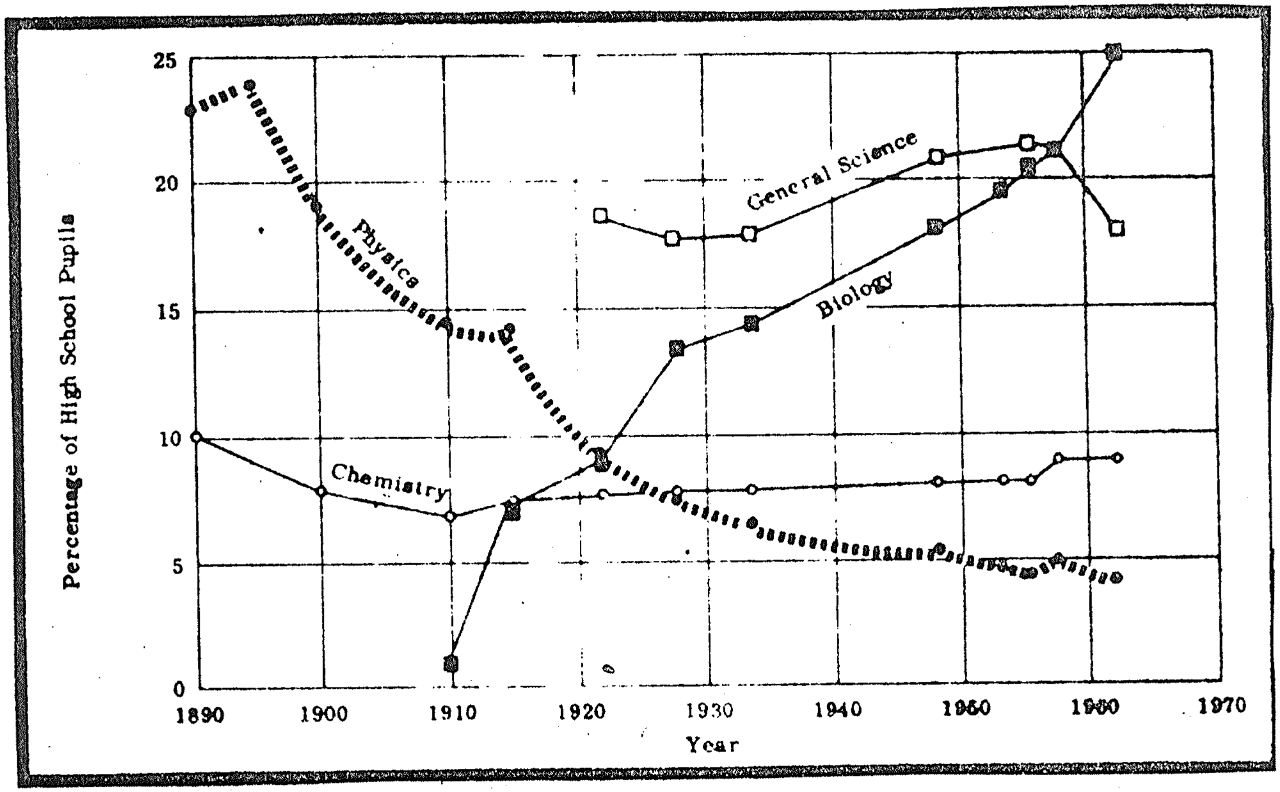
3 Ibid.

4 Caron, *Op. Cit.* p.16

FIGURE 2.1 SCIENCE ENROLMENTS
UNITED STATES



the development of new courses of study, Physical Science Study Committee (P.S.S.C.) Physics and Harvard Project Physics.

P.S.S.C. is the oldest of the new approaches to Physics, and probably has had the greatest influence on the design of more recent curriculum materials. All aspects of the program are closely integrated, and depend to a large extent on mathematics. Although the course generates interest in some students, it appears to do the opposite to others. There are indications that this is because of the mathematics requirement.

Harvard Project Physics is a program that attempts to bridge the gap between traditional Physics and P.S.S.C. The intent of this course is to create a Physics course that will appeal to a wide variety of students, including those who will make a career of science, and those who will go to college but major in some other field. It is to some degree a more humanitarian approach.

A study conducted in the State of Michigan[5], reported that implementation of P.S.S.C. Physics along with other curriculum innovations have not been effective in reversing the trend of declining enrolments. The study indicated that from 1960, when P.S.S.C. Physics was introduced in the high

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5 Thomas E. Van Koevring, "High School Physics and Chemistry Enrollments in Michigan", School Science and Mathematics, Vol. LXXII, No. 5, 1972, p. 379.

school curriculum in Michigan, until 1965, Physics enrolments continued to decline.

A similar study in Wisconsin[6], linking several popular texts in use to increasing and decreasing enrolment, reported that 18.6% of the teachers using the P.S.S.C. course showed an increase in enrolment, 67.4% showed no change, and 14% showed a decrease. With respect to Project Physics, 37.5% showed an increase, 50% showed no change, and 12.5% showed a decrease. Although there were increases in enrolment shown, the study concluded that the new courses were unable to produce any significant increase in enrolment in Physics.

A third study done in Ohio[7] suggested that Project Physics or a similar curriculum approach, could be successful in increasing Physics enrolments. The suggestion is based on responses from seniors not taking Physics, where 16% to 59% of them said they would take Physics if it was a course that stressed historical and humanitarian implications rather than just the subject matter of physics.

A fourth study, in Pennsylvania[8], which attempted to

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6 H.E. Hale and J.R. Smith, "Trends in High School Physics -- A Survey in Wisconsin", The Science Teacher, (Feb., 1971), p. 33.

7 Thomas S. Jordan, "Investigation in the Causes for Decreasing Enrollments in High School Physics", School Science and Mathematics, (May, 1972), p. 700.

8 J.R. Campbell, "Is Scientific Curiosity a Viable Outcome In Today's Secondary School Science Program?", School Science and Mathematics, (Feb., 1972), p. 139.

determine the effect of the philosophy of the new science courses (P.S.S.C. Physics, CHEM-Study, B.S.C.S. Biology) on the scientific curiosity of students as they move from junior high to senior high, indicated that the new courses do not foster the development of productive attitudes and values.

The study showed that senior high students had greater scores on the lowest level but surprisingly lower scores of involvement on the more advanced levels of the affective domain. In other words, a distinct crossover between levels 1 and 2 occurred. This implies that as a student moves from junior high to senior high, something happens that tends to destroy the students level of scientific curiosity and interest, and which the new courses are unable to maintain or re-awaken. It is even possible that the new courses may be contributing to the crossover and to the decline.

The Physics Teacher. A second area of concern expressed in research literature is the role of the Physics teacher in the student's election to enroll in Physics. Three student perceptions appear to be of most importance.

The first perception is that "students feel that Physics teachers understand little of their personal problems"[9]. The teaching objectives of the Physics teacher do not seem to be

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9 Walter E. Elliott, "Perceptions of High School Physics and Physics Teachers", The Physics Teacher, (Jan., 1971), p. 33.

people-oriented, nor do they appeal widely to the lower-ability or terminal student.

Many students perceived Physics to be personally useful and important to future goals. Moreover, they perceived Physics teachers as knowledgeable, as deriving joy from teaching, as able to make difficult ideas seem easier, as fair, as interested in them as students and in their school related problems, but as understanding little of their personal problems. The consensus among students seems to be that the Physics teacher tends to treat the student as an object. The suggestion is that the objectives of the Physics teacher should include something more than just the purely scientific aspects of Physics.

A second perception is that "Physics courses exhibit 'male selectivity'"[10]. This is a serious charge since enrolment figures indicate that approximately 46% of the total grade 12 enrolment in any school will be made up of female students. Generally speaking, female students are finding it difficult to identify with either the Physics course or the Physics teacher, and as a result, avoid the study of Physics. For example, in the United States in 1964, only 5.4% of the grade 12 students who elected Physics were female[11].

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10 Ibid.

11 Fletcher G. Watson, "Why Do We Need More Physics Courses?", The Physics Teacher, (May, 1967), p. 212.

The third perception of importance is that:

> Teachers' personalities and value systems are more strongly related to students' changes in Physics achievement, attitude towards Physics, and interest in science than are the extent of teachers preparation in Physics, mathematics, and the history and philosophy of science, their knowledge of Physics, and their years of Physics teaching experience(12).

The study goes on to show that teachers who like power and competition, who are aggressive and like to make group decisions, and are generally domineering, will have a positive effect on their students growth in Physics interest on the cognitive level. They, however, do not have a positive effect on the affective level, such as an awareness of the beauty of the universe.

The Student. The third concern centres around the reasons given by secondary students for enrolling or not enrolling in Physics. Some of the reasons mentioned are those given in student surveys while others are just impressions or opinions given by educators.

A poll[13] taken at Western Michigan University of 3,000 college freshmen in 1968 reveals the following reasons for

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12 A.T. Rothman, W.W. Welch, and H.J. Walberg, "Physics Teachers Characteristics and Student Learning", Journal of Research in Science Teaching, Vol. 6-1, 1968-69, p. 63.

13 H. Kruglak, "A Poll of College Freshmen of High School Physics", The Physics Teacher, (Oct., 1970), p. 394.

enrolling in Physics and for not enrolling in Physics.

Reasons for Taking High School Physics

1. Interest in the subject had the highest priority for the boys (40%), followed closely by counselor's recommendation (37%). The order was reversed for the girls (24% and 41%).

2. The challenge of a tough subject was ranked third by both boys and girls (15% and 19%).

3. The reputation of the teacher was the lowest ranking for each group.

Reasons for Not Taking High School Physics

1. Lack of interest in the subject was the preponderant response of boys and girls (67% and 83%).

2. The counselor's advice was ranked second by both groups (19% and 8%).

3. Fear of a low mark appears to have influenced relatively few students (7% and 5%).

4. The poor reputation of the teacher and subject difficulty were given as reasons by a small fraction of the respondents (14).

The reasons point out that interest in the subject and the counselor's recommendation are the two most important influences cited by the students. Consequently, Kruglak concludes that if high school Physics is to remain competitive with other core subjects, interest will need to be built into the curriculum both at the secondary and elementary level.

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14 Ibid.

Also something will need to be done to establish a better relationship with high school counsellors.

The findings of the Michigan poll are also supported by a survey carried out by the American Institute of Physics and by Caron's study in Alberta. However, they do not rate the above reasons as necessarily being prime.

The American Institute of Physics survey[15] would indicate the prime reasons to be:

1. Physics is too difficult.
2. Student's aren't prepared for Physics with proper mathematics, etc.
3. Students don't think they need Physics.
4. Physics isn't required for graduation.
5. Students aren't advised to take Physics by counsellors, administrators or parents.
6. Students are interested in other activities.
7. The Physics course isn't well prepared.
8. The schools find it difficult to find good Physics teachers.
9. Some schools cannot afford the necessary Physics equipment.
10. Students don't know what the course is about.[16]

It further stated that the data collected on the above reasons would furnish overwhelming evidence that high school students stay away from Physics because in their school the course is too difficult to suit their abilities and desires. The data also seem to show that the student of Physics is expected to work relatively harder than students of other

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15 Victor J. Young, "Survey on Enrollment in Physics", The Physics Teacher, (March, 1965), p. 117.

16 Ibid.

subjects in order to achieve high grades.

In Caron's study in Alberta[17], the aforementioned reasons also appeared significant. The findings were:

1. Students elect Physics primarily because of career choices.

2. Students do not elect Physics because they have been told negative statements regarding Physics.

3. Grade 12 students showed negative attitudes toward Physics even if they enrolled in it -- also negative toward the science teacher, but moreso toward the subject.

4. Students who were advised by their counselor to take Physics were more likely to have a negative attitude toward Physics than those who were not counselled.

5. Students were told that you had to be good in mathematics in order to take Physics.

6. Students were told that Physics is one of the most difficult subjects.

7. Physics students (as compared to non-Physics students) were more prepared to accept a depersonalized style of science teacher.

8. Attitudes (both positive and negative) were more strongly developed in Physics students than in non-Physics students.

9. Females agreed that Physics was slanted towards boys.

10. Students approved of lab work and involvement with equipment.

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17 Caron, *Op. Cit.*, p. 198

The findings of this Canadian study were different from those of the U.S. surveys in one interesting respect, namely the importance placed on career choice when electing Physics. Alberta students do not appear to elect Physics because they are particularly interested in the subject, but rather because they have to, in order to be able to enter the career of their choice. In fact, they appear to enroll in Physics even when they have negative attitudes toward the subject, just so they can meet the requirements for entrance into their chosen career.

A number of factors that might increase or decrease enrolment have been proposed by educators. Their comments do not necessarily relate directly to the science curriculum, the science teacher, or the science student, but rather to science education generally. Among their suggestions are the following:

1. Moving Physics from grade 12 to grade 10 might increase enrolment in Physics, because there are usually fewer subject options at the lower level, and interest in science on the part of the student is perhaps higher at the lower age level.

2. Physics may be perceived as not serving society in a useful way. Although Physics does play an

important role in the modern technology of medicine and food production, the student may be left with the impression that Physics is less involved with the immediate needs and problems of society. The importance of Physics is not related in our textbooks to the problems of sickness, poverty and pollution, but rather to the production of nuclear bombs which only kill, maim, or pollute man and his world.

3. Physics concepts may be too widely diffused throughout the science curriculum. Exposure in grades 9, 10 and 11 to many of the science terms which have their ultimate definition and explanation in Physics but which are taken over by the biosciences and chemistry before the student is exposed to Physics, tends to make students feel they have already had basic Physics, and do not need further contact.

SUMMARY

From the review of the literature, certain outcomes of further investigation appear predictable. Among the predictions are these:

1. An extremely low female enrolment in Physics.

2. Student decisions for enrolling or not enrolling in Physics are probably related to one or more of the

following: (a) career choice; (b) subject difficulty; (c) student interest; and (d) counsellor recommendation.

3. Most Physics students would have a high score with respect to academic ability and interest in science, and perhaps also significant differences in other characteristics as compared to students who take no science.

4. Science students in general are less people-oriented in their philosophy and outlook on life than students who take no science.

The present study hopes to explore these predictions and implications to a greater extent from a Canadian context, so that a better understanding to the same problem in Canada might be obtained.

Chapter III

ANALYSIS OF DATA AND FINDINGS

INTRODUCTION

In this chapter, data with respect to each of the three major questions given in Chapter I are collected, tabulated and analyzed. The purpose of this chapter is to report and analyze the findings pertinent to each of these questions.

THE CHANGING ENROLMENT PATTERN

The first question under investigation was:

What is the nature and extent of the changing enrolment patterns in Physics, Chemistry and Biology with respect to Manitoba?

This question was investigated at three different levels: 1) for the Province as a whole; 2) for a school division within the Province; 3) for a school within the division. The school division chosen was Brandon School Division #40, and the school within the Division was Brandon Collegiate Institute.

The data collected from Provincial records of enrolments and school division records of enrolments are tabulated in Appendix A, Tables A.1 to A.11. A graphical presentation of the data appears in Figures 3.1 to 3.5. Figures 3.3 to 3.5, representing percentage enrolment versus time, show

FIGURE 3.1 TOTAL GRADE 12 ENROLMENT IN MANITOBA

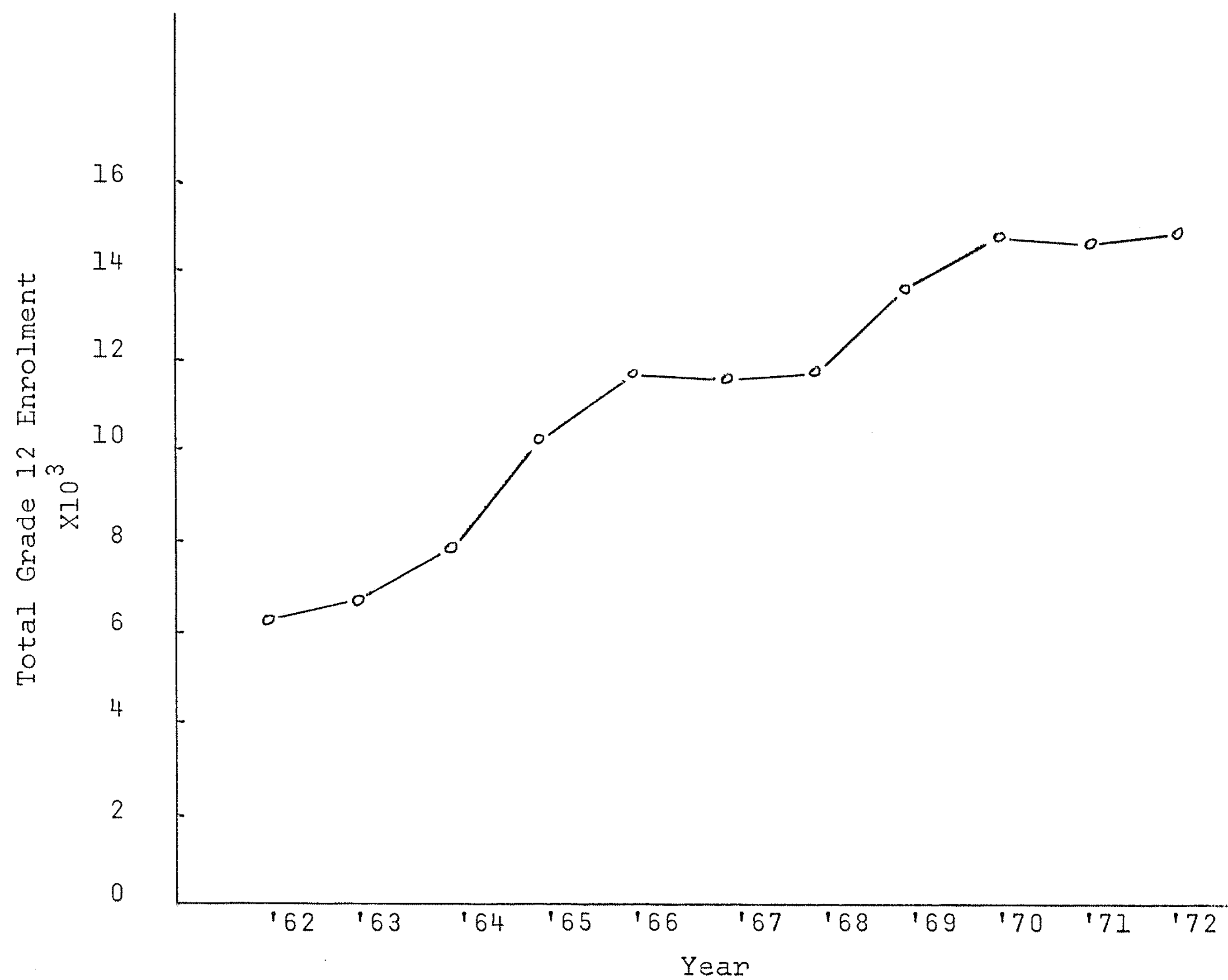


FIGURE 3.2 TOTAL GRADE 12 ENROLMENT IN BRANDON SCHOOL DIVISION #40

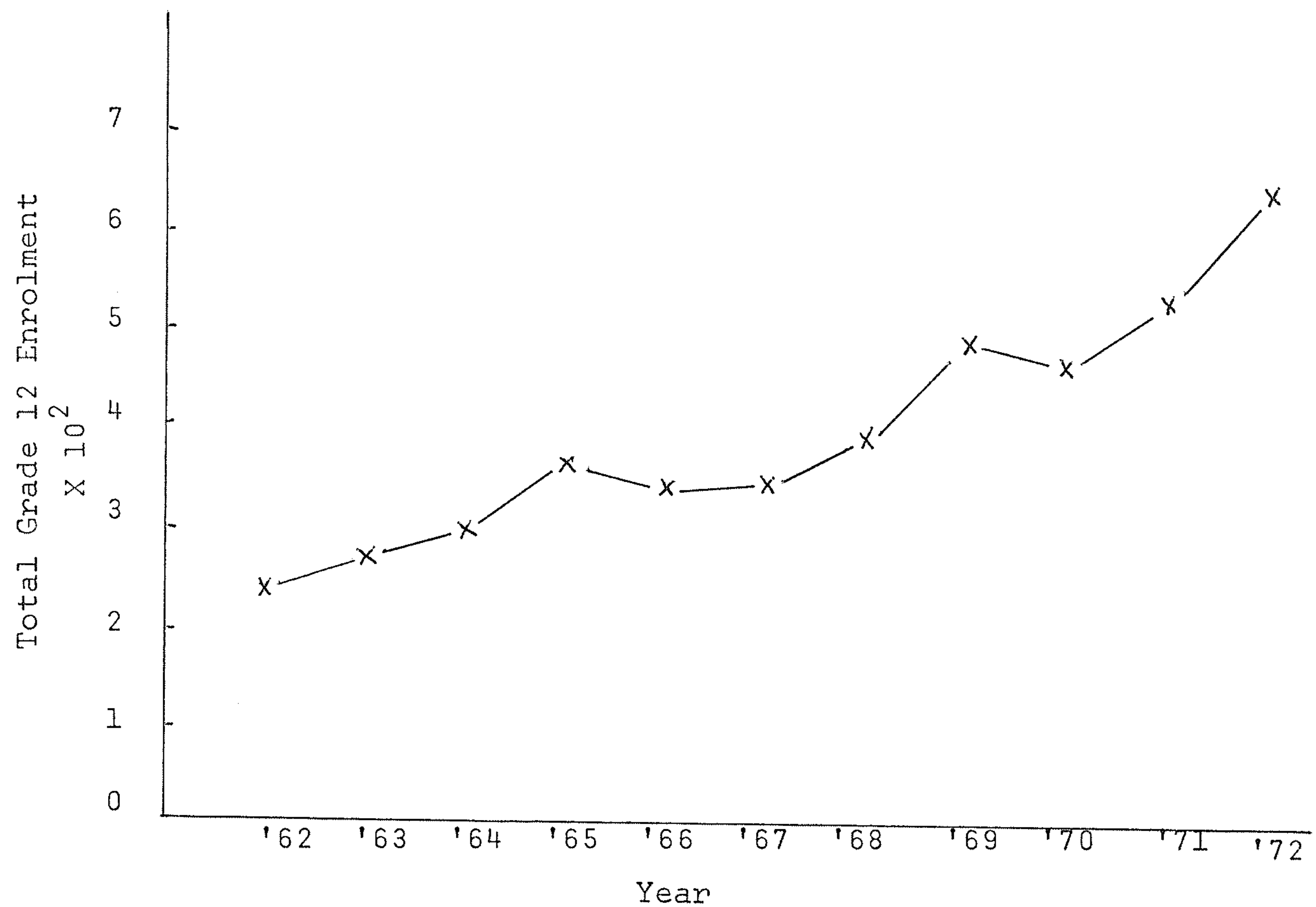


FIGURE 3.3 MANITOBA SCIENCE ENROLMENTS

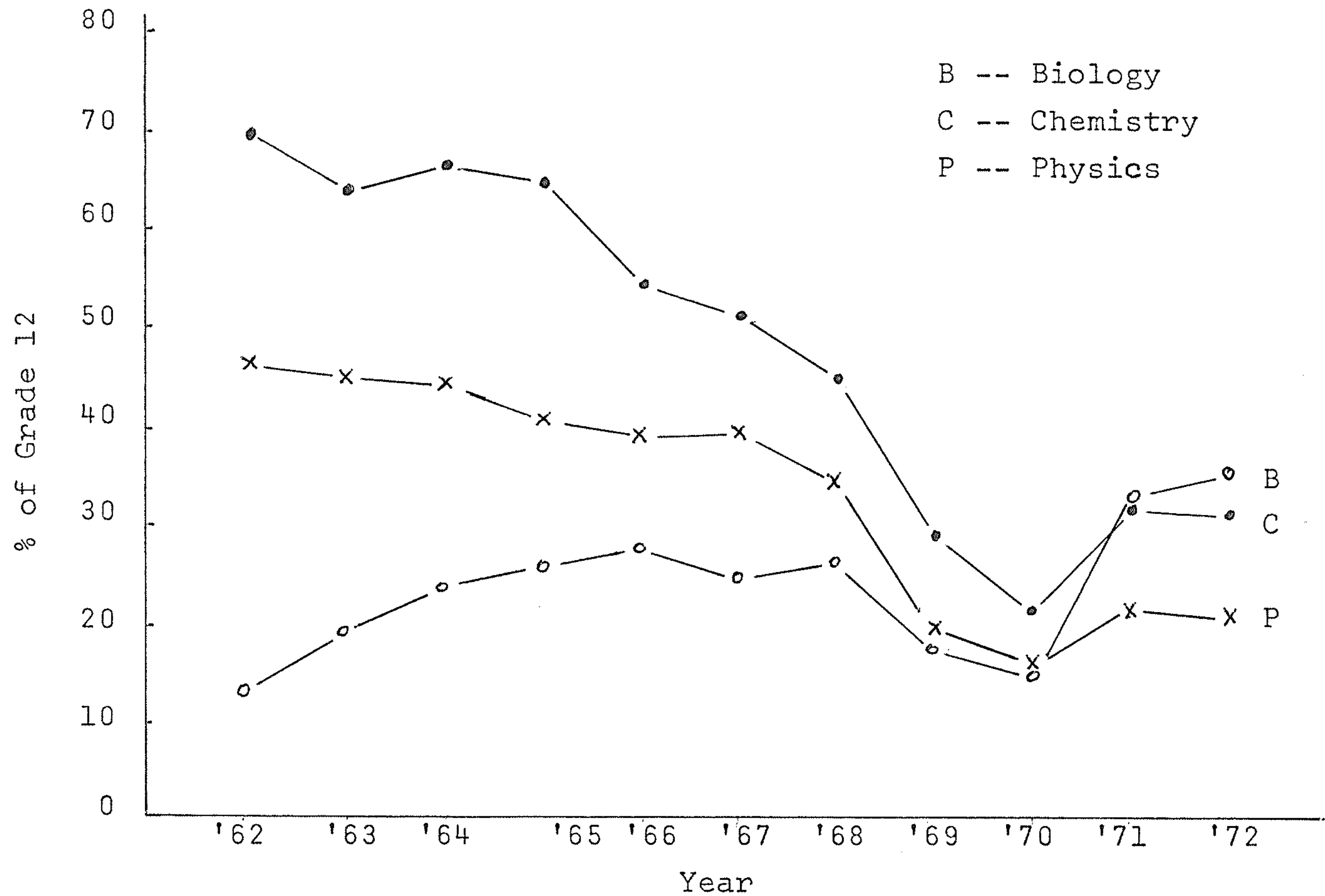


FIGURE 3.4 SCIENCE ENROLMENTS BRANDON SCHOOL DIVISION # 40

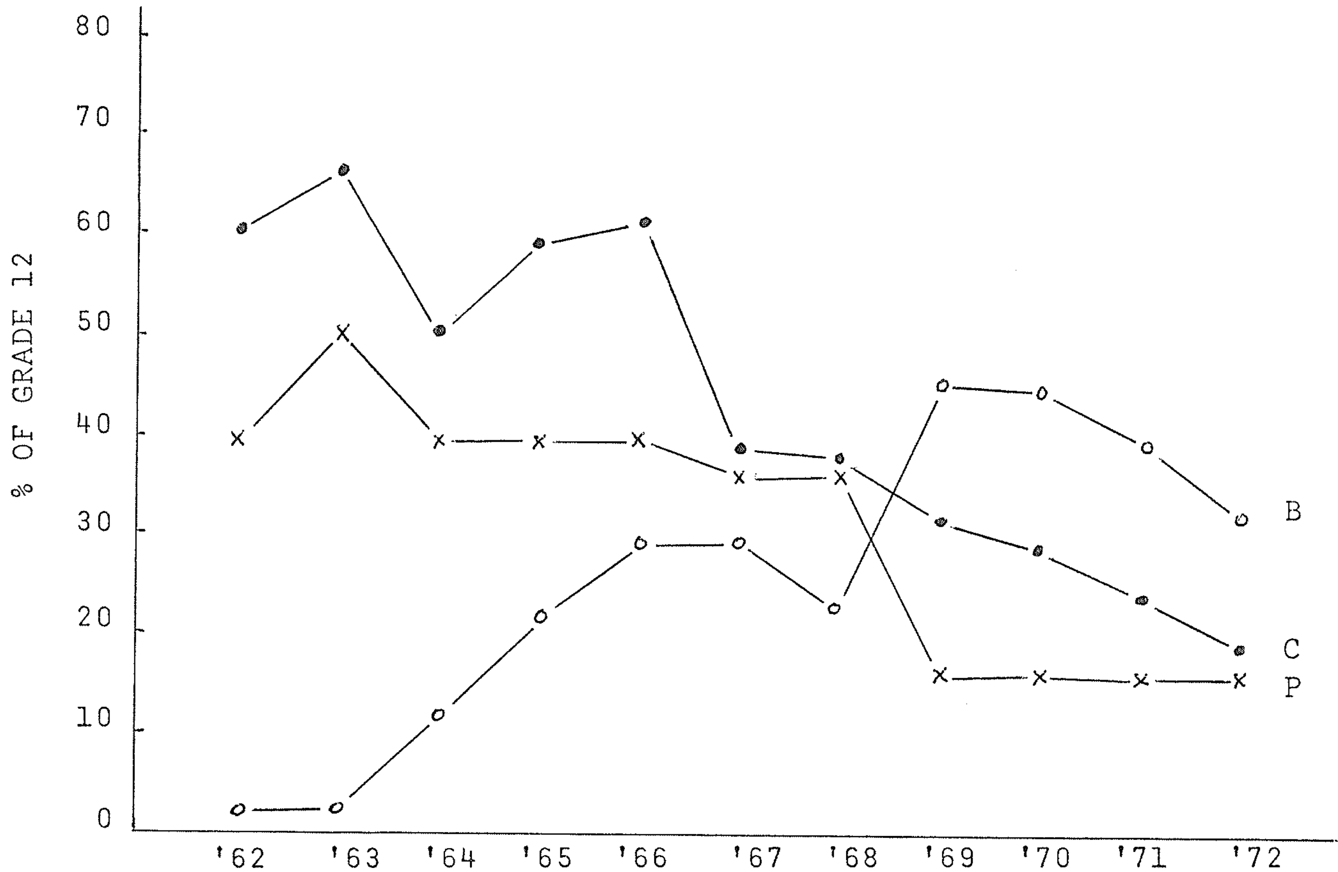
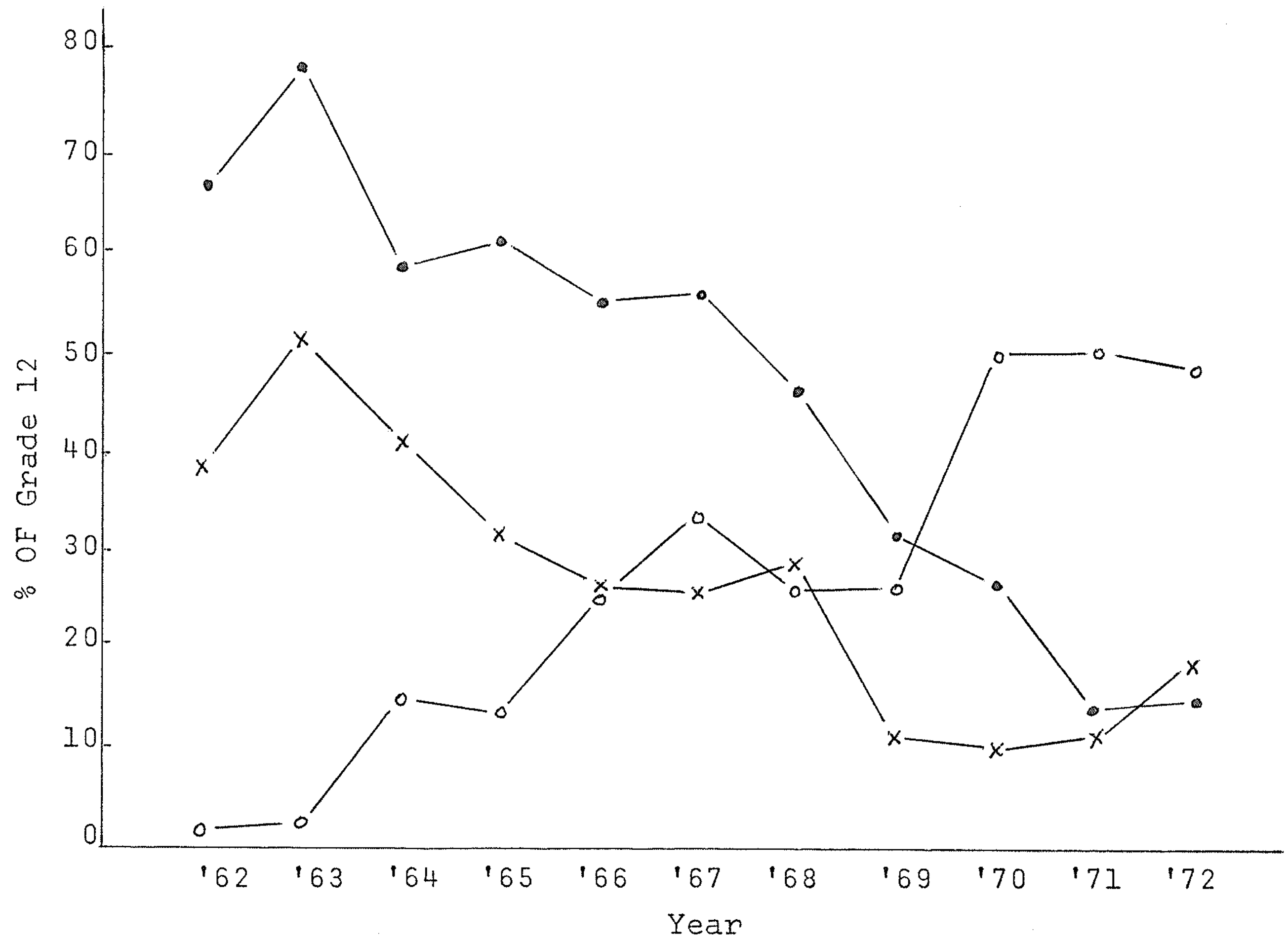


FIGURE 3.5 SCIENCE ENROLMENT BRANDON COLLEGIATE INSTITUTE



a generally negative trend for Physics and Chemistry enrolments, and a positive trend for Biology enrolments. From the years 1962-72, the data show that the enrolment pattern at the Provincial level paralleled those at the divisional and individual school levels.

However, a comparison of enrolment in Physics with that in Chemistry reveals a sharper drop in Chemistry enrolment at all three levels. Chemistry enrolments changed from a 1962 average value of approximately 65% of the total grade 12 enrolment to a 1972 value of approximately 22%. This represents a drop of 43% within a decade. The drop in Physics during the same time is found to be considerably less, approximately 23%.

Biology, on the other hand, underwent a positive change. The slopes of the Biology curves at the three different levels of investigation are similar, with an average positive change of approximately 32%.

Another interesting development illustrated by the enrolment figures was the dramatic decline in enrolments in Physics and Chemistry at all three levels beginning in the year 1969. In seeking an explanation for this sudden decline, it was discovered that 1968-69 was the year in which the Manitoba Department of Education introduced a combined program of studies entitled "Interim Modification: University Entrance and General Courses". Beginning in this year, senior students no longer had to choose or stay in one stream only, but could now elect to carry a partial University Entrance program combined with a partial General Course program. The purpose of this modification was to provide differentiation of studies to meet the varying needs, interests and abilities of students. When offered this differentiation of studies, many students who had previously enrolled in University Entrance Physics or Chemistry, now seemingly elected to enrol in the General Course option of Physical Science. This conclusion is supported by data appearing in Table A-11, which shows the increase in General Course enrolments.

DISTINGUISHING STUDENT CHARACTERISTICS

The second question investigated was:

What characteristics distinguish a student who: (a) is enrolled in science from one who is not enrolled in science; (b) is enrolled in Physics from one who is not enrolled Physics?

The variables investigated were: I.Q.; academic achievement; sex; age; aptitudes in verbal reasoning; numerical ability; abstract reasoning; mechanical reasoning; mechanical, computational, scientific, persuasive, artistic, and literary interests; and attitudes towards school subjects.

Hypotheses regarding each of these variables, except for attitudes toward school subjects, were tested using the Chi-square Test of "association". Student attitudes towards school subjects within the student categories were analyzed by comparing the mean group scale value of one category with that of another, as shown in Tables 3.5 and 3.6. The individual Chi-square Test results are given in Tables VAR003 to VAR020 (Appendix C). A summary of the Chi-square Tests is given in Tables 3.7 and 3.8.

Science Students. The results of the Chi-square Tests in Table 3.7, indicate that the only variable of statistical significance in differentiating between students taking science and those not taking science is verbal reasoning. The value of Chi-square for this variable (5.07) is significant at the 5 percent level of confidence warranting rejection of the null hypothesis and the conclusion that the verbal reasoning of science students is superior to that of the students not enrolled in science. Among other variables investigated, only the Chi-square value for I.Q., which was at the 10% level of confidence, seemed to be of interest. Although not significant the result is worth considering in view of the statement that:

TABLE 3.5

STUDENT ATTITUDES TOWARDS SCHOOL SUBJECTS

Subject	By Students Enrolled in Science	By Students Enrolled in No Science
Physics	5.1	4.2
Chemistry	4.3	3.6
Biology	6.5	6.3
History	4.2	4.3
English	7.8	8.2

TABLE 3.6

STUDENT ATTITUDE TOWARDS SCHOOL SUBJECTS

Subject	By Students Enrolled in Physics	By Students Not Enrolled in Physics
Physics	7.4	4.0
Chemistry	5.7	3.6
Biology	5.9	6.8
History	3.8	4.5
English	6.9	8.1

TABLE 3.7

CHI-SQUARE TEST RESULTS OF
THE NULL HYPOTHESES
Ho: $P_s = P_{ns}$

	Parameter	Chi-Square Value (X^2)
	I.Q.	4.74124
	Sex	0.30948
	Achievement	4.13947
Aptitudes	Verbal	5.07626**
	Numerical	1.05281
	Abstract Reasoning	0.87911
	Mechanical	0.10084
Interests	Mechanical	0.00653
	Computational	0.59087
	Scientific	0.18200
	Persuasive	0.05292
	Artistic	0.30948
	Literary	0.02915

** significant at the 5% level

TABLE 3.8

CHI-SQUARE TEST RESULTS OF THE NULL HYPOTHESES

Ho: $P_p = P_{np}$

	Parameter	Chi-Square Value (X^2)
	I.Q.	4.48921
	Sex	10.02442*
	Achievement	11.16175
Aptitudes	Verbal	2.15909
	Numerical	9.47532*
	Abstract Reasoning	5.07626**
	Mechanical	2.32345
Interests	Mechanical	4.63407**
	Computational	3.46195
	Scientific	0.00775
	Persuasive	0.55291
	Artistic	0.23778
	Literary	0.13687

* Significant at the 1% level

** Significant at the 5% level

> "...choice of significance level is to some extent arbitrary and will often depend on the use which is to be made of the observations. For example, if the observations are exploratory, it will not be advisable to choose too small a significance level (or critical region) for then small but promising departures from the null hypotheses may be overlooked"(18)

Therefore, the conclusion that I.Q. might have some bearing or meaningful association may be warranted.

The Purdue Masters'Attitude Scale Toward Any School Subject was administered to both groups to determine if attitudinal differences towards the school subjects of Physics, Chemistry, Biology, History and English were a factor. Summarized in Table 3.5, the results of this test indicate the various attitude scale values of each group. Interpretation of the scale values in relationship to the test in question (see Appendix D), may be stated as follows:

With respect to Chemistry and History:

> This subject will benefit only the brighter students;
>
> or
>
> My parents never had this subject, so I see no merit in it.

With respect to Physics; the groups consensus was:

> I haven't any definite like or dislike for this subject.

With respect to Biology:

> This subject is a good pastime.

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18 H.O. Lancaster, <u>The Chi-squared Distribution</u> (New York: John Wiley, & Sons, Inc., 1969) p. 164.

With respect to English:

> I am willing to spend my time studying this subject.

It was interesting to note that both groups reported a similar set of attitudes, that of being negative towards Physics, Chemistry and History; and positive towards Biology and English. Thus, there is no difference measured in attitudes between students enrolled in science and students not enrolled in science.

Physics Students. With respect to students enrolled in Physics as compared to students not enrolled in Physics, several of the variables tested may be judged significant. The variables of greatest significance (0.01%) as indicated in Table 3.8, were sex and the aptitude, numerical ability. The conclusion arrived at is that students who enrol in Physics are 1) more likely to be male; and 2) more capable of reasoning with numbers or dealing intelligently with quantitative materials and ideas than students who do not enrol in Physics.

Other variables that were significant at a slightly lower level (0.05%) were academic achievement, abstract reasoning and mechanical interests. It can be strongly stated that students enrolled in Physics are generally academically high achievers, have a superior ability to see relationships among things, objects, patterns, diagrams or designs, and have a greater interest or preference for working with machines and tools, than students who do not enroll in Physics.

The results of the "Purdue Master's Scale of Attitudes Towards School Subjects" were also analyzed with respect to students enrolled in Physics and students not enrolled in Physics. A comparison of the two groups is summarized in Table 3.6. The table reveals that Physics students have a positive attitude towards Physics and English and a negative attitude towards Chemistry, Biology and History. On the other hand, students not enrolled in Physics have a positive attitude towards Biology and English, but a negative attitude towards Physics, Chemistry and History. Thus there is a difference in attitudes between the two groups.

By referring to Appendix D the difference in attitudes between the two groups can be stated as follows:

Students Enrolled in Physics	Students Not Enrolled in Physics
Physics: This subject is a good pastime.	I see no merit in it.
Chemistry: I haven't any definite like or dislike for this subject.	I see no merit in it.
Biology: I haven't any definite like or dislike for this subject.	This subject is a good pastime.
History: I see no merit in it.	I see no merit in it.
English: This subject is a good pastime.	All lessons and all methods used in this subject are clear and definite.

In comparing Table 3.6 with Table 3.5, it is further revealed that students who are not enrolled in Physics have attitudes similar to students who are not enrolled in any science option, while students who are enrolled in Physics differ from students who are enrolled in one or more science options: the difference being in their attitudes towards Physics and Biology. Physics students have a positive attitude towards Physics, whereas science students generally do not, and secondly, Physics students have a negative attitude towards Biology, whereas science students generally exhibit a positive attitude toward that subject.

STUDENT REASONS FOR NOT ENROLLING IN PHYSICS

The third question investigated in this study was:

> What are the reasons offered by students for electing not to enroll in Physics?

To answer this question, a questionnaire consisting of twenty items was administered to all students in the population who were not enrolled in Physics. The items in the questionnaire were designed so that responses could be arranged in four groups according to academic, pedagogical, cultural-social and vocational reasons.

1. Academic Reasons -- measured by items 2, 10, 12, 18 and 19.

2. Pedagogical Reasons -- measured by items 5, 7, 13, 14 and 20.

3. Cultural-Social Reasons -- measured by items 4, 8, 9, 15 and 16.

4. Vocational Reasons -- measured by items 1, 3, 6, 11, and 17.

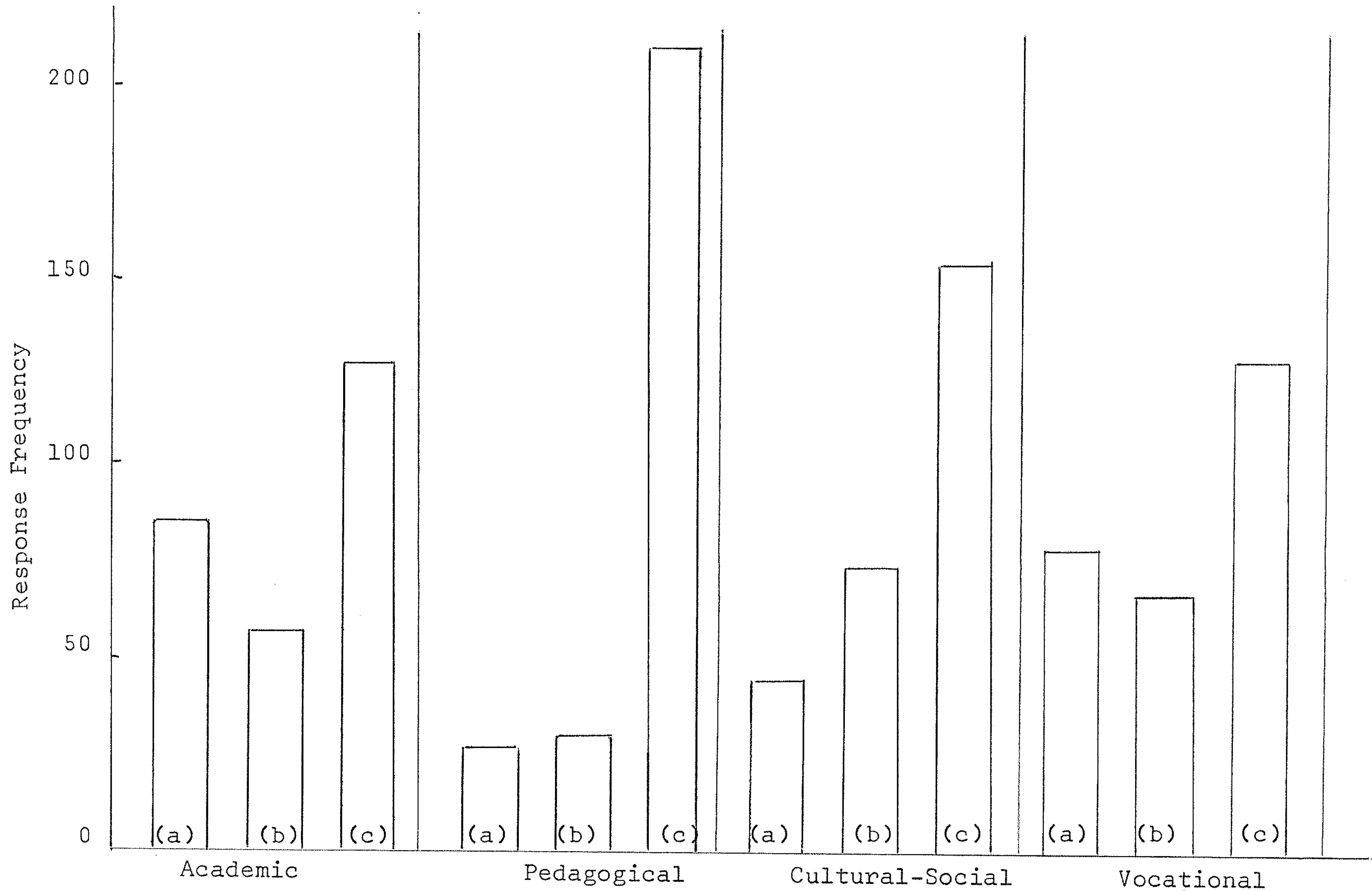
The questionnaire is presented in Appendix E.

In responding to the questions, the students were asked to indicate whether the factor: (a) influenced them strongly; (b) influenced them mildly; or (c) did not apply, in their decision not to enroll in Physics.

If after having completed the questionnaire, the students felt there were other reasons involved in their election not to enroll in Physics, they were asked to describe them under the section "Additional Comments".

To estimate the relative importance of reasons given by students for opting out of Physics, an item analysis was done on the questionnaire. Although the histogram (Figure 3.6) is inconclusive in its implications, it does point toward academic and vocational reasons as strongly influencing students not to enroll in Physics. The strong response to the academic reasons suggests that students do not enroll in Physics because Physics is too difficult, in terms of the mathematical skills required as well as the verbal comprehension of concepts

FIGURE 3.6: REASONS FOR NOT ENROLLING IN PHYSICS



Legend:
(a) if it influenced the student strongly
(b) if it influenced the student mildly
(c) if it did not apply to the student

involved. Secondly, the vocational reasons may be described as those related to career choices or university entrance requirements for particular vocations. Included in this is also the idea that the study of Physics leads only to vocations related to destructive technology or warfare.

Only 15% of the population not enrolled in Physics offered additional comments. However, their comments did indicate the possibility of reasons, other than those given in the questionnaire, influencing students not to take Physics. The reasons given under "Additional Comments" were almost entirely related in one way or another to the school, or some specific aspect of the school. The following comments made by students on the questionnaire are illustrative of the type of problems implied. The comments in some cases have been edited.

(1) Student-Status -- The problem with my school is student-status. It was the downfall for me. No initiative or responsibility was required of me -- sometimes bitter coffee was more pleasant than a class in which nothing was accomplished (Student No. 41).

(2) Student-Teacher Relationships -- There was too much changing of values by the teachers who had formed opinions of students before actually meeting them and talking to them (Student No. 42).

Teachers do not seem to be able or want to relate to their students. Teachers should not be as serious in their attitudes as they are. It would make the class easier to learn in (Student No. 45).

(3) Counseling Services -- I chose answer (c) for most of the questionnaire items because I don't know anything about the subject of Physics (Student No. 56). If a student knew exactly what he wanted to do when he got out of school, then he or she could take the course pertaining to that field. But at this stage a student doesn't know, so he picks the easiest of two options, not knowing how the course is going to benefit him in the end (Student No. 64).

(4) Pre-High School Experiences -- To be honest, I never considered Physics at the high school level at all. I learned to dislike it when I was in grade nine. Our teacher concentrated all year on Physics. He was a good teacher but expected us to do grade ten or eleven work. He was too tough and humorless with us. He turned me off Physics forever (Student No. 33).

(5) Priority of Interests -- I would like to have taken Physics, but chose Geography instead because as a subject it gives a broader scope of the world we live in. Physics is too narrow (Student No. 49).

These additional comments indicate that with respect to these students, the Student Questionnaire was possibly too general in nature, and didn't allow the student to become specific about his reasons for opting out of Physics. Perhaps asking each student to describe his reasons in an essay would have allowed him to become more personal in his objections to Physics. However, regardless of the weaknesses of the questionnaire, the student comments demonstrate that at least a small percentage of the student population is very perceptive about their school's effectiveness in helping them make the right choices in order to get the most out of their education.

The comments also demonstrate convincingly that for some students, one of the basic and crucial elements in the classroom is the personal relationships between the teacher and the individual student. This relationship appears to be the key to the students perception of his class, his attitude towards the subject, as well as his achievement in the subject. The whole area of student-teacher-school relationships is one which, perhaps, the study should have explored in more detail.

In relating these student comments to the findings of other researchers, it may be said that they lend support to researchers like Flanders[19] and developmental psychologists

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19 Flanders, N.A.; "Teacher Effectiveness", Encyclopedia of Educational Research, 4th Ed. (Toronto, MacMillan Publishing Co. Ltd., 1969), pp 1423-1437.

like Erikson[20] and sociologists like Friedenberg[21], who have studied the effects on adolescents of the school as an institution. Together, their findings indicate that student achievement and attitude scores were significantly higher for those schools in which students were exposed to indirect methods of teaching. Teachers who used the indirect approach, encouraging the student to ask questions, accepting student ideas and feelings, had classes who obtained the highest scores in achievement and attitudes.

The question now arises, is this area of student-teacher-school relationships a crucial one for the majority of students who elect not to enroll in a given subject like Physics? The few comments given above suggest it is for some, approximately 15% of the population. The Student Questionnaire perhaps suggests that it isn't, since the majority of students who elected not to enroll in Physics indicated that school related reasons such as measured by items 5, 7, 13, 14 and 20, did not have a significant influence in their election not to enroll in Physics.

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20 Ericson, E.; Childhood and Society, 2nd Ed., (New York: W.W. Norton & Co., 1963)

21 Friedenberg, E.Z.; Nordstorm, Carl; and Gold, H.; Society's Children: A Study of Resentment in the Secondary School. (New York: Random House, Inc., 1967).

Chapter IV

SUMMATION

The overall purpose of this study was to determine the nature and extent of the changing enrolment patterns in high school science and to investigate possible reasons for any changes in enrolment detected.

The study points to several conclusions which warrant discussion, and from which implications and recommendations for educational practice may be drawn.

CONCLUSIONS

In the following, conclusions will be preceded by the original questions posed.

Question 1: What is the nature and extent of the changing enrolment patterns in grade 12 Physics, Chemistry and Biology in Manitoba:

With respect to question 1, the data from the years 1962 to 1972 established that generally in Manitoba:

1) Enrolments in Physics and Chemistry at the Grade 12 level declined at a rate of approximately 3% per year.

2) Biology enrolments at the grade 12 level increased at a rate of approximately 3% per year.

Question 2: What characteristics distinguish a grade 12 student who: (a) is enrolled in science from one who is not enrolled in science; (b) is enrolled in Physics from one who is not enrolled in Physics?

In answer to question 2, the study determined that the changing enrolment pattern was associated with the following student characteristics:

1) Science students have a greater ability to carry out verbal reasoning than students not enrolled in science.

2) Students in Manitoba who enroll in Physics are predominantly male.

3) Students in Manitoba who enroll in Physics are more capable of numerical reasoning than students who do not enroll in Physics.

4) Students in Manitoba enrolled in Physics have a higher level of academic achievement than students who do not enroll in Physics.

5) Students in Manitoba who enroll in Physics are more capable of abstract reasoning than students who do not enroll in Physics.

6) Students in Manitoba enrolled in Physics have a higher level of mechanical interests than students who do not enroll in Physics.

7) Students in Manitoba enrolled in Physics generally have a more positive attitude towards Physics and Chemistry than students who do not.

Question 3: What are the reasons offered by grade 12 students for electing not to enroll in Physics?

With respect to question 3, the study sought to identify factors, other than student characteristics, that had a bearing on their election not to enroll in Physics. The results indicated that students do not enroll in Physics because of:

1) academic reasons related particularly to skills in mathematics and verbal comprehension;

2) vocational reasons related to career choices and university entrance requirements;

3) personal reasons related directly or indirectly to student-teacher-school relationships.

DISCUSSION

From the conclusions reached in answer to question 1, and from trends identified earlier in the United States and Alberta, it is obvious that the changing enrolment patterns described are widespread. What has happened in Manitoba appears to be similar to what has happened in Alberta, suggesting that these changes may be national in scope.

The study also suggests that if the pattern of declining enrolments in Physics and Chemistry, and the negative attitude of students generally towards Physics and Chemistry continues, Manitoba can expect to have less than 10% of its senior high school student population enrolled in Physics and Chemistry. Barring intervening factors, however, Biology enrolments will continue to rise.

The Provincial enrolment trend described in an earlier chapter indicates that possibly there are factors that occasionally arise which counteract the overall negative trend observed. For example, Chemistry and Physics did show an increase in percentage enrolment in Manitoba during 1971. However, since both subject areas again showed a decrease in 1972, it is difficult to determine what, if any, factors had intervened to arrest the downward trend.

With respect to question 2, most of the conclusions were not unexpected, particularly in view of the studies cited in Chpater 2. An interesting point, however, is that the study has now verified by measurement what has heretofore been conjecture. For example, previous studies indicated that students were of the opinion that one needed good mathematics skills in order to take Physics, but the studies cited did not seek to measure the numerical ability of Physics students. This study has verified that Physics students are, in fact, superior to non-physics students in mathematics. The study suggested a profile of the Physics student as being a male with high levels of ability in verbal, numerical and abstract reasoning, high academic achievement, mechanical interests and a positive attitude toward Physics and Chemistry.

A surprising element in question 2 is perhaps the level at which the null hypotheses with respect to sex and numerical ability were rejected. Most of the previous studies did indicate that Physics courses exhibit male selectivity and that they demand a high degree of mathematical ability, but 1% level of significance determined for these two variables is indeed impressive.

Another result that was not anticipated in the investigation of question 2 was the pattern of attitudes generally of students towards school subjects. For example, why should the attitude of students enrolled in science by negative towards Physics and Chemistry, and yet positive towards Biology. However, the result is not as surprising in view of the enrolment trends established in the investigation of question 1.

Again, why should the general attitude of all students be positive towards English and Physics. It would seem that a great deal of additional exploration in the areas of attitudes is necessary, if answers to these questions are to be found.

The conclusions arrived at in answer to question 3, are similar to and supportive of those cited in other studies described by Chapter 2. For example, the Alberta study by Caron indicated that both career choices and academic skills in mathematics were major factors having a bearing on student election of enrolling or not enrolling in Physics. It should be noted that the aspect of "career choices" appears to be particularly Canadian, since it does not appear as a significant factor in the American studies.

IMPLICATIONS FOR EDUCATIONAL PRACTICE

The conclusions given above, based upon results with a high level of statistical significance, suggest that if enrolment in Physics is to be maintained at its historical level, positive action must be taken. Accordingly, the following are recommended: (1) an integrated science course option; (2) re-organization of the curriculum.

An Integrated Science Course Option: To overcome male selectivity and the enrolment problems associated with verbal reasoning, numerical reasoning, abstract reasoning, mechanical interests, academic achievement, and student interests and attitudes, it is recommended that schools offer an integrated science option.

The low science aptitude student, the student with problems in numerical reasoning and abstract reasoning, the slow to average academic student, whose formal science education ended with grade 10, poses unique problems for educators and curriculum materials publishers. The current programs do little to satisfy these special needs. Students who cannot handle the more rigorous science courses, but who have an interest, should be allowed to choose a suitable science option, geared for their interests and abilities. Such a course should appeal to a much wider range of student needs, interests and abilities. This course should not replace the present academic science courses offered (P.S. P.C. Physics, CHEM Study, B.S.C.S. Biology), but should be offered as an option to those students who do not normally enrol in the more rigorous courses for reasons given above.

The course should appeal to those who wish to make a career of science, as well as those who will go to college but major in some other field. It is for this reason that a tri-science integration is suggested, with topics of study from all three of the major fields of Physics, Chemistry and Biology. The broader the appeal, the greater the enrolment. In this way, many students who are now graduating with only a Biology background, or no science background, would also have the opportunity to obtain a background in both Physics and Chemistry. Thus, the total number of students studying Physics should increase.

The method of achieving this goal is two fold. Firstly, a "heart" will need to be put into the integrated science course. Humanistic elements must be included in the textbooks and the supplementary materials, exercises and program instruction so that the interests of the students will be met.

The integrated science course would need to be structured to encourage involvement by allowing this kind of a student to earn a passing grade and by providing laboratory experiences that speak directly and meaningfully to the student, using his language and vocabulary. This is one of the ways in which we can help the student overcome his weaknesses.

Secondly, the one-year, one-subject approach to learning a major science option needs to be eliminated. It is gratifying to see Manitoba move in this direction. In a recent study carried out by the Manitoba Department of Education on the re-organization of secondary schools in Manitoba, it has been recommended:

> "All classifications of courses into discrete and separate programs, such as the present so-called academic, vocational and occupational, should be eliminated ... the school should offer a wide range of opportunities to enable the student to follow up his interests and abilities."(22)

In the place of the one-year, one-subject approach should be a co-operatively planned flexible program, that will take

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22 The Report of the Core Committee on the Reorganization of the Secondary School, Department of Education, Province of Manitoba, 1973; p. 18.

advantage of the students' abilities, but equally important, at the same time attempt to remedy or by-pass the students weaknesses in verbal reasoning, numerical reasoning, abstract reasoning, or whatever.

An approach to this kind of science might be a pilot project of a large variety of topics or units, each of some suitable length of time. For example, areas considered relevant to students might be:

Units	Length of Time		Credit
Inquiry (I)	2%		1/5
Analytical Skills (I)	2%		1/5
Mechanics (P)	2%		1/5
Nature of Light & Sound (P)	2%	Physics	1/5
Electricity (P)	2%	Major	1/5
The New Physics (P)	2%		1/5
Evolution (B)	2%		1/5
Genetics (B)	2%	Biology	1/5
Homeostasis (B)	2%	Major	1/5
Ecology (B)	2%		1/5
Atomic Theory of Matter (C)	2%		1/5
Solutions (C)	2%	Chemistry	1/5
Elements & Their Compounds(C)	2%	Major	1/5
Chemical Calculations (C)	2%		1/5
Technologies (G)	2%		1/5
Individual Project (G)	2%		1/5

This is just a sampling of what could be offered. Such an offering should never remain static, but as needs and interests of the students change, so should the content. This is what is meant by a co-operatively planned flexible program, with the interests and needs of the student at its center.

Re-organizing the Curriculum: Widening the appeal, and thus making science accessible to all students, also implies the necessity of re-organizing the curriculum.

An example of this re-organization would be giving students not only a large number of science topics or units from which they are allowed to select those that interest them most, but assigning each such unit a credit value as noted above. Grading would then be determined by credit accumulation. The accumulation of 12% would result in one full credit. This would replace the present sequencing method followed in most schools today. Non-sequencing would allow more students to become acquainted with many aspects of science, and hopefully, more aspects of Physics, and might conceivably uncover a hidden reservoir of talent. Traditionally, students have had to get a long "running start" on a science program, before getting to something really interesting. Presently, a major science option takes one or two years to complete, with no mid-term exit possibilities or entrances. It is almost impossible to exit for remedial work for a few weeks and re-enter. The only entrance point presently is September.

It may be argued that opening access to science in this way will reduce enrolment of students taking a major Physics option, rather than increase it. This is perhaps possible, but the net result should be that more students will have at least some background in Physics, especially those who now elect not to enroll.

In summary, these two recommendations, an integrated science course option and reorganization of the curriculum, are not dictated by the results of this study, nor are they the sole methods of coping with declining enrolment in Physics. They merely suggest two types of action that would encourage more students to enroll in a Physics program in Manitoba high schools.

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APPENDICES

Appendix A: Manitoba Enrolment Tables

TABLE A.1

MANITOBA ENROLMENT IN GRADE 12

Year	Manitoba Province	Brandon School Division #40	Brandon Collegiate Institute
1962	6,223	236	96
1963	6,705	270	87
1964	7,899	292	95
1965	10,152	353	142
1966	11,730	332	103
1967	11,586	347	90
1968	11,684	390	95
1969	13,584	498	150
1970	14,769	460	97
1971	14,483	536	87
1972	14,827	644	94

TABLE A.2

MANITOBA ENROLMENT IN
GRADE 12 PHYSICS

Year	Enrolment	% Enrolment
1962	2,863	46.0
1963	3,021	45.4
1964	3,507	44.4
1965	4,117	40.5
1966	4,562	38.8
1967	4,518	39.2
1968	4,006	34.2
1969	2,594	19.1
1970	2,217	15.0
1971	3,158	21.8
1972	3,055	20.4

TABLE A.3

MANITOBA ENROLMENT IN
GRADE 12 CHEMISTRY

Year	Enrolment	% Enrolment
1962	4,377	70.5
1963	4,330	64.5
1964	5,310	67.4
1965	6,653	65.5
1966	6,429	54.7
1967	6,074	52.6
1968	5,323	45.6
1969	3,916	28.8
1970	3,280	22.2
1971	4,702	32.4
1972	4,630	31.2

TABLE A.4

MANITOBA ENROLMENT IN
GRADE 12 BIOLOGY

Year	Enrolment	% Enrolment
1962	1,023	16.4
1963	1,244	18.5
1964	1,848	23.4
1965	2,599	25.6
1966	3,182	27.1
1967	2,697	23.1
1968	3,113	26.6
1969	2,399	17.7
1970	2,076	14.4
1971	4,648	32.0
1972	5,188	34.8

TABLE A.5

PHYSICS ENROLMENT IN
BRANDON SCHOOL DIV. #40

Year	Enrolment	% Enrolment
1962	93	39.0
1963	133	50.0
1964	112	38.0
1965	137	38.8
1966	132	39.8
1967	123	35.6
1968	143	36.8
1969	82	16.5
1970	81	17.5
1971	89	16.5
1972	110	17.0

TABLE A.6

CHEMISTRY ENROLMENT IN
BRANDON SCHOOL DIV.#40

Year	Enrolment	% Enrolment
1962	148	60.0
1963	179	66.5
1964	147	50.0
1965	245	69.0
1966	207	62.4
1967	133	38.2
1968	147	37.6
1969	161	32.4
1970	136	29.6
1971	132	24.6
1972	127	19.5

TABLE A.7

BIOLOGY ENROLMENT IN
BRANDON SCHOOL DIV.#40

Year	Enrolment	% Enrolment
1962	4	1.7
1963	7	2.6
1964	36	12.3
1965	73	20.4
1966	98	29.4
1967	101	29.2
1968	91	23.0
1969	223	45.0
1970	204	44.5
1971	210	39.2
1972	211	32.8

TABLE A.8

PHYSICS ENROLMENT IN
BRANDON COLLEGIATE INSTITUTE

Year	Enrolment	% Enrolment
1962	37	38.6
1963	45	51.8
1964	39	41.1
1965	45	31.6
1966	27	26.2
1967	23	25.6
1968	27	28.4
1969	18	12.0
1970	10	10.3
1971	10	11.5
1972	17	18.1

TABLE A.9

CHEMISTRY ENROLMENT IN
BRANDON COLLEGIATE INSTITUTE

Year	Enrolment	% Enrolment
1962	63	65.6
1963	68	78.1
1964	55	57.8
1965	87	61.0
1966	57	55.2
1967	51	56.6
1968	44	46.5
1969	47	31.3
1970	28	28.8
1971	12	13.8
1972	14	14.9

TABLE A.10

BIOLOGY ENROLMENT IN
BRANDON COLLEGIATE INSTITUTE

Year	Enrolment	% Enrolment
1962	1	1.0
1963	2	2.3
1964	14	14.7
1965	18	12.7
1966	26	25.2
1967	31	34.4
1968	25	26.4
1969	39	26.0
1970	49	50.5
1971	44	50.5
1972	45	48.0

TABLE A.11

MANITOBA GENERAL COURSE ENROLMENTS, GRADE 12

Subject	1965	1966	1967	1968	1969	1970	1971	1972
Physical Science 301	213	397	615	915	1449	1653	1797	1736
Biology 301	179	235	363	616	1114	1517	1585	1516

APPENDIX B

TABLE B.1

CHI-SQUARE DISTRIBUTION OF PERCENTAGE POINTS

No.	Probability 0.25	0.11	0.10	0.06	0.05	0.01
1	1.323	2.56	2.706	2.54	3.841	6.635
2	2.773	4.42	4.605	5.63	5.991	9.210
3	4.108	6.04	6.251	7.40	7.815	11.345
4	5.385	7.53	7.779	9.04	9.488	13.277
5	6.626	8.98	9.236	10.59	11.070	15.086
6	7.841	10.38	10.645	12.10	12.592	16.812
7	9.037	11.74	12.017	13.55	14.067	18.475
8	10.219	13.06	13.362	14.95	15.507	20.090
9	11.389	14.38	14.684	16.35	16.919	21.666
10	12.549	15.67	15.987	17.72	18.307	23.209

APPENDIX C

CHI-SQUARE TEST RESULTS

INTERPRETATION SCALE

Variable Number	Variable	
VAR001	Student Number	
VAR002	I.Q.	
VAR003	Achievement	
VAR004	Sex	
VAR005	Age	
VAR006	Physics	
VAR007	Chemistry	
VAR008	Biology	
VAR009	Mathematics	
VAR010	Verbal	Differential Aptitude Tests
VAR011	Numerical	
VAR012	Verbal/Numerical	
VAR013	Abstract	
VAR014	Mechanical	
VAR015	Mechanical	Interests
VAR016	Computational	
VAR017	Scientific	
VAR018	Persuasive Powers	
VAR019	Artistic	
VAR020	Literary	

TABLE C.1

CROSSTABULATION OF VAR002
IQ BY SUBJECT

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	3 60.0 14.3 3.9	2 40.0 3.6 2.6	5 6.6
2.00	12 32.4 57.1 15.8	25 67.6 45.5 32.9	37 48.7
3.00	6 17.6 28.6 7.9	28 82.4 50.9 36.8	34 44.7
Column Total	21 27.6	55 72.4	76 100.0

Chi Square = 4.74124 with 2 degrees of freedom

TABLE C.2

CROSSTABULATION OF VAR002
IQ BY VAR006 PHYSICS

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	5 100.0 9.1 6.6	0 0.0 0.0 0.0	5 6.6
2.00	29 78.4 52.7 38.2	8 21.6 38.1 10.5	37 48.7
3.00	21 61.8 38.2 27.6	13 38.2 61.9 17.1	34 44.7
Column Total	55 72.4	21 27.6	76 100.0

Chi Square = 4.48921 with 2 degrees of freedom

TABLE C.3

CROSSTABULATION OF VAR004
SEX BY SUBJECT

VAR004	Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
FEMALE	1.00	7 22.6 33.3 9.2	24 77.4 43.6 31.6	31 40.8
MALE	2.00	14 31.1 66.7 18.4	31 68.9 56.4 40.8	45 59.2
	Column Total	21 27.6	55 72.4	76 100.0

Corrected Chi Square = 0.30948 with
1 degree of freedom

TABLE C.4

CROSSTABULATION OF VAR004
SEX BY VAR006 PHYSICS

VAR004	Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
FEMALE	1.00	29 93.5 52.7 38.2	2 6.5 9.5 2.6	31 40.8
MALE	2.00	26 57.8 47.3 34.2	19 42.2 90.5 25.0	45 59.2
	Column Total	55 72.4	21 27.6	76 100.0

Corrected Chi Square = 10.02442 with
1 degree of freedom

TABLE C.5

CROSSTABULATION OF VAR003
ACHIEVEMENT BY SUBJECT

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	3 42.9 14.3 3.9	4 57.1 7.3 5.3	7 9.2
2.00	10 37.0 47.6 13.2	17 63.0 30.9 32.3	27 35.5
3.00	8 20.5 38.1 10.5	31 79.5 56.4 40.8	39 51.3
4.00	0 0.0 0.0 0.0	3 100.0 5.5 3.9	3 3.9
Column Total	21 27.6	55 72.4	76 100.0

Chi Square = 4.13977 with 3 degrees of freedom

TABLE C.6

CROSSTABULATION OF VAR003 ACHIEVEMENT BY VAR006 PHYSICS

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	6 85.7 10.9 7.9	1 14.3 4.8 1.3	7 9.2
2.00	25 92.6 45.5 32.9	2 7.4 9.5 2.6	27 35.5
3.00	22 56.4 40.0 28.9	17 43.6 81.0 22.4	39 51.3
4.00	2 66.7 3.6 2.6	1 33.3 4.8 1.3	3 3.9
Column Total	55 72.4	21 27.6	76 100.0

Chi Square = 11.16175 with 3 degrees of freedom

TABLE C.7

CROSSTABULATION OF VAR010
DAT VERBAL BY SUBJECT

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	18 37.5 85.7 23.7	30 62.5 54.5 39.5	48 63.2
2.00	3 10.7 14.3 3.9	25 89.3 45.5 32.9	28 36.8
Column Total	21 27.6	55 72.4	76 100.0

Corrected Chi Square = 5.07626 with
1 degree of freedom

TABLE C.8

CROSSTABULATION OF VAR010
DAT VERBAL BY VAR006 PHYSICS

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	38 79.2 69.1 50.0	10 20.8 47.6 13.2	48 63.2
2.00	17 60.7 30.9 22.4	11 39.3 52.4 14.5	28 36.8
Column Total	55 72.4	21 27.6	76 100.0

Corrected Chi Square = 2.15909 with
1 degree of freedom

TABLE C.9

CROSSTABULATION OF VAR011
DAT NUMERICAL BY SUBJECT

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	13 34.2 61.9 17.1	25 65.8 45.5 32.9	38 50.0
2.00	8 21.1 38.1 10.5	30 78.9 54.5 39.5	38 50.0
Column Total	21 27.6	55 72.4	76 100.0

Corrected Chi Square = 1.05281 with
1 degree of freedom

TABLE C.10

CROSSTABULATION OF VAR011
DAT NUMERICAL BY VAR006 PHYSICS

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	34 89.5 61.9 44.7	4 10.5 19.0 5.3	33 50.0
2.00	21 55.3 38.2 27.6	17 44.7 81.0 22.4	38 50.0
Column Total	55 72.4	21 27.6	76 100.0

Corrected Chi Square = 9.47532 with
1 degree of freedom

TABLE C.11

CROSSTABULATION OF VAR013
DAT CRITICAL THINKING BY SUBJECT

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	10 35.7 47.6 13.2	18 64.3 32.7 23.7	28 36.8
2.00	11 22.9 52.4 14.5	37 77.1 67.3 48.7	48 63.2
Column Total	21 27.6	55 72.4	76 100.0

Corrected Chi Square = 0.87911 with
1 degree of freedom

TABLE C.12

CROSSTABULATION OF VAR013
DAT CRITICAL THINKING BY VAR006 PHYSICS

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	25 89.3 45.5 32.9	3 10.7 14.3 3.9	28 36.8
2.00	30 62.5 54.5 39.5	18 37.5 85.7 23.7	48
Column Total	55 72.4	21 27.6	76 100.0

Corrected Chi Square = 5.07626 with
1 degree of freedom

TABLE C.13

CROSSTABULATION OF VAR014
DAT MECHANICAL BY SUBJECT

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	15 25.9 71.4 19.7	43 74.1 78.2 56.6	58 76.3
2.00	6 33.3 28.6 7.9	12 66.7 21.8 15.8	18 23.7
Column Total	21 27.6	55 72.4	76 100.0

Corrected Chi Square = 0.10084 with
1 degree of freedom

TABLE C.14

CROSSTABULATION OF VAR014
DAT MECHANICAL BY VAR006 PHYSICS

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	45 77.6 81.8 59.2	13 22.4 61.9 17.1	58 76.3
2.00	10 55.6 18.2 13.2	8 44.4 38.1 10.5	18 23.7
Column Total	55 72.4	21 27.6	76 100.0

Corrected Chi Square = 2.32345 with
1 degree of freedom

TABLE C.15

CROSSTABULATION OF VAR015
INT MECH BY SUBJCT

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	7 30.4 33.3 9.2	16 69.6 29.1 21.1	23 30.3
2.00	14 26.4 66.7 18.4	39 73.6 70.9 51.3	53
Column Total	21 27.6	55 72.4	76 100.0

Corrected Chi Square = 0.00653 with
1 degree of freedom

TABLE C.16

CROSSTABULATION OF VAR015
INT MECH BY VAR006 PHYSICS

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	21 91.3 38.2 27.6	2 8.7 9.5 2.6	23 30.3
2.00	34 64.2 61.8 44.7	19 35.8 90.5 25.0	53 69.7
Column Total	55 72.4	21 27.6	76 100.0

Corrected Chi Square = 4.63407 with
1 degree of freedom

TABLE C.17

CROSSTABULATION OF VAR016
INT COMP BY SUBJECT

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	5 20.0 23.8 6.6	20 80.0 36.4 26.3	25 32.9
2.00	16 31.4 76.2 21.1	35 68.6 63.6 46.1	51 67.1
Column Total	21 27.6	55 72.4	76 100.0

Corrected Chi Square = 0.59087 with
1 degree of freedom

TABLE C.18

CROSSTABULATION OF VAR016
INT COMP BY VAR006 PHYSICS

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	22 88.0 40.0 28.9	3 12.0 14.3 3.9	25 32.9
2.00	33 64.7 60.0 43.4	18 35.3 85.7 23.7	51 67.1
Column Total	55 72.4	21 27.6	76 100.0

Corrected Chi Square = 3.46195 with
1 degree of freedom

TABLE C.19

CROSSTABULATION OF VAR017
INT SCIENTIFIC BY SUBJECT

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	10 24.4 47.6 13.2	31 75.6 56.4 40.8	41 53.9
2.00	11 31.4 52.4 14.5	24 68.6 43.6 31.6	35 46.1
Column Total	21 27.6	55 72.4	76 100.0

Corrected Chi Square = 0.18200 with
1 degree of freedom

TABLE C.20

CROSSTABULATION OF VAR017
INT SCIENTIFIC BY VAR006 PHYSICS

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	30 73.2 54.5 39.5	11 26.8 52.4 14.5	41 53.9
2.00	25 71.4 45.5 32.9	10 28.6 57.6 13.2	35 46.1
Column Total	55 72.4	21 27.6	76 100.0

Corrected Chi Square = 0.00775 with
1 degree of freedom

TABLE C.21

CROSSTABULATION OF VAR018
INT PERS BY SUBJECT

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	10 27.8 47.6 13.2	26 72.2 47.3 34.2	36 47.4
2.00	11 27.5 52.4 14.5	29 72.5 52.7 38.2	40 52.6
Column Total	21 27.6	55 72.4	76 100.0

Corrected Chi Square = 0.05292 with
1 degree of freedom

TABLE C.22

CROSSTABULATION OF VAR018
INT PERS BY VAR006 PHYSICS

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	28 77.8 50.9 36.8	8 22.2 38.1 10.5	36 47.4
2.00	27 67.5 49.1 35.5	13 32.5 61.9 17.1	40 52.6
Column Total	55 72.4	21 27.6	76 100.0

Corrected Chi Square = 0.55291 with
1 degree of freedom

TABLE C.23

CROSSTABULATION OF VAR019
INT ART BY SUBJECT

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	14 31.1 66.7 18.4	31 68.9 56.4 40.8	45 59.2
2.00	7 22.6 33.3 9.2	24 77.4 43.6 31.6	31 40.8
Column Total	21 27.6	55 72.4	76 100.0

Corrected Chi Square = 0.30948 with
1 degree of freedom

TABLE C.24

CROSSTABULATION OF VAR019
INT ART BY VAR006 PHYSICS

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	34 75.6 61.8 44.7	11 24.4 52.4 14.5	45 59.2
2.00	21 67.7 38.2 27.6	10 32.3 47.6 13.2	31 40.8
Column Total	55 72.4	21 27.6	76 100.0

Corrected Chi Square = 0.23778 with
1 degree of freedom

TABLE C.25

CROSSTABULATION OF VAR020
INT LIT BY SUBJECT

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	14 28.0 66.7 18.4	36 72.0 65.5 47.4	50 65.8
2.00	7 26.9 33.3 9.2	19 73.1 34.5 25.0	26 34.2
Column Total	21 27.6	55 72.4	76 100.0

Corrected Chi Square = 0.02915 with
1 degree of freedom

TABLE C.26

CROSSTABULATION OF VAR020 INT LIT BY VAR006 PHYSICS

Count ROW PCT COL PCT TOT PCT	0.0	1.00	ROW TOTAL
1.00	35 70.0 63.6 46.1	15 30.0 71.4 19.7	50 65.8
2.00	20 76.9 36.4 26.3	6 23.1 28.6 7.9	26 34.2
Column Total	55 72.4	21 27.6	76 100.0

Corrected Chi Square = 0.13687 with 1 degree of freedom

APPENDIX D

A SCALE TO MEASURE ATTITUDE TOWARD ANY SCHOOL SUBJECT

Form A

Edited by H. H. Remmers

Date________________________

Name (optional)____ Sex (circle one) M F

Age______________________________ Grade______________________________

Directions: Following is a list of statements about school subjects. Put a plus sign (+) before each statement with which you agree about the subjects listed at the left of the statements. The person in charge will tell you the subject or subjects to write in at the head of the columns to the left of the statements. Your score will not affect your grade in any course.

Subject						
					1.	No matter what happens, this subject always comes first.
					2.	This subject has an irresistible attraction for me.
					3.	This subject is profitable to everybody who takes it.
					4.	Any student who takes this subject is bound to be benefited.
					5.	This subject is a good subject.
					6.	All lessons and all methods used in this subject are clear and definite.
					7.	I am willing to spend my time studying this subject
					8.	This subject is a good pastime.
					9.	I don't believe this subject will do anybody any harm.
					10.	I haven't any definite like or dislike for this subject.
					11.	This subject will benefit only the brighter students.
					12.	My parents never had this subject, so I see no merit in it.
					13.	I am not interested in this subject.
					14.	This subject reminds me of Shakespeare's play -- "Much Ado About Nothing."
					15.	I would not advise anyone to take this subject.
					16.	This subject is a waste of time.
					17.	I look forward to this subject with horror.

INTERPRETATION OF ATTITUDE SCALE VALUES

Type of Attitude As Described By Test Item	Scale Value
1	10.3
2	9.6
3	9.2
4	8.9
5	8.5
6	8.1
7	7.7
8	6.5
9	6.0
10	5.5
11	4.7
12	3.6
13	3.1
14	2.6
15	2.2
16	1.6
17	1.0

Mean scale value of $\geq$ 6.0 indicates a positive attitude by the group towards the subject. Mean scale value of $<$ 6.0 indicates a negative attitude towards the subject.

APPENDIX E

STUDENT QUESTIONNAIRE

The purpose of this questionnaire is to gather information from secondary school students about their reasons for not electing to study Physics in High School. It is hoped that this information will be helpful in developing or improving Physics courses.

INSTRUCTIONS --

Read each question carefully, choose your answer, and then blacken the appropriate space on your I.B.M. score sheet as follows:

a -- if it influenced you strongly in electing not to study Physics

b -- if it influenced you mildly in electing not to study Physics

c -- if you cannot decide, or if the statement does not apply in your case.

After having answered the questions, should you feel that there were other reasons other than the ones mentioned that influenced you not to elect to study Physics, please feel free to add these under the section entitled "Additional Comments".

I did not elect to study Physics because:

1. I did not need it for entrance into university.
2. I was afraid it would lower my academic average.
3. I believed Physics did not help open doors to jobs.
4. I felt a knowledge of Physics was not important to the average person.
5. I did not know what Physics was about.
6. I had no interest in things mechanical.
7. I was unable to elect Physics because of a timetable conflict.
8. I was told Physics would not help me develop as a person.
9. Physics is non-humanitarian in its implications.
10. Physics requires too much time in terms of lab work, as well as homework.
11. I did not need it in the career I intend to follow.
12. I am poor in mathematics.
13. The Physics lab in my school is poorly equipped.
14. I believe Physics teachers mark harder than non-science teachers.
15. Physics is too machine oriented in practice and philosophy.
16. Physics gives no sense of direction or meaning to life.
17. Physics leads only to jobs related to war and the destruction of man and his world.
18. I had a poor science achievement in Junior High.
19. Physics texts are dull, unimaginative, and very difficult to read.
20. Physics teachers are too strict or demanding, and without a sense of humor.