EVALUATION OF THE EFFECTIVENESS OF THE NECHAKO VALLEY SECONDARY SCHOOL MATHEMATICS PROGRAM: AN INTERRUPTED TIME SERIES ANALYSIS

by

Lynn Maksymchak

B.Ed., Loughborough University, 1977

THESIS PROPOSAL SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF EDUCATION

in

CURRICULUM AND INSTRUCTION

© Lynn Maksymchak, 1998

THE UNIVERSITY OF NORTHERN BRITISH COLUMBIA

June 1998

All rights reserved. This work may not be reproduced in whole or in part, by photocopy or other means, without the permission of the author.
ABSTRACT

This study, a program evaluation, investigated how the introduction and use of the Nechako Valley Secondary (NVSS) Mathematics Program to teach mathematics to all students in the school affected the mean examination score and the participation rate for Math 12. The study examined provincial examination statistics for Math 12, Chemistry 12 and Physics 12, and the GPA scores of the students taking Math 12. Time series analysis was used to investigate trends within the data. Results did not support the two main hypotheses that the introduction of the NVSS Mathematics Program improved mean score and participation rate. However when evidence of cohort effects, self selection effects and district trends was considered, the program, was judged to, at worst, yield results no different than the traditional approach. Some evidence suggests there may have been a slight improvement particularly in the relative increase in participation rate.
TABLE OF CONTENTS

Abstract  ii

Table of Contents  iii

List of Tables  v

List of Figures  vi

Acknowledgment  viii

PURPOSE OF THE STUDY  1
Mathematics Curriculum in British Columbia  1
The Nechako Valley Secondary School Mathematics Curriculum  4
Testing Within The NVSS Mathematics Program  7
  Test rewrites within the program  8
  Exceptions to the cut score rule  9
Goals of the NVSS Program  9
  Mathematics 12 modifications  10
  The provincial examination  11
Concerns and Issues  11
  Media Coverage  12
Program Evaluation  13
  Quantitative Methods  14
  Qualitative Methods  14
  Which Method is Appropriate?  15
Quasi-Experimentation  16
  Causation  16
  Cohort design  17
  Interrupted time series analysis  17
  Outcome measures  18
Research Questions  18
  The NVSS Mathematics Mean Score  18
  The NVSS Participation Rate  18
  Statistical Hypotheses  19

LITERATURE RELATED TO THE STUDY  20
Evaluation of Educational Programs  22
Selecting an Appropriate Evaluation Model  23
  Evaluation Models  23
  Determining the Model for This Study  26
  Judging Success  28
Quasi-Experimentation - An Appropriate Method  28
  Ex Post Facto Evaluation  30
List of Tables

1. Math 12 Examination Data 42
2. Math 12 Participation Rates 47
3. Values Assigned to GPA Scores 52
4. Mean GPA Scores for NVSS Students Taking Math 12 53
5. NVSS Mean Examination Scores for Chemistry 12, Math 12 and Physics 12 56
6. NVSS Participation Rates for Chemistry 12, Math 12 and Physics 12 59
7. Math 12 Examination Mean Scores for NVSS, FSJSS and FLESS 62
8. Math 12 Participation Rates for NVSS, FSJSS and FLESS 64
9. Summary of Results 69
List of Figures

1. NVSS Math 12 provincial examination means showing two different trends 43
2. NVSS Math 12 provincial examination means showing a single trend 44
3. Comparison of NVSS and provincial Math 12 examination means 45
4. The z-score relationship between NVSS and provincial Math 12 examination means 46
5. NVSS participation rate for Math 12 provincial examination 48
6. Provincial participation rate for Math 12 provincial examination 48
7. Relationship between NVSS Math 12 participation rate and provincial examination means 50
8. Comparison of participation rate and mean score for Math 12 51
9. Mean GPA scores of NVSS students taking Math 12 53
10. Comparison of mean examination scores and mean GPA scores 54
11. The relationship between GPA score and NVSS Math 12 provincial examination means 55
12. The relationship between GPA score and the NVSS Math 12 participation rate 55
13. Comparison of NVSS Chemistry 12, Math 12 and Physics 12 examination means 56
14. Chemistry 12 provincial examination means 57
15. Physics 12 provincial examination means 58
16. NVSS participation rates for Chemistry 12, Math 12 and Physics 12 59
17. NVSS participation rates for Chemistry 12 60
18. NVSS participation rates for Physics 12 60
<table>
<thead>
<tr>
<th></th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Comparison of participation rate and mean score for Chemistry 12</td>
<td>61</td>
</tr>
<tr>
<td>20</td>
<td>Comparison of Math 12 provincial examination means for NVSS, FSJSS and FLESS</td>
<td>62</td>
</tr>
<tr>
<td>21</td>
<td>FSJSS Math 12 provincial examination means</td>
<td>63</td>
</tr>
<tr>
<td>22</td>
<td>FLESS Math 12 provincial examination means</td>
<td>63</td>
</tr>
<tr>
<td>23</td>
<td>Participation rate in Math 12 for NVSS, FSJSS and FLESS</td>
<td>64</td>
</tr>
<tr>
<td>24</td>
<td>FSJSS participation rate for Math 12</td>
<td>65</td>
</tr>
<tr>
<td>25</td>
<td>FLESS participation rate for Math 12</td>
<td>66</td>
</tr>
</tbody>
</table>
Acknowledgment

This study would not have been possible without the cooperation and assistance of the personnel of School District 91 (Nechako Lakes), formerly School District 56 (Nechako). I am indebted to my supervisor, Dr. Peter MacMillan, for his encouragement and valuable advice throughout the writing of this report. I also acknowledge the comments and help of Dr. Anne Lindsay and Dr. Bruno Zumbo, members of my supervising committee. Finally, thanks must go to Tony, Daniel, Alison and Nicholas Maksymchak without whose constant support I would not have seen this project to conclusion.
CHAPTER 1: PURPOSE OF THE STUDY

The evaluation of educational programs is undertaken in order to improve these programs or to judge their overall effectiveness. This evaluation may also help educators to defend the programs and practices used in schools (Worthen, Borg & White, 1993).

The evaluation of a program may be formative, occurring as the program is developed in order to improve the implementation. Or it may be summative, occurring after the program has been implemented in order to assess its impact. What is important is that the program evaluation occurs (a) when the program is well defined and implemented; (b) when the program has been used long enough to have had an impact; and, (c) when there are important decisions to be made about the program.

In a practical setting, such as a school, the distinction between formative and summative evaluation blurs. End of year data, summative findings, can be used to modify, a consequence of formative evaluation, the program’s form the following year (Scriven, 1993). Program evaluation is concerned with gathering evidence which can be used when making judgments about the program. The evaluator should determine how well the program is functioning and to what extent the program’s goals and purposes are being achieved (Berk & Rossi, 1990).

Mathematics Curriculum In British Columbia

Responsibility for the development and implementation of mathematics curriculum in British Columbia rests with the provincial Ministry of Education. In April 1996, this ministry underwent a name change and became the Ministry of Education, Skills and Training. On February 18, 1998, the name of the ministry reverted to Ministry
of Education. For the purposes of this study, the title Ministry of Education will be used throughout.

The Mathematics Curriculum in British Columbia was revised during the period 1983 to 1985. Input was sought from a variety of interest groups including teachers and university faculty. The focus of this revised curriculum was “the need for all students to be provided with a balance of mathematical experiences” (Ministry of Education, 1988 p. vi). The curriculum guide went on to suggest that all members of society need mathematical skills and that mathematics is an important component of education. It was also recommended that every student receive instruction appropriate to their needs and abilities.

The rationale behind these beliefs was based on a number of points. It was suggested that mathematics permeates other curriculum areas and that mathematics is a necessary tool. In order to understand mathematics, a student needs to be able to think analytically and to reason logically. Positive attitudes towards mathematics are developed when students are provided with experiences which develop their understanding of mathematics and which are appropriate to the level of ability of the student. It is “critical that students have successful experiences” because success is a powerful reinforcement (Ministry of Education, 1988 p. viii). These experiences should be developmental in nature and should be organized sequentially.

The curriculum guide also emphasized that the mathematical ability of students falls along a continuum. Therefore the “content and presentation [in math classes] should be appropriate to the increasingly diverse needs of all students” (Ministry of Education,
1988 p. viii). The guide informed teachers that emphasis should be placed on the development of mathematical skills in students because these skills were seen as necessary for the student to function in society and for the student to pursue further study in areas involving mathematical applications. All students should be encouraged to foster positive attitudes towards life-long learning.

The curriculum guide then outlined the pathways which students could take through the mathematics courses offered. Until the end of Grade 8 all students were required to follow the same mathematics curriculum. After Grade 8, the path splits into two. On one route, a student was directed through Math 9, Math 10 and Math 11, all of which emphasize abstract concepts and symbolic notation. In British Columbia, Grade 12 mathematics courses are electives and are not required. After Math 11, the student was given a choice of Math 12 or Survey Math 12. The other route took the student through Math 9A, Math 10A and Math 11A. These courses place less emphasis on abstractions and notation, and allow students to cover the required material at a slower rate (Ministry of Education, 1988 p. xiii). The student who took the second route was provided an opportunity to re-enter the first route. Introductory Math 11 was designed to allow students who had completed Math 10A to qualify for Math 11. As Math 11 is the fifth math course, it would be taken in the Grade 12 year. The Math 12 course is then not accessible to students who have chosen this route.

The whole British Columbia mathematics curriculum was reviewed following the 1990 Provincial Assessment of Mathematics (Ministry of Education, 1996). In 1996, new Integrated Resource Packages (IRPs) replaced the old curriculum guides.
Mathematics 8 is still taught to every student across the province. After Grade 8, the IRPs outline two different pathways for all grades 9 to 12. These pathways are named Principles of Mathematics and Applications of Mathematics. The Principles of Mathematics pathway for grades 9 through 12 covers the same content as the former Math 9, Math 10, Math 11 and Math 12 did. There is an increased emphasis on problem solving and the use of graphing calculators, but the topics remain the same. The Applications of Mathematics pathway cannot be compared to the former Math 9A, Math 10A, and Math 11A courses since it does not cover the same material. Pressure from individual school districts has persuaded the Ministry of Education to allow schools to continue offering these A courses until they too can be examined and updated.

Principles of Mathematics 12, which replaces the old Mathematics 12, must be implemented in all schools in September 1998. The provincial examination based on this course will be offered for the first time in January 1999.

The Nechako Valley Secondary School Mathematics Curriculum

In 1993, the mathematics teachers at Nechako Valley Secondary School (NVSS), a Grade 8 to Grade 12 school, developed an individualized, modularized, self-paced mathematics program for their students. The program was implemented for a number of reasons most of which can be related to the philosophy and goals of the British Columbia Curriculum. The program was used to teach all students in the school so that all were exposed to the same mathematical experiences. The program was designed so that students earned marks no lower than a B (73%). The program allowed for individual
differences in learning styles and speeds since students worked individually and independently.

NVSS mathematics teachers developed the program believing that mathematics is an important part of education and that all students should take as many math courses as they are able to complete. These mathematics courses should also be at the highest level offered. By using this program, it was intended that the student set their own timeline for studying mathematics. This implied that some students would need more, or less, time than was suggested by the curriculum guide. Students were allowed to take as many semesters as they needed to cover all of the curriculum. In the NVSS program, all learning outcomes specified by the curriculum guide are included.

This means that students must cover all of the topics listed in the curriculum guide instead of being exposed only to those topics for which the whole class had time. In traditional classrooms, the pace at which content is delivered must match the pace at which the average student is able to absorb the material. Traditionally, mathematics classes did not cover the whole curriculum because of time constraints. There was too much material in the curriculum to be covered in the time scheduled. The decision as to which areas to miss out was left with the teacher. In the NVSS program, students covered all topics and so were actually exposed to more content than had previously been the case. The average student was still able to manage this but students with less than average mathematical ability did find that the scheduled time was not enough. The program allowed for this by letting students take more time to finish a course.
Positive attitudes towards math are fostered when students understand the content and are able to cope with the academic requirements. The NVSS mathematics program, required all students to earn a specified grade in order to pass a test, and each test must be passed before any student was allowed to move on. These minimum cut scores ensured that the student got good grades which in turn may have motivated the student to keep studying. Math teachers felt that students understood more of the content when they passed the tests.

The NVSS curriculum was organized developmentally and sequentially. Students are first tested on individual learning outcomes, then on larger and larger clusters of outcomes. This system allowed the student to work with the basic ideas before being asked to apply them. Once the basic concepts were acquired, grouping of concepts would have allowed the student to see how concepts fit together and how they can be applied.

NVSS mathematics teachers also believed that the instruction a student received should be appropriate to the student’s needs and abilities. The NVSS mathematics program allowed students to work at their own pace. Teachers provided instruction as it was needed by the student. This learning environment should have provided all students with the opportunity to learn and to progress.

The presentation of material happened in a variety of ways. Students worked from textbooks and used teacher-prepared materials. Students could access tutorials, pre-tests and review exercises. Each student was provided with a list of resources cross-referenced to the appropriate grade of mathematics. The textbooks used were not always the ones recommended by the Ministry of Education for that grade but were used because
of the suitability of their content and for their ease of use. All textbooks used were approved by the Ministry of Education for use in schools.

NVSS mathematics classes are organized to suit students’ scheduling. Most classes are composed of students from different grades within the school taking a variety of mathematics courses. The activities one might have observed include students working cooperatively with each other or with a peer tutor; learning assistance teachers offering their expertise to some students; and individual teaching occurring at the teacher’s desk. Students worked at their desks to learn concepts and facts, and then moved to testing stations when they were ready.

**Testing Within The NVSS Mathematics Program**

The program was structured around a series of core tests, unit tests and module exams. The word *test* was used for examinations comprised of 10 short answer items. *Exam* was used for examinations of 20 short answer and problem solving items.

Throughout this thesis the use of test or exam applies to all the examination types.

Core tests were designed to assess the student’s understanding of one individual learning objective and to determine whether mastery in that topic had been achieved. It was decided that 80% would be the pass/fail cut score in grades 8 through 10, and 60% in grade 11. Unit tests were designed to assess the student’s understanding of a group of core topics given together and to aid the student in linking concepts. The unit test was developed using more complex questions which required several steps to solve. Unit test questions required the application of a concept as well as understanding. The cut score for a unit test was set at 70% for grades 8 through 10 and 60% for grade 11. Module
exams were designed to assess the student's grasp of the concepts from several core topics and unit tests. The module exam replaced traditional midterm and final exams but was not cumulative in content. For example, the Module 4 Exam covered only the material in that module and not material from the first three modules. The intent behind the module exam was to give the student the chance to relate several principles and to use them to solve more involved questions. The cut score on this exam was set at 60% for all grades.

Generally four versions of each test were developed. The different versions were written by the same teacher but have not been compared for equivalence. The mathematics teacher decided which version of each test a student should take. If the student met the cut score requirement, the test score was recorded and the student moved on. If the cut score was not met, the student was directed to study the topic further, instruction was provided and then a different version of the test was assigned. On this attempt, scores were treated as they would have been after the first attempt. If the student failed again, the teacher would insist that the student correct all mistakes. These corrections were then used to determine what the problems were and to remedy them. Then the student tried another, different version of the test. If all four versions were used and the student had not passed, the cycle began again.

Test rewrites within the program. A student could rewrite any test to get a better mark even when the minimum pass requirement was met. No mark penalties were assessed when students rewrote a test. In all cases the mark from the highest scoring test was used in determining the student's final grade. For both unit tests and module exams,
students were encouraged to do an exam review exercise before writing the test. The
teacher insisted that all students completed practice questions between any two attempts.
These practice questions were usually assigned from a review exercise, although students
also selected review questions.

**Exceptions to the cut score rule.** There was one exception to the guidelines listed.
The exception was invoked in the case of a student who had attempted all four versions of
the test on any topic and had not been able to achieve the desired cut score. In this
situation the teacher would allow that student to move on as though the standard had been
met, provided that the student had attained a score of at least 50%. This exception was
built into the program to help reduce the level of frustration in a student who had gained a
basic understanding of the topic and who was able to gain a score of 50%, but who for
other reasons, such as poor arithmetic skills or carelessness, could not meet the required
cut score. A student was given this opportunity once per module without mark penalty.
If the situation arose again within the module the student was penalized by a reduction of
10% from the module total for each additional test the student failed.

**Goals of the NVSS Program**

It was hoped that the implementation and use of this program would give NVSS
students better math skills as they worked to master mathematics material at an
individualized pace. As a result, increased levels of competence and confidence amongst
the students were expected. These effects should then have lead to larger Mathematics 12
classes and to greater student success. The Mathematics 12 provincial examination
scores and the proportion of NVSS students taking Mathematics 12 were seen as indicators of successful implementation.

**Mathematics 12 modifications.** The Mathematics 12 program was developed in a somewhat modified form. The Mathematics 12 program consisted of only core and unit tests. Module exams were omitted because of the provincial examination which must be written by each student. In addition, Mathematics 12 students received direct instruction on a daily basis and followed a timeline established by the teacher. This meant that all students wrote core and unit tests for the first time at the same time. No minimum cut scores were established. However, as in other grades, at least four versions of each test were developed so students were able to rewrite any test to improve their understanding and to raise their marks. As in other grades, the highest score on every core or unit test was used as a component of the final school grade.

The incorporation of direct instruction and the teacher driven timeline occurred as a remedy to procrastination on the part of many students. When students were left to cover the material at their own pace, many were not ready for the provincial examination as scheduled. Rescheduling caused many administrative difficulties. It was then determined, by the teachers of senior level mathematics in the school, that there was too much content for a student to complete independently in one semester. This was because many of the topics required a depth of knowledge not previously required by other mathematics courses.

The Mathematics 12 curriculum was developed in such a way that each topic, or unit of work, is discrete and is covered thoroughly. The teachers of senior level
mathematics at NVSS felt that this coverage was difficult to achieve in an individualized program. The mathematics teachers believed that this coverage was best obtained through direct instruction.

The provincial examination component also meant that students needed to familiarize themselves with examination practices. This was a new requirement for students since final examinations are not part of the NVSS Mathematics Program. It was felt that mathematics teachers best provide detailed examination review questions and techniques through direct instruction.

**The provincial examination.** The Mathematics 12 provincial examination, offered at different times throughout the school year, is developed by the Ministry of Education in Victoria, British Columbia, from a bank of test items. The examination is sent to each school for students to write at the same time province wide. At NVSS most Mathematics 12 students wrote the provincial examination in January, the end of semester one. Some students chose to defer and to write the examination in April or June for the first time. Other students elected to write the exam again at these times if they were dissatisfied with initial results. Officials in Victoria combine the best exam mark, worth 40% of the final grade, and the submitted school mark, worth 60%, to award a final grade.

**Concerns And Issues**

The NVSS mathematics program was developed to provide students with more of the opportunities the provincial curriculum guide suggested. The mathematics teachers
hoped that, as a result of the program's use, NVSS students would take more mathematics courses and that more students would enroll in Math 12.

**Media Coverage**

In March 1996, the local Vanderhoof newspaper, the Omineca Express, ran a story on its front page about provincial examination scores. The heading read “District schools rate poorly in academics” (District Schools, 1996). The story listed the provincial examination scores for all schools in the province. The listing was in rank order and NVSS’ mathematics score appeared at position 177 (out of 194). The only data given was the rank order and the examination mean score for one session.

The Ministry of Education publishes a much more comprehensive statistical analysis of these scores showing the number of students who wrote, the mean and standard deviations, the breakdown of scores by grade and the success rate. The Ministry also publishes cautionary notes about comparing districts and schools (Ministry of Education, 1995b). The Ministry suggests that results for one session may be deceiving. Comparisons should take into account the particular school's policy on who can write the examination since some schools encourage all students to take examinable courses while others encourage only the top academic students. Some schools also insist that students who are failing a course withdraw while others encourage these students to write the examination.

One of the goals of the NVSS mathematics program was to increase the number of students taking Math 12. This means that students who may have avoided Math 12
before the implementation of the program are now included in the statistics reported.

Enlarging the pool of examinees means that it is not just the brightest whose marks are counted. Another goal was for students to take as many mathematics courses as possible. The NVSS mathematics teachers did not see any benefit in asking students who were lower achievers to drop out of the course. Exposing students to better and more mathematical experiences will provide them with better skills, the ones that society demands.

The way in which the media handled this story lead to a misunderstanding of the issues involved. The abuse of statistics generated a public analysis of math teaching which NVSS administrators and mathematics teachers felt was superficial and flawed. If the newspaper had used all of the statistics available to paint the whole picture, or if the newspaper had compared examination results across only those districts which are matched by demographics, then the story would have had much more credibility. If the reporter had read the cautionary notes from the Ministry of Education, a cleaner picture might have emerged.

In order to counteract this negative publicity, the NVSS mathematics teachers began an assessment of the mathematics program. The teachers wanted to know whether the program was doing the job for which it was developed and whether it was meeting the goals which had been established.

Program Evaluation

One of the functions of educational research is to improve practice. Evaluation research examines practice at a particular site and is concerned with assessing the merit or
worth of a specific practice. The level of generalizability is low since the results are usually specific to the site under study and to the specific practice at that site. Evaluation research is often used to “advance the research and methodology of a specific practice [and to] aid in decision-making at [a] given site” (McMillan & Schumacher, 1997, p.20).

Two different paradigms can be applied when evaluating programs. Quantitative and qualitative methods are both used in this field. Before beginning any program evaluation, the evaluator must decide which method best fits the situation under examination.

Quantitative Methods

Quantitative methods are concerned with determining the relationship between variables, with confirming or disconfirming hypotheses, and with identifying common properties (Guba & Lincoln, 1981). In this paradigm, evaluators are interested in getting the answers to specific questions, and in verifying their working theories. The emphasis is on change and growth. The evaluator seeks to ascertain what would have happened without the treatment. The method can be applied when comparing past performance with current when a program has been applied universally.

Qualitative Methods

Qualitative inquiry is more oriented to activities that to intents (Guba & Lincoln, 1981). In this paradigm, the identification of the issues drives the research design which then provides the information to be studied. Responsive evaluation gives its audience the information it requires. The context in which the program exists is just as important as its objectives. The design of the evaluation emerges from the information that is collected.
The measurement instrument is the evaluator and much depends on the training and competence of this person. The evaluator is charged with discovering the context, identifying the pluralism of values held and producing a thick description of the program in context.

Which Method is Appropriate?

The method of evaluation chosen is a function of the way in which the particular program was developed. The NVSS Mathematics program was a curriculum initiative. Curriculum may be developed in a number of ways. A theoretical stance can be taken where the program developers base the program in previous research and the knowledge gained from it. Or, curriculum can be mandated by a Ministry of Education and be applied across an administrative region. Or, curriculum can be developed, or in this case modified, in response to the needs of a particular situation and the concerns of the stakeholders involved.

In the case under study the latter framework was used. The mathematics teachers sought to develop a program that would improve the learning of the students in their classrooms. Following the Tylarian model, used in developing mathematics curricula for many years, the NVSS mathematics teachers developed a program which was objective based. Specific outcomes were expected and tested for. Progression through the program was based on assessment of student learning after exposure to each of these concepts. Evaluation of such a program should be undertaken using the same objective based criteria.
Guba and Lincoln (1981) pointed out that program evaluation is only useful when it deals with the actual concerns and issues of the stakeholders. In the situation covered by this study, the concerns and issues are centered on examination results and actual figures. The best way to address the concerns and issues is to analyze the figures. This is best done through statistical analysis and quantitative methods.

**Quasi-Experimentation**

A quasi-experimental design is a systematic approach to evaluation that can be utilized when random assignment is not possible but the evaluator is still able to identify treatments and to measure outcomes (Cook & Campbell, 1979). In the NVSS case, quasi-experimentation is suitable since all students had to take mathematics courses using the NVSS Mathematics Program. There is no opportunity to compare the program with students taking math in some other fashion. The NVSS Mathematics Program is a full coverage program. A series of terms with descriptions and/or definitions follows.

**Causation**

Causation is an important element in social science research because of its impact on social policy. Quasi-experiments can be used to determine causation. In making causal inferences there has to be a temporal order to the cause and effect (Palys, 1992, p. 277). The implementation of the program in 1993 provides a treatment point against which results can be compared. By examining figures before and after the introduction of the program it is possible to determine whether any effects are noticeable. This means that the temporal order condition of causation can be analyzed. It is also what the math
teachers at NVSS are most concerned with: Did the introduction of the program have an effect?

Cohort design

One model of quasi-experimentation employs a cohort design. This compares groups of students and their situation with students who experienced the same environment but another program or no program at all.

Students who took Math 12 before the implementation of the NVSS program form one group of interest and could be considered a quasi-control group. The students who took Math 12 after implementation form the other. These groups are similar on several dimensions: age, gender, socio-economic status, institutional experience.

Interrupted time series analysis

Interrupted time series are used to analyze the effects of full coverage programs. The analysis employs a series of repeated measures to look for trends before and after the introduction of a treatment (Berk & Rossi, 1990). Outcome measures are graphed and by pinpointing the time of the treatment, it is possible to determine whether any change in the trend of the graph occurred. An advantage here is this simple graphing technique is "readily credible ... [and] easily understood" (Cook & Campbell, 1979 p. 230). This method is particularly appropriate for outcome statistics which are obtained from government agencies.
Outcome measures

It is possible to identify and measure the outcomes of the provincial examination. Data supplied by the British Columbia Ministry of Education is available for scrutiny and analysis. These statistics are also repeated measures since the ministry has been keeping these records since 1988.

Research Questions

The NVSS Mathematics Mean Score

The NVSS Mathematics Program had two specific goals at the Mathematics 12 level. The first goal was to increase student success. The measurement of success was an increase in the scores on the provincial mathematics examination. The first question is: Did the NVSS Mathematics 12 post-implementation mean provincial examination score increase in comparison to the pre-implementation mean score?

The NVSS Participation Rate

The second goal of the NVSS Mathematics Program for Mathematics 12 was to increase the number of students taking the course. This goal was evaluated by assessing whether there was an increase in the proportion of NVSS students taking Mathematics 12. The second research question was: Did the proportion of NVSS students taking Mathematics 12 post-implementation increase in comparison to the pre-implementation proportion?
Statistical Hypotheses

1. The mean NVSS examination score for the provincial Mathematics 12 examination changed in the post 1993 years. The statistical hypotheses to be tested were as follows:

   \[ H_0: \quad \mu_{\text{pre1993}(ma)} = \mu_{\text{post1993}(ma)} \]

   \[ H_1: \quad \mu_{\text{pre1993}(ma)} \neq \mu_{\text{post1993}(ma)} \]

   \( \mu_{\text{pre1993}(ma)} \) was the provincial examination mean prior to 1993 for Mathematics 12.

   \( \mu_{\text{post1993}(ma)} \) was the provincial examination mean after 1993 for Mathematics 12.

2. The proportion of NVSS students taking Mathematics 12 changed in the post 1993 years. The statistical hypotheses to be tested were as follows:

   \[ H_0: \quad \pi_{\text{pre1993}(ma)} = \pi_{\text{post1993}(ma)} \]

   \[ H_1: \quad \pi_{\text{pre1993}(ma)} \neq \pi_{\text{post1993}(ma)} \]

   \( \pi_{\text{pre1993}(ma)} \) was the proportion of NVSS students taking Mathematics 12 prior to 1993.

   \( \pi_{\text{post1993}(ma)} \) was the proportion of NVSS students taking Mathematics 12 after 1993.
CHAPTER 2: LITERATURE RELATED TO THE STUDY

Research may be classified as basic, applied or evaluation (McMillan & Schumacher, 1997). Evaluation research differs in many ways from both basic and applied research. The results of basic research are related to previous findings and to knowledge already acquired. Applied research, while both abstract and general in nature, is concerned with the relationship between knowledge and practice. Evaluation research focuses on a particular practice and a given site and aims to give specific information to the participants. This study is evaluation research examining the effects of a particular educational program at a specific site.

Miller (1976) defined programs developed by teachers as having certain key components: the presentation of the material, desirable outcomes and student use of material. The NVSS Mathematics Program is one such teacher developed program. It has objectives, modules, and a cut score which determines promotion to the next level. Students use the materials independently with the teacher’s role that of a learning manager. It is what Provus (1973) described as an “instant installation” program. It was quickly formulated, uses available resources and was conceived with the hope that it would do something better than the traditional method being applied till its inception. A traditional mathematics instructional program is teacher-centred and paced with students assessed at common testing times.

Glass (1997) differentiated among several reasons for program development. Among them are experimental purposes and response to community need. The NVSS program was developed in response to community needs. In this case the community was
the students and math teachers at NVSS. Too many students were dropping out of the courses that lead to Math 12 because they did not feel that they thoroughly understood the material covered by these courses. The math teachers were concerned with the low rate of participation in Math 12 and with the classroom management issues that arose when students were enrolled in mathematics classes unsuitable to their level of ability. For example, some students enrolled in Math 10A could have easily handled the content of Math 10.

The large question behind this study was to determine whether the NVSS Mathematics Program was successful in affecting the way that NVSS students learned mathematics. The particular question that came from this global view was whether the NVSS provincial examination mean score changed with the introduction of the program. Did this program do a better job than a traditional approach? Secondary to this was the other question. Did the participation rate increase? That is, did more students take Math 12 as a Grade 12 elective? These questions form the items of a program evaluation.

It was necessary to determine whether program evaluation methods were suitable to this study and which of these methods was most suitable. As was indicated in Chapter 1, the method assumed to be most suitable is a quasi-experimental, time-series design. This chapter develops the points already made in order to strengthen the case for the use of this method.
Evaluation of Educational Programs

Evaluation is an integral part of the curriculum sequence which also includes planning and development (Madaus & Stufflebeam, 1989; Tyler, 1949). Program evaluation is a purpose rather than a method (Babbie & Wagenaar, 1989). The purpose of program evaluation is to assess the program’s product. It is an appraisal of the program’s worth or quality (Haug, 1996; Lam, 1995; Popham, 1988). The information collected can be used to improve, maintain or terminate the program (Conrad & Wilson, 1986; Provis, 1973; Worthen, 1995). Evaluation should contribute to the educational process (Worthen & Sanders, 1991).

The evaluator must consider what was intended by the program’s introduction, whether this intention can be measured, and, if it can, how (Babbie & Wagenaar, 1989; Hedrick & Shipman, 1988). The aim is to find out “how far the learning experiences as developed and organized are actually producing the desired results” (Tyler, 1949, p. 107).

The NVSS program was developed in response to British Columbia’s mathematics curriculum’s emphases. Its educational accomplishments of improving the way mathematics is taught and its effect on student outcomes should be as high as possible (Fraser, Walberg, Welch & Hattie, 1987).

In this study, the evaluation is investigative (Smith & Hauer, 1990). The organization of the NVSS Mathematics Program facilitates ongoing modifications which means that this evaluation is formative in nature. The program is at a stage where it is important to ask what changes have taken place as a result of the intervention and whether modifications are needed. Tyler (1949) wrote that at this point in the
development and use of a program, evaluation is a key step since it provides "information about the success of the school to the school's clientele" (p. 125).

The purpose of this study, and of other program evaluations, was to collect information which would address questions about mathematics teaching. It was also important to be responsive to the concerns of the stakeholders, the larger community (American Evaluation Association, 1996).

Selecting an Appropriate Evaluation Model

Program evaluators need to consider carefully "how to evaluate dynamic, unstable programs or efforts when there exists little prior knowledge about them or about how to evaluate them" (Smith & Hauer, 1990, p. 490). Different conclusions may be reached depending on which evaluation model is used (Haug, 1996).

Evaluation Models

The model of program evaluation chosen to a large extent depends upon the curriculum orientation of the program. Aoki (1985) identified three curriculum orientations: the Empirical-Analytic (Technical), the Situational and the Critical-Reflective

The Empirical-Analytic Orientation is the dominant curriculum model. It is based on an explanation of the way the world works and emphasizes technical knowledge. Curriculum research in this orientation is scientific in nature and makes use of experimentation. It is concerned with cause and effect and empirical knowing.
Evaluation is goal based and achievement oriented. Judgement is made based on external standards.

The Situational Orientation is concerned with the meaning that students give to situations. Its emphasis is on communication and phenomenological description. Program evaluation is interpretive and encourages each person to make their own meaning. Therefore the researcher must enter into dialogue with people in the situation. What is needed are first order descriptions which are immediate interpretations of the situation. The program evaluator is concerned with the quality of this lived experience.

The Critical-Reflective Orientation is based on reflection and the intent to bring about change. The evaluator in this context is seeking to discover the underlying assumptions, interests and values which underpin the student’s experience and which underpin the curriculum as delivered. In this orientation, the researcher must question the descriptive accounts provided and encourage critical reflection about the program. The individual perceptions lead to multiple interpretations of the situation.

Worthen and Sanders (1987) outlined four methodological approaches to program evaluation: the Experimentalists, the Eclectics, the Describers and the Benefit-Cost Analyzers (p. 55). The first three of these can be linked directly to Aoki’s curriculum orientations.

The Experimentalists seek to identify causal links and employ experimental and quasi-experimental designs. They might see curriculum from an Empirical-Analytic orientation. Program evaluation could be based on tests scores (e.g. Datta, 1974; Evaluation Update, 1998; Sanders, 1994), causal modeling (e.g. Eichelberger, 1974;
Wang & Walbert, 1983), or the analysis of data derived for other purposes (e.g. Lee, Croninger & Smith, 1997; Schmidt & McKnight, 1995; Westbury & Hsu, 1996).

The Eclectics seek to enhance the search for causal links by examining process and context and would utilize case studies and descriptions. They might see curriculum from a Situational orientation. Program evaluation could be based on interviews (e.g. Bruckerhoff & Bruckerhoff, 1996; White, Gamoran, Smithson & Porter, 1996), surveys or questionnaires (e.g. DeRoche, 1981; Tyler & Klein, 1974) or site visits or observations (e.g. Bruckerhoff & Bruckerhoff, 1996; Gross & Davis, 1985).

The Describers seek to present a complete picture of the program from the point of view of the people using it by using ethnography, case studies and triangulation. If the description is obtained in order to bring about change, the describers might see curriculum from a Critical-Reflective orientation. Program evaluation could be based on in-depth interviews which lead to an analysis of the issues (e.g. Florida Community Colleges, 1993) or on personal reports supported by examples of student work and observations of classroom interactions (Lazarus, 1982).

Determining the Model for This Study

The Benefit-Cost Analyzers probably hold the dominant position in the evaluation of school programs. They seek to determine what return, or output, has been gained from the expenditure of resources, or input. In this instance, the teachers, district staff, parents and the media were very concerned with how the NVSS Mathematics Program had increased student output in terms of examination results. This orientation can be directly related to the objective based development of the program. It is therefore logical to
conduct a program evaluation using a method which examines the input-output orientation. The method should also be empirical-analytic since this is the orientation of the curriculum revision on which the program is based.

**Support For This Decision**

Basic assumptions about program evaluation should guide the development of every evaluation. The evaluation must look at student behavior as it is changes in behavior that education seeks to achieve (Tyler, 1949). Program evaluation measures outcomes based on student-attainment goals (Beswick, 1990). The first evaluation of any program should not attempt to cast the net too wide. It is far better to limit the number of questions asked (Hammond, 1973). The evaluation should use pertinent reliable information (Provis, 1973).

Hammond (1973) suggested that in evaluating any program, such as the NVSS Mathematics Program, it is necessary to ask whether the program was “really effective in achieving its expressed objectives” (p. 157). How great was the effect of the input, the program, on the output, the examination statistics? This is a causal question (Fraser, Walberg, Welch & Hattie, 1987). The question suggests an object-based, goal-based, model of evaluation (Conrad & Wilson, 1986). This model enables the evaluator to determine how the program performed in relation to what was intended, the instructional objectives (Haug, 1996; Popham, 1988). The program’s objectives form the base for the program performance evaluation (Lam, 1995).

Objective-based evaluation has a long history. Set in a logical positivism, utilitarian paradigm, the empirical-analytic model was flourishing by 1918 (Worthen &
Sanders, 1991). Ralph W. Tyler played a seminal role in perfecting this model (Madaus & Stufflebeam, 1989). He suggested that it is necessary for the curriculum worker to clearly define and assess the range of objectives for each program (Tyler, 1949). The program’s objectives are drawn from knowledge about the learners who will be affected and about what it is that the greater community expects.

Under the Tylerian model each program has three components: outcomes, antecedents and processes. Outcomes are the program’s objectives about who will be affected; what change in behavior will result; how the change will be measured; and how success will be defined (Lam, 1995). The goals of any program are operationalized by its objectives. Antecedents are the resources needed to enable the program to function. Processes are the actual activities undertaken by the stakeholders: teachers and students.

Evaluation calls for the collection and analysis of data. The evaluator has to decide what behavior will indicate that the objectives are being met. It is also necessary to consider the circumstances in which the program is situated and to determine how well the students must perform in order for the success of the program to be established (Beswick, 1990).

Glaser (1963) discussed achievement measurement and that is what this evaluation is about. In the evaluation of instructional programs, achievement tests can be used to provide information about the instructional treatments. Evaluation results may be scores as long as they summarize the behavior under study appropriately (Tyler, 1949). In this evaluation much of the data comes from examination statistics published by the
British Columbia Ministry of Education. The ministry is also responsible for collecting the data from the scores for each examination written.

**Judging Success**

Whenever curriculum developers design educational programs they should anticipate what successful implementation will look like. This anticipation of success should be based on the teachers' educational experience and their knowledge of the population with which they are working (Babbie & Wagenaar, 1989; Lam, 1995). Using Tyler's objective-based model, any educational program is as successful as the degree to which its objectives are met (Popham, 1988). The first level of decision therefore is whether the objectives were attained (Lam, 1995).

It is acceptable to use performance scores to judge the success of any program (Lam, 1995). In fact, outcomes should be validated against the most direct measures possible (Madaus & Stufflebeam, 1989, pp. 4 - 5). The criteria for success should be a matter of agreement and should be based on externalized objectivism (Worthen & Sanders, 1987). If the objective is to evaluate success as a change in the provincial examination statistics, then as Tyler (1949) insisted in his own evaluations, it is necessary to provide evidence about these scores.

**Quasi-Experimentation - An Appropriate Method**

The evaluation documented in this study is of an educational program situated in real life (Babbie & Wagenaar, 1989; Kratochwill, 1978). The archival data to be used is naturally occurring also (Glass, 1997). However, in evaluating the NVSS Mathematics
Program causal questions must be asked: Did the introduction of the program change the NVSS mean score for the provincial examination; and, Was there a change in the participation rate? The nature of these questions has to form the basis for deciding which evaluation method to employ (Hedrick & Shipman, 1988).

The determination of cause, important in the social sciences, occurs through the analysis of the factors that can be varied at will (Cook & Campbell, 1979). A scientific experiment is used to deliberately manipulate the components of a situation and thus make possible this determination (Glass, 1980, 1997). Unfortunately social phenomena occur outside of controlled settings and manipulation is difficult when one is dealing with humans in a field context. The feasibility of experimental methods in field settings is poor (Sawyer, 1987).

The impediments to true experimentation are further compounded by the fact that a full coverage program eliminates the opportunities to compare two groups to which students have been randomly assigned (Glass, 1997). In this evaluation there is a single, undifferentiated group, the subject, (Glass, 1980) and a program administered in a single intact institution (Campbell, 1976). It has to be decided how change could be assessed from single subject data (Crosbie, 1993). This lack of randomization means that quasi-experimentation will have to be used (Babbie & Wagenaar, 1989; Campbell & Stanley, 1963; Cook & Campbell, 1979). Quasi-experiments have treatments, outcome measures and experimental units.

To ensure some degree of rigor in this quasi-experimental situation, the use of cohort groups provides a degree of control. The use of cohort groups is appropriate for
institutional evaluation (Babbie & Wagenaar, 1989). The cohorts should be drawn from convenient groups in the same community so there is a demographic match. While not as good as random assignment to condition, this method does allow comparability of results (Cook & Campbell, 1979).

Ex Post Facto Evaluation

Ex post facto evaluations utilize data generated in the past whether there is one data collection or a collection over time (Beswick, 1990). They are used when an intervention has already occurred to assess the degree of concomitant variation (Kratochwill, 1978). Concomitant variation refers the extent to which the effect is present when the cause is, and not present when the cause is not.

The Suitability of Time Series Designs

Time series experimentation is the "study of individuals and/or groups using time as a variable" (Kratochwill, 1978, p.2). The design is an excellent method of field research (Smith & Glass, 1987) and is "of the greatest importance for program evaluation" (Campbell, 1976, p. 34). It is particularly useful where program evaluation is exploratory (Kratochwill, 1978). The design is versatile, unobtrusive, and suited to analyzing sequential data (Sawyer, 1987). Many evaluators have capitalized on these strengths. For example, McConnell (1982) used the design to evaluate bilingual education programs; Hedrick (1988) to evaluate welfare reform programs; Bertrand, Stiver & Porter (1989) to evaluate contraceptive social marketing programs; Mauser and Holmes (1992) to evaluate the 1977 Canadian firearms legislation; and Patterson et al.
(1992) to evaluate a supermarket nutrition education program. In fact, time series experiments are the most frequently used quasi design (Glass, 1980).

Time series experiments are a standard method of causal analysis in applied research (Glass, 1997). The temporal order shows whether or not cause came before effect and whether or not these elements covary in time (Palys, 1992). These experiments are good for one-subject, full-coverage programs (Campbell, 1976; Glass, 1980). In this situation they are named single case time series and have a single situation with multiple time points (Sawyer, 1987). They are also appropriate to use when dealing with archival data which has been routinely collected for administrative rather than experimental purposes. Time series experiments can be used when different groups cannot be treated in different ways (Glass, 1997; Patterson et al., 1992; Smith & Glass, 1987). They do not require the withholding of treatment from anyone (McConnell, 1982). This latter point is particularly important in an ethical enterprise such as educational programming.

Time series are easily understood, easy to follow and produce relevant information (Campbell, 1976; Worthen & Sanders, 1987). The design can be used in objective-based evaluation. In fact this powerful evaluation tool can analyze the interaction between time and the introduction of a program which is a further recommendation when evaluating whether the initiation of a program had any effect on exam scores. The design can be used to separate intervention effects from long term trends already present (Glass, 1980).

Interrupted time series designs are better than pre-test/post-test designs as the series of measures representing the situation before program implementation form a
control for the quasi-experiment (Glass, 1980; Kratochwill, 1978; McConnell, 1982). In evaluating the success of any program it is essential to determine what was happening before the program’s introduction (Tyler, 1949). Repeated measures in a time series allow the evaluator to judge whether the intervention changed the pattern. There is therefore an extension into the past and the future beyond that of the pre-test/post-test design.

Cohort groups, as long as they represent the same background (McConnell, 1982), can be taken as the same subject (Kratochwill, 1978). This gives repeated measurements under baseline, before the initiation of the program, and intervention, after the initiation, conditions. These successive points in time are unit replications with the selection criteria the same for each successive group. This increases the chance of similarity between the groups.

The comparability of results comes from the consistent application of measurement standards (Lam, 1995). The British Columbia Ministry of Education has not changed its administration techniques over the course of the time series. As Lam noted, this assumption that the treatment of data has been constant leads to high construct validity.

Advantages of the Design

The most important requirement is the fit of this design to the experimental criterion: the comparison of the dependent variable before and after the introduction of the treatment, or educational program (Kratochwill, 1978). The purpose of the evaluation
is to show the main effect of one variable rather than the interaction of two others (Campbell & Stanley, 1963). The tests most suitable for measuring individual differences will differentiate when everyone is exposed to the same treatment as is the case with this program (Glaser, 1963).

Some of the major threats to validity are not a concern in this case. In this $n = 1$ paradigm, the periodic measurements have undergone no change in unit or administration and so the instruments are reliable (Campbell, 1976). There is no threat of testing since a different group was tested each time. Maturation is not a concern since the students involved were all the same age by group. The intervention was introduced randomly and not when the trend of the series was rising without any intervention (Kratochwill, 1978).

Cautions

In using a time series design, the evaluator is assuming that it is possible to evaluate a program using a sample of situations. It is important to ask whether the evaluation device actually provides evidence of the behavior desired (Tyler, 1949). It is especially important that the variables be measured validly and reliably (Kratochwill, 1978).

The threat of history is a prime concern. The time variable represents all the other things that happened as time passed (Veney, 1993). There is a risk of historical confounding (Kratochwill, 1978). Other events could explain any effects found (Campbell, 1976; Campbell & Stanley, 1963; McConnell, 1982). Cook and Campbell (1979) suggested that the evaluator should examine what ought to be affected by any
program intervention and any components that should not be affected. If supplemental measures are also affected, it is probably not the intervention that caused the observed change (Babbie & Wageman, 1989). Evaluation designs fail when the intervention is seen as the only event happening in the series (Cooley & Leinhardt, 1980).

The observational series should be arranged so that the cycles are held constant (Campbell & Stanley, 1963). This is a necessary condition since it is important to distinguish between real effects and regular fluctuations in the series, between random displacements and deterministic ones (Babbie & Wageman, 1989; Glass, 1980, 1997). Trends already present in the data may give the appearance of an effect when there is none and so, ideally, the data should be stable before the introduction of any intervention (Kratochwill, 1978).

It is also incumbent upon the program evaluator to specify in advance the expected time relationships between the intervention and the manifestation of the effect (Campbell & Stanley, 1963). The evaluator needs to describe any expectations about how the series will change and to keep these uppermost when examining the series as a protection against making Type I errors (Glass, 1980). It is necessary to predict whether the effect be immediate or delayed, time lagged (Campbell, 1976; Glass, 1997; Veney, 1993). Students who wrote the Math 12 provincial examination in 1994 had not been exposed to the treatment of the program for as long as students who wrote the examination in 1996. Delayed effects are more difficult to interpret and give more room for alternative explanations (Cook & Campbell, 1979).
The degree of stationarity in the series is another concern. A stationary series fluctuates minimally between two limiting points. In other words, there is no systematic increase or decrease in the level of the series as it drifts up and down. However, most time series produced by data collections from the social sciences are non-stationary. A non-stationary series fluctuates across the whole grid at random (Cook & Campbell, 1979; Glass, 1980). A stationary series is the one to work with for detection purposes since any effect caused by the intervention is easily identified (Glass, 1997). However a non-stationary series is more common with class size groups.

Administering This Time Series Experiment

In a time series experiment, measures are taken, graphed and studied. By plotting the examination statistics and examining the series for any discontinuity an assessment of the program’s impact can be made (Campbell, 1976; Kratochwill, 1978). The measuring of change happens through visual judgment of the series and through the application of inferential statistical tests.

The NVSS Mathematics Program is the treatment. It is the effort aimed at student growth and is therefore the presumed cause of any effects noticed (Cooley & Leinhardt, 1980; Glass, 1997; Wolf, 1974). This treatment is the independent variable. The dependent variables are the examination statistics since these should change as a result of the intervention. Entire Mathematics 12 classes, and not individual students, represented by the mean of their scores, are the units of analysis.
CHAPTER 3: METHOD

In evaluating the NVSS Mathematics Program, the concerns and issues are centred on examination means and participation rates. The evaluation is a function of the statistics examined and the way in which they were examined. These statistics are determined by the students, the subjects who wrote the examination year after year. The statistics, the measures, are the provincial examination mean scores and participation rates. The procedure followed in the evaluation is the way in which these statistics were examined.

Subjects

Vanderhoof is located in the centre of the province of British Columbia, Canada. The town, rural-residential, is situated in the Nechako Valley and is a central service area for the surrounding districts (Vanderhoof Chamber of Commerce, 1996). The two main industries are forestry and agriculture. Vanderhoof is a family town with single detached houses making up 77% of the total housing units. English is the primary language spoken at home by 82% of the population.

In 1991 the population of the school district was 15,610 with 4300 people living in Vanderhoof (Ministry of Education, 1995a). The growth rate for the district was 0.5% annually for the years 1986 to 1991. Of these 4300 inhabitants, 344 (8%) were between the ages of 15 and 19.

In line with the work of Cook & Campbell (1979), these cohort groups are similar in background characteristics. The participants completed Mathematics 12 during the
school years 1987 - 1988 to 1996 - 1997 inclusive. They all attended NVSS and lived in the community of Vanderhoof or in the immediate rural area. As NVSS is a formal institution, the subjects were exposed to the same organizational history with some modifications to school administration and timetable format over the years involved.

The study examined the records of all 240 students who wrote the provincial examination in Mathematics 12 in the years 1988 to 1997 inclusive. These students were either in Grade 11 or in Grade 12 at the time they took the provincial mathematics examination. Their ages ranged from 16 years to 19 years. There were 117 male and 123 female students.

Measures

The measures used were provincial examination means and participation rates published by the British Columbia Ministry of Education and students' GPA scores provided by the administration at NVSS, Vanderhoof. The published data is free of any identifying information other than the name of the school and the year of the examinations. The school data was supplied with gender information and GPA scores. At no time were individual students identified. Permission to use the data was granted by the Superintendent of Schools, School District 56 (Nechako), British Columbia. (See Appendix A.)
Mean Scores

The British Columbia Ministry of Education claims that provincial level results are stable over time (Ministry of Education, 1997b). The mean scores are provided by the ministry so that school districts can compare their results over time.

The annual mean scores used were calculated from the scores at all exam sessions in the given year. The exam marks were for those students who had written the provincial examination at any session during the year specified.

The cumulative yearly report was used in order to accommodate the differences in exam difficulty at each individual session and the differences in the number of students writing at each session. The yearly summary also equalized the changes in timetabling at the school because this eliminated the need to compare results taken from different examination sessions. On a linear (year long) timetable all students would have written the examination in June. On a semester (half year) timetable students may have written the exam at the end of semester one, in January, or at the end of semester two, in June depending on the placement of Mathematics 12 in the timetable.

Participation Rates

The exam participation rate is calculated by the British Columbia Ministry of Education and is published with exam results. The participation rate is calculated by dividing the number of unique exam writers by the school's September 30 Grade 12 enrollment figures (Ministry of Education, 1997a). Unique exam writers is the designation given to the number of individual students who wrote a provincial
examination during the selected year. Each student is counted only once no matter how many times they attempt the examination.

Procedure

The program evaluation was concerned with the differences between subjects. Two cohort groups were identified as the subjects of interest. Cohort groups may be used when dealing with formal institutional data (Cook & Campbell, 1979). The actual design is diagrammed below where O indicates the group of interest and X indicates the years of treatment.

\[ O_1 \, O_2 \, O_3 \, O_4 \, O_5 \, X \, O_6 \, XX \, O_7 \, XXX \, O_8 \, XXXX \, O_9 \, XXXXX \, O_{10} \]

The first five groups of subjects completed Mathematics 12 prior to the introduction of the NVSS Mathematics Program. The following groups completed Mathematics 12 after being taught using the NVSS program. As the treatment was applied to one set of groups and not to the other, this reduces threats of history, selection and testing as Cook & Campbell (1979) suggested. The situation was also ethical in that the first set of groups had no opportunity to take Mathematics 12 using the NVSS Mathematics Program because it had not been developed when these students were at the school. The second set of groups all completed Mathematics 12 using the program because this was used with every math class in the school. The students who wrote the Math 12 provincial examination in 1993 had been exposed to the NVSS Mathematics program only during this final math course. The students who wrote the exam in 1994 had completed both Math 11 and Math 12 using the NVSS Mathematics Program. By
1997, the students who wrote the provincial examination had completed all of their math
courses, Math 8 through Math 12, using the NVSS Mathematics Program. In this type of
study causal inferences are possible.

Archival data was used in the program evaluation. Ministry of Education records
were used to identify mean scores and participation rates. The evaluation of the
Mathematics Program at NVSS began with the comparison of NVSS mean scores and
provincial means scores for the Mathematics 12 provincial exam. Likewise, comparisons
were made between NVSS participation rates in the Mathematics 12 provincial exam and
province wide participation rates. These variables were examined in both pre-program
implementation years and during the years in which the program was in effect. A series
of other variables was examined with the intent of assessing the plausibility of rival
hypotheses which might account for observed changes in the variables primarily of
interest in this study.

Alpha level

An alpha level of .10 was chosen for all statistical testing. This level is
appropriate since the study was based on a small number of data points. When n is small
there is the possibility of excessive Type II error, failure to reject $H_0$ when it is false.
CHAPTER 4: RESULTS

This section summarizes the study's results. The material is organized according to the research questions.

Question 1: Was there a change in the NVSS mean score?

Table 1 displays the mean scores on the Math 12 provincial examination for the NVSS students who wrote the examination and for all students in the province. It also gives the z-score relationship for these sets of means.

The NVSS Mathematics program was implemented with students taking Math 12 in the 1992-93 school year. Year 6 (*) is therefore the year of implementation. Students who wrote the provincial examination in Year 7 had received two years of treatment from the program. Students in Year 10 had had five years of treatment.

The Ministry of Education asserts that "provincial level examination results reflect stability over time" (Ministry of Education, 1997b, p. 1). However, it is clear from the table below that the provincial means listed do show variation from year to year. The lowest mean score is 63.36 and the highest is 66.57, a range of 3.21. For this reason, the z-scores shown are used to provide a standardized way of relating NVSS scores to provincial scores. Z-scores also account for variation in student ability over the years corrected for variation within the level of difficulty of the provincial examination and for sample size.
### Table 1

Math 12 Examination Data

<table>
<thead>
<tr>
<th>Year</th>
<th>NVSS Math 12 examination mean</th>
<th>Provincial Math 12 examination mean</th>
<th>Provincial Math 12 examination standard deviation</th>
<th>Number of NVSS students taking Math 12</th>
<th>z-score relationship between NVSS and provincial means</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987-88</td>
<td>(1) 58.53</td>
<td>64.64</td>
<td>16.16</td>
<td>28</td>
<td>-2.00</td>
</tr>
<tr>
<td>1988-89</td>
<td>(2) 59.59</td>
<td>66.57</td>
<td>15.63</td>
<td>22</td>
<td>-2.09</td>
</tr>
<tr>
<td>1989-90</td>
<td>(3) 59.86</td>
<td>63.32</td>
<td>16.93</td>
<td>16</td>
<td>-0.82</td>
</tr>
<tr>
<td>1990-91</td>
<td>(4) 55.95</td>
<td>64.45</td>
<td>15.41</td>
<td>20</td>
<td>-2.32</td>
</tr>
<tr>
<td>1991-92</td>
<td>(5) 63.45</td>
<td>65.20</td>
<td>17.03</td>
<td>20</td>
<td>-0.46</td>
</tr>
<tr>
<td>1992-93</td>
<td>(6*) 61.73</td>
<td>64.92</td>
<td>17.58</td>
<td>25</td>
<td>-0.65</td>
</tr>
<tr>
<td>1993-94</td>
<td>(7**) 56.20</td>
<td>65.76</td>
<td>18.53</td>
<td>21</td>
<td>-2.36</td>
</tr>
<tr>
<td>1994-95</td>
<td>(8*** 52.45</td>
<td>65.72</td>
<td>18.54</td>
<td>41</td>
<td>-4.58</td>
</tr>
<tr>
<td>1995-96</td>
<td>(9****) 52.46</td>
<td>66.35</td>
<td>17.86</td>
<td>34</td>
<td>-4.46</td>
</tr>
<tr>
<td>1996-97</td>
<td>(10***** 64.92</td>
<td>66.51</td>
<td>18.80</td>
<td>13</td>
<td>-0.32</td>
</tr>
</tbody>
</table>

1. The numbers in parentheses indicate the corresponding x value on all graphs. The * symbols indicate the number of years of treatment to which each group was exposed.

The NVSS means suggest an increase in scores in the years 1987 - 88 (Year 1) to 1991-92 (Year 5), the year before the NVSS program was introduced, although 1990-91 (Year 4) does not follow this trend. Following the implementation of the NVSS program in 1992-93 (Year 6), the means seem to decrease until 1996-97 (Year 10) when there is another increase. Years 8 and 9 show the greatest enrollments and also the lowest z-scores. The pattern can be seen more clearly when this data is graphed (see Figure 1).
Table 1

Math 12 Examination Data

<table>
<thead>
<tr>
<th>Year</th>
<th>NVSS Math 12 examination mean</th>
<th>Provincial Math 12 examination mean</th>
<th>Provincial Math 12 examination standard deviation</th>
<th>Number of NVSS students taking Math 12</th>
<th>z-score relationship between NVSS and provincial means</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987-88</td>
<td>(1) 58.53</td>
<td>64.64</td>
<td>16.16</td>
<td>28</td>
<td>-2.00</td>
</tr>
<tr>
<td>1988-89</td>
<td>(2) 59.59</td>
<td>66.57</td>
<td>15.63</td>
<td>22</td>
<td>-2.09</td>
</tr>
<tr>
<td>1989-90</td>
<td>(3) 59.86</td>
<td>63.32</td>
<td>16.93</td>
<td>16</td>
<td>-0.82</td>
</tr>
<tr>
<td>1990-91</td>
<td>(4) 55.95</td>
<td>64.45</td>
<td>15.41</td>
<td>20</td>
<td>-2.32</td>
</tr>
<tr>
<td>1991-92</td>
<td>(5) 63.45</td>
<td>65.20</td>
<td>17.03</td>
<td>20</td>
<td>-0.46</td>
</tr>
<tr>
<td>1992-93</td>
<td>(6*) 61.73</td>
<td>64.02</td>
<td>17.50</td>
<td>25</td>
<td>-0.65</td>
</tr>
<tr>
<td>1993-94</td>
<td>(7**) 56.20</td>
<td>65.76</td>
<td>18.53</td>
<td>21</td>
<td>-2.36</td>
</tr>
<tr>
<td>1994-95</td>
<td>(8****) 52.45</td>
<td>65.72</td>
<td>18.54</td>
<td>41</td>
<td>-4.58</td>
</tr>
<tr>
<td>1995-96</td>
<td>(9***** ) 52.69</td>
<td>66.35</td>
<td>17.86</td>
<td>34</td>
<td>-4.46</td>
</tr>
<tr>
<td>1996-97</td>
<td>(10******) 64.92</td>
<td>66.51</td>
<td>18.00</td>
<td>13</td>
<td>-0.32</td>
</tr>
</tbody>
</table>

1. The numbers in parentheses indicate the corresponding x value on all graphs. The * symbols indicate the number of years of treatment to which each group was exposed.

The NVSS means suggest an increase in scores in the years 1987-88 (Year 1) to 1991-92 (Year 5), the year before the NVSS program was introduced, although 1990-91 (Year 4) does not follow this trend. Following the implementation of the NVSS program in 1992-93 (Year 6), the means seem to decrease until 1996-97 (Year 10) when there is another increase. Years 8 and 9 show the greatest enrollments and also the lowest z-scores. The pattern can be seen more clearly when this data is graphed (see Figure 1).
Trend 1 indicates the line of regression \( b = 0.62 \) that the NVSS provincial examination means would have approximated based on the pre-1993 results. A slope of 0.62 means there was a mean gain of 0.62 points per year or an approximate gain of 6 points over 10 years. Trend 2 indicates the line of regression \( b = 0.29 \) that the NVSS provincial examination means would have approximated based on the post-1993 results. A slope of 0.29 means that there was a mean gain of 0.29 points per year or an approximate gain of 3 points over 10 years. The difference between pre- and post-1993 weighted mean scores is not significant \( t = -0.379, df = 8, p > .10 \).

However, the suggested trends may in fact be the result of simple trending up and down through random fluctuation. Analyzing the trend across all the data points, using linear regression \( b = -0.17 \), suggests a slight downward trend across the years (see Figure 2). The downward trend is not significant \( r^2 = 0.01, df = 8, p > .10 \).
Figure 2. NVSS Math 12 provincial examination means showing a single trend.

As the examination is administered at the provincial level, the means were analyzed in relation to the provincial means. Figure 3 compares the means for NVSS and provincial candidates. This graph indicates that the provincial mean is much more constant. The fluctuations in the means from year to year are not as great at the provincial level as they are for the NVSS scores. This observation is to be expected since the provincial statistics are based on a much larger sample (NVSS $n = 240$, Provincial $N = 143,315$) and so are more likely to be stable over time. It can also be seen that the NVSS means remain below the provincial average for all of the years shown.
Figure 3. Comparison of NVSS and provincial Math 12 examination means.

Although the Ministry of Education (1995b) claims that the examinations are stable over time, the actual provincial examination changes from session to session. The abilities of the various groups of students tested do not remain constant either. Therefore the z-score relationship between the NVSS and provincial scores was examined. The z-scores were calculated using the provincial examination mean and standard deviation scores published by the Ministry of Education in their report to schools at the end of each academic year and NVSS n values which were provided by the school. The equation used was:

\[ z = \frac{x - \mu}{\frac{\sigma}{\sqrt{n}}} \]

From Figure 3, it can be seen that the NVSS mean is always lower than the provincial mean resulting in negative z-scores throughout (see Table 1).

Graphing these scores shows again the fluctuations in the level of the NVSS mean scores over time (see Figure 4). The difference between pre- and post-1993 z-scores is
not significant ($t = -0.380, df = 8, p > .10$). This is the same result as the one obtained by testing the actual mean scores (see page 42).

Figure 4. The z-score relationship between NVSS and provincial Math 12 examination means.

In comparing the graphs of mean examination scores and of z-scores, it can be seen that an increase from Year 2 to Year 3 is followed by a dip in Year 4. Both graphs then display a rise in Year 5 followed by consecutive declines until Year 8. From Year 8 to Year 9 there is a slight rise in both graphs. This is followed by a sharp rise from Year 9 to Year 10. The only difference in the graphs occurs between Years 1 and 2. The graph of mean examination scores rises slightly from Year 1 to Year 2. The z-score graph shows a slight decline between these two years.

The use of both t-tests and regression analysis on raw mean scores and on standardized z-scores indicate no difference pre- and post-implementation of the NVSS Mathematics Program. However these results do not take account of the fact that other variables may be influencing the trends indicated by graphing. Alternative explanations are reported later in the chapter.
Question 2: Was there a change in the NVSS participation rate?

Table 2 displays the participation rate for both NVSS and for the provincial situation. The data begins with the 1989-90 (Year 3) academic year as this was the first year in which the Ministry of Education kept such records. An attempt was made to calculate participation rates for the years prior to this but the necessary information could not be obtained from either the Ministry of Education or from the school.

Table 2

<table>
<thead>
<tr>
<th>Year</th>
<th>NVSS participation rate</th>
<th>Provincial participation rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989-90</td>
<td>3</td>
<td>17.4%</td>
</tr>
<tr>
<td>1990-91</td>
<td>4</td>
<td>16.1%</td>
</tr>
<tr>
<td>1991-92</td>
<td>5</td>
<td>23.2%</td>
</tr>
<tr>
<td>1992-93</td>
<td>6(*)</td>
<td>10.4%</td>
</tr>
<tr>
<td>1993-94</td>
<td>7(**)</td>
<td>9.5%</td>
</tr>
<tr>
<td>1994-95</td>
<td>8(***</td>
<td>16.7%</td>
</tr>
<tr>
<td>1995-96</td>
<td>9(****)</td>
<td>11.9%</td>
</tr>
<tr>
<td>1996-97</td>
<td>10(*****</td>
<td>6.2%</td>
</tr>
</tbody>
</table>

The provincial participation rate is higher than that of NVSS for all the years examined. There is some fluctuation in the NVSS rate (see Figure 5) with the highest rate occurring in 1991-92 (Year 5) and the lowest in 1996-97 (Year 10). The average rate across the years listed is 13.9% and the range is 17.2%. However, the line of regression (b = -1.43) shows a steady decline in the percentage of students taking the Math 12 course. The difference between pre- and post-1993 participation rates is not significant ($r^2 = .41$, df = 6, $p > .10$).
Figure 5. NVSS participation rate for Math 12 provincial examination.

The provincial rate is more steady (see Figure 6) with a high in 1996-97 (Year 10) and a low in 1989-90 (Year 3). The average rate across the years listed is 34.8% with a range of 6.5%. While the NVSS participation rate is clearly declining, there would seem to be a steady increase in the provincial level of participation. The line of regression ($b = 0.99$) displays this increase.

Figure 6. Provincial participation rate for Math 12 provincial examination.
Statistical testing indicates that there is no difference in the participation rates pre- and post-implementation of the NVSS Mathematics program. In light of the increase in provincial participation rates, the decrease in the NVSS rate seems quite serious. However other results have not yet been examined and so there may be alternative explanations for these results.

Other Explanations

It is possible that the NVSS Mathematics Program had some effect on the type of student who enrolled in Math 12. In order to determine whether the characteristics of the students taking Math 12 had changed as a result of the change in the way in which the course was delivered, other relationships must be considered. The relationship between participation rate and examination mean score was examined. An analysis was also made of the relationship between mean provincial examination score and the mean GPA score for the students taking Math 12.

In order to establish whether any differences in NVSS Math 12 provincial examination results were a function of the treatment, comparisons were also made for Chemistry 12 and Physics 12 results for the same years. These courses were selected since they attract similar students and no special treatments were used in curriculum delivery during the same period. If the NVSS Mathematics Program had been responsible for any significant differences in Math 12 results, there should be no indication of a change over time in the means of Chemistry 12 or Physics 12.

NVSS is one of three high schools in School District 56 (Nechako). The others are Fort St. James Secondary School (FSJSS) and Fraser Lake Elementary Secondary
School (FLESS). In order to analyze the overall change in mean examination scores at NVSS, the examination scores for Math 12 from these other two schools were obtained in order to determine if there is a district wide pattern to the examination results.

**Participation Rate and Mean Provincial Examination Score**

Figure 7 displays the relationship between participation rate and mean examination score for the NVSS Math 12 provincial examination results. The correlation across Year 3, Year 4, and Year 5 is positive ($r = 0.94$, $df = 1$, $p > .10$). This suggests that before introduction of the NVSS Mathematics program, an increase in the participation rate was reflected by an increase in the mean examination score. On the other hand, the correlation across the treatment years, Year 6 to Year 10, shows a significant inverse relationship ($r = -0.81$, $df = 3$, $p < .10$). This suggests that after the introduction of the NVSS Mathematics program, an increase in the participation rate was reflected by a decrease in the mean examination score.

![Diagram of relationship between participation rate and mean examination score](image)

**Figure 7.** Relationship between NVSS Math 12 participation rate and provincial examination means.
Linear regression ($b = -0.05$) on all data points shows a near zero relationship. If one were to analyze the relationship between mean score and participation rate across the entire study, the one trend would simply cancel the other. The correlation between participation rate and mean score across all data points is not significant ($r^2 = 0.004$, df = 6, $p > .10$). Figure 8 shows the relationship between participation rate and mean score over time. From this it can be seen that an increase in participation in Year 8 was related to a decrease in the mean examination score. In Year 10, a decrease in the participation rate is related to an increase in the mean examination score.

![Figure 8](image.png)

**Figure 8.** Comparison of participation rate and mean score for Math 12

**Grade Point Average Scores**

It is possible that the NVSS program had no effect on the Math 12 examination means or the participation rate. Natural selection into the Math 12 course may have affected achievement rate. In order to check this explanation, the school’s Grade Point Average (GPA) scores for each group of students were obtained and analyzed.
Nechako Valley Secondary School determines a GPA score for each student based on final school marks. The provincial examination score is not included in these calculations. Table 3 shows how the final school marks are assigned a Grade Point.

Table 3
Values Assigned to GPA Scores

<table>
<thead>
<tr>
<th>Final Letter Grade</th>
<th>Percentage Range</th>
<th>Grade Point Assigned</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>86 - 100</td>
<td>4.0</td>
</tr>
<tr>
<td>B</td>
<td>73 - 85</td>
<td>3.0</td>
</tr>
<tr>
<td>C+</td>
<td>67 - 72</td>
<td>2.5</td>
</tr>
<tr>
<td>C</td>
<td>60 - 66</td>
<td>2.0</td>
</tr>
<tr>
<td>C-</td>
<td>50 - 59</td>
<td>1.5</td>
</tr>
<tr>
<td>F</td>
<td>0 - 49</td>
<td>0</td>
</tr>
</tbody>
</table>

A student’s GPA score is determined by converting the final school mark, shown as a percentage, in every course taken by the student to the corresponding grade point score. These scores are then averaged to determine the overall GPA assigned to the student.

Table 4 shows the GPA scores for each group of students taking Math 12 in the years under study. The average GPA score is 3.11 with a range of 0.63. The highest mean GPA occurred in 1991-92 (Year 5) and the lowest in 1988-89 (Year 2).
Table 4

Mean GPA Scores for NVSS Students Taking Math 12

<table>
<thead>
<tr>
<th>Year</th>
<th>GPA scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987-88</td>
<td>2.86</td>
</tr>
<tr>
<td>1988-89</td>
<td>2.80</td>
</tr>
<tr>
<td>1989-90</td>
<td>3.28</td>
</tr>
<tr>
<td>1990-91</td>
<td>3.23</td>
</tr>
<tr>
<td>1991-92</td>
<td>3.43</td>
</tr>
<tr>
<td>1992-93</td>
<td>3.31</td>
</tr>
<tr>
<td>1993-94</td>
<td>2.85</td>
</tr>
<tr>
<td>1994-95</td>
<td>3.01</td>
</tr>
<tr>
<td>1995-96</td>
<td>3.22</td>
</tr>
<tr>
<td>1996-97</td>
<td>3.40</td>
</tr>
</tbody>
</table>

Figure 9 displays the GPA data in graph form. This graph appears to roughly follow the pattern of the NVSS mean examination scores with corresponding dips in Years 4 and 7 and corresponding highs in Years 5 and 10.

Figure 9. Mean GPA scores of NVSS students taking Math 12.

The similarity between the pattern of mean examination scores and GPA scores can be seen more clearly in Figure 10 where both sets of data are shown.
Figure 10. Comparison of mean examination scores and mean GPA scores.

Figure 11 displays the relationship between GPA scores and the NVSS provincial examination mean scores. Linear regression across all data points ($b = 8.29$) indicates that as the GPA score increases the mean examination score also increases. The correlation between GPA scores and NVSS mean scores is not significant ($r^2 = 0.21$, $df = 8, p > .10$). It is also noted that there is no clear pattern formed by the treatment years. However, Year 1, Year 2 and Year 7 all had GPA scores less than 3.0 (B) but the correlation between GPA scores and NVSS mean scores for these years is not significant ($r^2 = .39$, $df = 1, p > .10$). On the other hand, Years 3, 4, 5, 6, 9 and 10 all had GPA scores greater than 3.0 (B) and the correlation between GPA scores and NVSS mean scores for these years is significant ($r^2 = .83$, $df = 4, p < .10$). This would seem to indicate that the second group is made up of cohorts with larger numbers of able students.
Figure 11. The relationship between GPA score and NVSS Math 12 provincial examination means.

Figure 12 displays the relationship between GPA scores and the NVSS participation rate. Linear regression ($b = 5.66$) indicates that as the GPA score increases the participation rate also increases. However, the correlation between GPA scores and the NVSS participation rate is not significant ($r^2 = 0.04$, $df = 8$, $p > 10$).

Figure 12. The relationship between GPA score and the NVSS Math 12 participation rate.
Comparison of Examination Data Across School Courses

Mean Scores

Next, Math 12 mean scores were compared with the examination scores for Chemistry 12 and Physics 12. Table 5 shows the NVSS mean examination scores for Chemistry 12, Math 12 and Physics 12. Figure 13 represents this data graphically.

Table 5

<table>
<thead>
<tr>
<th>Year</th>
<th>Chemistry 12</th>
<th>Math 12</th>
<th>Physics 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987-88</td>
<td>(1) 62.54</td>
<td>58.53</td>
<td>67.08</td>
</tr>
<tr>
<td>1988-89</td>
<td>(2) 56.04</td>
<td>59.59</td>
<td>70.08</td>
</tr>
<tr>
<td>1989-90</td>
<td>(3) 56.41</td>
<td>59.86</td>
<td>72.00</td>
</tr>
<tr>
<td>1990-91</td>
<td>(4) 54.12</td>
<td>55.95</td>
<td>59.90</td>
</tr>
<tr>
<td>1991-92</td>
<td>(5) 60.37</td>
<td>63.45</td>
<td>74.07</td>
</tr>
<tr>
<td>1992-93</td>
<td>(6*) 59.75</td>
<td>61.73</td>
<td>66.53</td>
</tr>
<tr>
<td>1993-94</td>
<td>(7**) 53.09</td>
<td>56.20</td>
<td>61.90</td>
</tr>
<tr>
<td>1994-95</td>
<td>(8*** 57.52</td>
<td>52.45</td>
<td>58.50</td>
</tr>
<tr>
<td>1995-96</td>
<td>(9**** 72.00</td>
<td>52.69</td>
<td>73.23</td>
</tr>
<tr>
<td>1996-97</td>
<td>(10***** 71.20</td>
<td>64.92</td>
<td>61.00</td>
</tr>
</tbody>
</table>

Figure 13. Comparison of NVSS Chemistry 12, Math 12 and Physics 12 examination means.
The patterns in all three cases follow each other. A high in Year 3 in all subjects is followed by a dip in Year 4 which is then followed by another high in Year 5. All three lines continue downward in Year 6 and Year 7. There would seem to be a cohort effect.

The difference between Chemistry 12 mean scores pre- and post-introduction of the NVSS Mathematics Program is not significant ($t = 0.289$, df $= 8$, $p > .10$). The difference between Physics 12 mean scores pre- and post-introduction of the NVSS Mathematics Program is also not significant ($t = -0.255$, df $= 8$, $p > .10$). The results indicate that there are no significant changes in these means over time as there was no significant change in the Math 12 mean over time.

Linear regression ($b = 1.16$) on the Chemistry 12 means suggests an increase in Chemistry 12 means over time (see Figure 14). The increase in not significant however ($r^2 = 0.28$, df $= 8$, $p > .10$).

Figure 14. Chemistry 12 provincial examination means.
Linear regression ($b = -0.62$) on the Physics 12 means suggests a decrease in Physics 12 means over time (see Figure 15). The decrease is not significant however ($r^2 = 0.10$, df = 8, $p > .10$).

![Graph showing mean scores over years](image)

**Figure 15.** Physics 12 provincial examination means.

In comparing the three subjects, it seems that while Chemistry mean examination scores have shown a slight overall increase with time, the mean examination scores for both Physics 12 and Math 12 have decreased. None of the trends, however, differ significantly from zero (no change).

**Participation Rate**

As for examination means, participation rates for the three subjects were also compared. Table 6 displays the participation rate for Chemistry 12, Math 12 and Physics 12. Figure 16 displays this same data graphically.
Table 6

NVSS Participation Rates for Chemistry 12, Math 12 and Physics 12

<table>
<thead>
<tr>
<th>Year</th>
<th>Chemistry 12</th>
<th>Math 12</th>
<th>Physics 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989-90</td>
<td>3</td>
<td>14.0%</td>
<td>17.4%</td>
</tr>
<tr>
<td>1990-91</td>
<td>4</td>
<td>20.2%</td>
<td>16.1%</td>
</tr>
<tr>
<td>1991-92</td>
<td>5</td>
<td>30.5%</td>
<td>23.2%</td>
</tr>
<tr>
<td>1992-93</td>
<td>6(*)</td>
<td>14.0%</td>
<td>10.4%</td>
</tr>
<tr>
<td>1993-94</td>
<td>7(**)</td>
<td>9.5%</td>
<td>9.5%</td>
</tr>
<tr>
<td>1994-95</td>
<td>8(***</td>
<td>7.7%</td>
<td>16.7%</td>
</tr>
<tr>
<td>1995-96</td>
<td>9(****</td>
<td>5.9%</td>
<td>11.9%</td>
</tr>
<tr>
<td>1996-97</td>
<td>10(*****</td>
<td>7.1%</td>
<td>6.2%</td>
</tr>
</tbody>
</table>

Figure 16. NVSS participation rates for Chemistry 12, Math 12 and Physics 12.

Again, the patterns in all three subjects follow each other. A low in Year 4 is followed by a high in Year 5 followed by a dip in Year 6. The pattern continues downward in Year 7 but the Math 12 rate goes against the trend in Year 8, rising while the rates for Chemistry 12 and Physics 12 fall.

Linear regression on the Chemistry 12 participation rate ($b = -2.29$) suggests an overall decrease in the percentage of students taking Chemistry 12 over time (see Figure 17). This decrease is significant ($r^2 = 0.46, df = 6, p < .10$).
Figure 17. NVSS participation rates for Chemistry 12.

Linear regression on the Physics 12 participation rate ($b = -0.93$) suggests a decrease in the percentage of students taking Physics 12 over the years also (see Figure 18). This decrease is not significant ($r^2 = 0.30$, df = 6, $p > .10$).

Figure 18. NVSS participation rates for Physics 12.

In all three courses, Math 12, Chemistry 12 and Physics 12, the participation rate has declined over time. Math 12 ($b = -1.43$, base = 17.4%) dropped approximately 10
percent over the data series. Both Chemistry 12 (b = -2.29, base = 14%) and Physics 12 (b = -0.93, base = 5.8%) dropped approximately 16 percent.

It is worthy of note that in Year 8, the participation rate for Chemistry 12 is higher than for the other two subjects. For the same year, the Chemistry 12 examination mean score is closer to the other two than at any other time. It would seem that the relationship displayed in Figure 7, as participation rate increases mean examination score decreases, is true for both Math 12 (see Figure 8) and Chemistry 12 (see Figure 19).

![Graph](image.png)

**Figure 19.** Comparison of participation rate and mean score for Chemistry 12

Figure 19 shows that from Year 7 to Year 9, the mean score for Chemistry 12 is increasing while the participation rate is decreasing. In Year 10, the pattern has reversed; the mean score is moving downward while the participation rate is moving upward.
Comparison With Other Schools In The Same School District

Table 7 displays the Math 12 mean examination scores for three schools, NVSS, FSJSS and FLESS, which are all part of School District 56 (Nechako). Figure 20 displays the same data graphically.

Table 7

<table>
<thead>
<tr>
<th>Year</th>
<th>NVSS Math 12</th>
<th>FSJSS Math 12</th>
<th>FLESS Math 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987-88</td>
<td>1</td>
<td>58.53</td>
<td>63.55</td>
</tr>
<tr>
<td>1988-89</td>
<td>2</td>
<td>59.59</td>
<td>70.89</td>
</tr>
<tr>
<td>1989-90</td>
<td>3</td>
<td>59.86</td>
<td>64.88</td>
</tr>
<tr>
<td>1990-91</td>
<td>4</td>
<td>55.95</td>
<td>55.72</td>
</tr>
<tr>
<td>1991-92</td>
<td>5</td>
<td>63.45</td>
<td>63.72</td>
</tr>
<tr>
<td>1992-93</td>
<td>6(*)</td>
<td>61.73</td>
<td>64.00</td>
</tr>
<tr>
<td>1993-94</td>
<td>7(**)</td>
<td>56.20</td>
<td>78.93</td>
</tr>
<tr>
<td>1994-95</td>
<td>8(*** )</td>
<td>52.45</td>
<td>59.22</td>
</tr>
<tr>
<td>1995-96</td>
<td>9(****)</td>
<td>52.69</td>
<td>64.70</td>
</tr>
<tr>
<td>1996-97</td>
<td>10(***** )</td>
<td>64.92</td>
<td>59.46</td>
</tr>
</tbody>
</table>

Figure 20. Comparison of Math 12 provincial examination means for NVSS, FSJSS and FLESS.
Linear regression \((b = -0.23)\) on the FSJSS Math 12 mean scores suggests a slight decrease in the scores over time (see Figure 21). This decrease is not significant \((r^2 = 0.01, \text{df} = 8, p > .10)\).

![Figure 21. FSJSS Math 12 provincial examination means.](image)

Linear regression \((b = -1.12)\) on the FLESS Math 12 mean scores suggests a decrease in the scores over time (see Figure 22). This decrease is not significant \((r^2 = 0.18, \text{df} = 8, p > .10)\).

![Figure 22. FLESS Math 12 provincial examination means.](image)
The situation appears to be the same at all three schools. In all cases the trend over time is a decrease in Math 12 provincial examination scores. In comparing the three schools, it would seem that the overall decrease in scores is slightly less at NVSS (\( b = -0.17 \)) than it was at the other two schools (FSJSS \( b = -0.23 \), FLESS \( b = -1.12 \)).

Table 8 displays the participation rates for the three schools, NVSS, FSJSS and FLESS. Figure 23 represents this data graphically.

Table 8

<table>
<thead>
<tr>
<th>Year</th>
<th>NVSS Participation Rate</th>
<th>FSJSS Participation Rate</th>
<th>FLESS Participation Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989-90</td>
<td>3</td>
<td>17.4%</td>
<td>34.6%</td>
</tr>
<tr>
<td>1990-91</td>
<td>4</td>
<td>16.1%</td>
<td>27.3%</td>
</tr>
<tr>
<td>1991-92</td>
<td>5</td>
<td>23.2%</td>
<td>19.0%</td>
</tr>
<tr>
<td>1992-93</td>
<td>6(*)</td>
<td>10.4%</td>
<td>11.4%</td>
</tr>
<tr>
<td>1993-94</td>
<td>7(**)</td>
<td>9.5%</td>
<td>12.9%</td>
</tr>
<tr>
<td>1994-95</td>
<td>8(***</td>
<td>16.7%</td>
<td>13.3%</td>
</tr>
<tr>
<td>1995-96</td>
<td>9(****)</td>
<td>11.9%</td>
<td>9.3%</td>
</tr>
<tr>
<td>1996-97</td>
<td>10(*****</td>
<td>6.2%</td>
<td>9.1%</td>
</tr>
</tbody>
</table>

Figure 23. Participation rate in Math 12 for NVSS, FSJSS and FLESS
Linear regression ($b = -3.38$) on the FSJSS participation rate data suggests a dramatic decrease over time (see Figure 24). This decrease is significant ($r^2 = 0.80$, $df = 6$, $p < .05$).

![Figure 24. FSJSS participation rate for Math 12.](image)

Linear regression ($b = -2.80$) on the FLESS participation rate data also suggests a dramatic decrease over time (see Figure 25). This decrease is significant ($r^2 = 0.48$, $df = 6$, $p < .10$).
In all three schools, therefore, the participation rate has declined over time. Again, the overall decrease in the participation rate for NVSS (b = -1.43) is less than that of the other two schools (FSJSS b = -3.38, FLESS b = -2.80). However, the decline of approximately one point per year in the Math 12 participation rate at NVSS compared with three points per year decline at the other schools must be regarded in light of the lower initial values for NVSS. NVSS (b = -1.43, base = 17.4%) dropped an average of eight percent. Both FSJSS (b = -3.38, base = 34.6%) and FLESS (b = -2.80, base = 26.7%) dropped an average of 10 percent.

The results are summarized in tabular form in Chapter 5. Therefore they are not presented in summary form here.
CHAPTER 5: SUMMARY AND CONCLUSIONS

The purpose of this chapter is to provide a forum in which the study’s findings can be interpreted and placed in the context of the hypotheses originally stated. It is also the section where the implications and limitations of the study can be examined critically.

Summary of the Study

This study evaluated the NVSS Mathematics Program. The program was developed by the mathematics teachers at NVSS in response to the belief that the curriculum, as published by the British Columbia Ministry of Education, did not meet the needs of the local situation. In particular the NVSS math teachers wanted to increase the number of students studying higher level mathematics and to improve their math skills so that they would do well at this higher level.

The NVSS Mathematics Program was adopted in the Spring of 1993 and was used with all math classes in the school from the Fall of 1993 on. This means that students who took Math 12 in the 1993-94 school year were exposed to the NVSS Mathematics program in both Math 11 and Math 12 courses whereas students who completed Math 12 in the 1996-97 school year were exposed to the NVSS Mathematics Program for all of their high school math courses.

The effectiveness of the program was evaluated in terms of the way in which it met the goals of the teachers who developed it. Did this program enable, and even encourage, more students to take Math 12? Did the mean score on the provincial Math 12 examination improve as a result of the implementation of the program?
To evaluate a program of this type, time series analysis was determined to be the best method. Time series analysis is used for intact programs where archival evidence is available and useful. In this case the program was already in use when evaluation was first conducted and archival evidence, provincial examination mean scores, and participation rates, from both school records and Ministry of Education publications, was available. In time series analysis, the program evaluator charts data points to look for trends and changes to these trends.

The unit of analysis was Math 12 classes for the years 1987-88 (Year 1) to 1996-97 (Year 10). Although a different set of students comprised each of these classes, they were representative cohort groups and so could be used in a time series analysis. The classes were similar demographically coming from the same location and being exposed to similar educational experiences.

Conclusions

As there are no simple trends in the data, the two main hypotheses are first examined. This is followed by interpretation of the results of testing the alternate hypotheses. Only then is a conclusion about the NVSS Mathematics program reached. Examination means, participation rates and GPA scores all fluctuate with time and appear to interact in complex ways. The results are summarized in Table 9.
### Table 9

**Summary of Results**

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Result</th>
<th>Tentative Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Hypotheses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. achievement</td>
<td>$t = -0.38; \text{ns}$;</td>
<td>There is no significant ($\alpha = 0.10$) difference in achievement between the</td>
</tr>
<tr>
<td></td>
<td>$b = -0.17$</td>
<td>pre- and post-intervention</td>
</tr>
<tr>
<td>2. participation</td>
<td>$t = -0.15; \text{ns}$;</td>
<td>While there is no difference in participation between the pre- and post-intervention,</td>
</tr>
<tr>
<td></td>
<td>$b = -1.43$</td>
<td>there is an important downward trend in NVSS Math 12 participation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Alternate Hypotheses</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Provincial Trends</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. achievement</td>
<td>$t_2 = 0.38; \text{ns}$</td>
<td>There is no significant ($\alpha = 0.10$) difference in achievement between the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pre- and post-intervention when provincial trends are taken into account</td>
</tr>
<tr>
<td>2. participation</td>
<td>$b_{prev} = 0.99$</td>
<td>The downward trend in NVSS Math 12 participation is in contrast to a provincial upward trend</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Achievement vs. Participation Rate Interaction</strong></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$r^2 = .004; \text{ns}$;</td>
<td>Increasing the pool of students who completed Math 12 did not lower overall achievement</td>
</tr>
<tr>
<td></td>
<td>$b = -0.05$</td>
<td></td>
</tr>
</tbody>
</table>
## Interaction with Ability as Measured by GPA (self selection - cohort effects)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. achievement</td>
<td>( r^2 = .21; ) ns (( \alpha &gt; .10 ))</td>
<td>There is a positive, direct relationship between GPA scores and mean exam scores.</td>
</tr>
<tr>
<td></td>
<td>( b = 8.29 )</td>
<td></td>
</tr>
<tr>
<td>2. participation</td>
<td>( r^2 = .04; ) ns;</td>
<td>There is a positive, direct relationship between GPA scores and the participation rate.</td>
</tr>
<tr>
<td></td>
<td>( b = 5.66 )</td>
<td></td>
</tr>
</tbody>
</table>

## Ability as Measured by NVSS Chemistry and Physics (self selection - cohort effects)

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. achievement</td>
<td>( t_{\text{chem}} = 0.29; ) ns;</td>
<td>While Chemistry exam scores increased slightly over time, the mean scores for Math and Physics declined.</td>
</tr>
<tr>
<td></td>
<td>( b_{\text{chem}} = 1.16; )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( t_{\text{phys}} = -0.26; ) ns;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( b_{\text{phys}} = -0.62 )</td>
<td></td>
</tr>
<tr>
<td>2. participation</td>
<td>( r^2_{\text{chem}} = .46; )</td>
<td>The decline across time in participation occurred in all three subject areas. The decline in Math 12 participation was slowed by the interaction.</td>
</tr>
<tr>
<td></td>
<td>( b_{\text{chem}} = -2.29; )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( r^2_{\text{phys}} = .30; ) ns;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( b_{\text{phys}} = -0.93 )</td>
<td></td>
</tr>
</tbody>
</table>

## Comparison of NVSS Math 12 with FSJSS and FLESS Math 12

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. achievement</td>
<td>( r^2_{\text{FSJSS}} = .01; ) ns;</td>
<td>In all 3 schools there is an overall decline in achievement. The decline is less at NVSS than at the other schools.</td>
</tr>
<tr>
<td></td>
<td>( b_{\text{FSJSS}} = -0.23; )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( r^2_{\text{FLESS}} = .18; ) ns;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( b_{\text{FLESS}} = -1.12 )</td>
<td></td>
</tr>
<tr>
<td>2. participation</td>
<td>( r^2_{\text{FSJSS}} = .80; )</td>
<td>In all 3 schools there is an overall decline in participation. The decline is less at NVSS than at the other schools.</td>
</tr>
<tr>
<td></td>
<td>( b_{\text{FSJSS}} = -3.38; )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( r^2_{\text{FLESS}} = .48; )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>( b_{\text{FLESS}} = -2.80 )</td>
<td></td>
</tr>
</tbody>
</table>
Mean Scores

There are no significant differences in the means before or after the introduction of the NVSS Mathematics Program. However there is an overall downward tendency to the means across time. Examination of the z-scores which compare school and provincial examination means confirm these fluctuations and the lack of significant differences.

Participation Rate

There are no significant differences in the participation rates before or after the introduction of the NVSS Mathematics Program. There is an overall downward tendency to the participation rate across time.

It was discovered that the relationships between participation rate and achievement is an inverse one. As the participation rate increased, the mean score decreased. However this decrease was not statistically significant. This is of interest since the increase in the pool of students taking Math 12 would have been caused by the self selection of students whose math skills had previously kept them out of the course. If it is true that students with weaker math skills were encouraged to take Math 12 because of the way in which the curriculum had been delivered to them in previous math courses, then it is natural that the mean scores would be lower because these students would not do as well on the final examination as students with stronger math skills.

GPA Scores

The GPA scores to a large degree followed the pattern of the mean examination scores. There were corresponding highs in both means and GPA scores in Years 5 and 10
and corresponding lows in Years 4 and 7. In particular, Year 5 was the highest point in both series. Year 5 was also the year in which the highest participation rate was recorded.

Comparing GPA Scores and Mean Examination Scores

The pattern formed by the plotting of GPA scores across time is similar to the pattern produced by plotting the mean examination scores with corresponding dips and highs. This means that when the Math 12 group included students with a lower overall academic standing, the mean score on the final examination was lower. This should be expected since students who routinely earned lower marks in school would also earn a lower mark on the final exam. What is important is that these students were included in the Math 12 group and that it was no longer only the choice of students who earned high marks overall.

There was no clear pattern to the points representing GPA score versus mean examination score but it is noticeable that the treatment years are well represented in the points at the upper end of the scale. Year 6, Year 8, Year 9 and Year 10 are all included in the group of points which show a steady increase in GPA score and mean examination score.

Comparing Chemistry 12, Math 12 and Physics 12

The Math 12 results are a part of an overall school trend. All three courses, Chemistry 12, Math 12 and Physics 12, followed a similar pattern of ups and downs across the time series. In all three courses, Year 5 was the high point in both series: mean scores and participation rate. In comparing the series across time, it was noted that while
Chemistry 12 mean scores increased slightly over time, the mean scores for Math 12 and Physics 12 showed an overall decline. However, the trend in participation rates for all three courses was the same. It declined over time.

The Math 12 results do vary in one instance. In Year 8, participation in Math 12 increased while it continued to decrease in both Chemistry 12 and Physics 12. In this same year, the mean scores for Math 12 and Physics 12 are decreasing while the mean for Chemistry 12 is increasing. It would seem that the increased participation in Math 12 that year did not affect the trend of the mean score series.

Since the Math 12 achievement results follow a similar pattern to the Chemistry and Physics results, the trends seen in the Math 12 program may not be caused by the introduction of the NVSS Mathematics Program. In fact, the introduction of the NVSS Mathematics Program would appear to have slowed down the decline in participation rate while maintaining the mean score situation. While increasing the number of students who took the course, the achievement for all students was not adversely affected.

Comparing NVSS, FSJSS and FLESS

The fluctuations noted in the time series for all NVSS data are also present when the data for the other schools in the district is plotted. In all three schools, there is an overall decline in both the mean examination scores for Math 12 and in the participation rates. As all three schools follow the same pattern, it can be concluded that the introduction of the NVSS Mathematics Program was not responsible for this trend. In fact, it should be noted that while the series for mean scores and participation rates for all three schools showed a downward trend, the trend at NVSS was less than that at the other
two schools. It may be the case that the NVSS Mathematics program counteracted the decreasing participation rate.

Summary of Interpretation of Results

Analysis of provincial examination mean scores shows a downward trend across all data points. This analysis is confirmed by plotting z-scores for these means. Also, the mean exam scores across all three secondary schools in the district show a downward trend. However the rate of decline is less for the NVSS scores than for the other schools. This would support the conclusion that it was not the introduction of the NVSS Mathematics program which brought about the decline in provincial examination scores.

Participation rates also appear to be in decline across time. The participation rates for Chemistry 12, Math 12 and Physics 12 are all in decline. The participation rates across all three secondary schools also show a downward trend. However the NVSS series declines at a slower rate than at either of the other schools. This shows that the NVSS Mathematics program did not cause the decline. In fact, introduction of the program may have stemmed the decline for Math 12.

It is reasonable to suggest that the impact of a change in teaching practice was a positive one for the students at NVSS. The relationships between the mean examination score and between GPA scores and both mean scores and participation rate suggest that student selection is an important factor. The NVSS Mathematics Program does appear to have had some influence on the type of student selecting to take Math 12.
Conclusion

While these conclusions suggest that the implementation of the program was good for the NVSS situation they must be seen in terms of the original hypotheses defined in Chapter 1. Consequently the first hypothesis, that the mean scores on the Math 12 provincial examination after implementation would increase in comparison to the mean scores before implementation, is rejected. Furthermore, the second hypothesis, that the participation rate in Math 12 after implementation would increase in comparison to the participation rate before implementation, is also rejected.

Although the main hypotheses in their original form are rejected, the intervention was successful for a number of reasons. The introduction of the program brought about a decrease in the rate of decline for both achievement and participation. There was an increase in the pool of students taking Math 12 and this increase did not affect achievement. Math 12 results at NVSS are in better shape than results in Chemistry 12 or Physics 12 and also better than Math 12 results at the other secondary schools in the district. For these reasons, it would appear that the change in curriculum delivery and the implementation of the NVSS Mathematics Program was a successful venture for the school and its students.

Limitations

It should be remembered that the NVSS Mathematics Program was developed by teachers on site with particular goals in mind and for use in one particular school. The school was not selected at random but it was not selected because it was known to be different either. The school is a typical secondary school in the province of British
Columbia. It offers the courses offered at other secondary schools and it has a mix of students like those at any other school. The generalizations made are reasonable within the limitations expressed.

The program was introduced to students as it was being developed by the teaching staff. The mathematics teachers did not choose a particular point in the time series at which to implement the program. In fact, the point of implementation was at a time when the trend in the time series for mean examination scores and for participation rate was downward. Without the outlying data points of Year 5, this downward trend would have been even more pronounced.

There is a diluted treatment effect due to the lag time within the program. The intervention did not happen overnight. Students had to work their way through the program at the different levels and then select to take Math 12 from a wide variety of course offerings. The evaluation conducted in this study focused on only two discrete aspects of the implementation of the program and did not analyze the effect of the program in other areas. For example, the study did not examine the number of students who took Math 11 but opted not to take Math 12.

**Deficiencies**

The time series examined are short. The longer series contain only ten data points: five points on either side of the treatment. The time series used for participation rate analysis are even shorter. It was not possible to obtain participation rates for Years 1 and 2 since the necessary data was not available. The use of annual results as a unit of
analysis resulting in only 10 data points means that statistical tests are extremely prone to Type II error.

A short time series does provide a better picture than a simple pre- and post-test situation (Cook & Campbell, 1979). However, the last data point used in this study is also the first data point to represent a group of students who have taken all of their math courses using the NVSS Mathematics Program. This is the group of students who have been immersed in the aims and procedures of the program throughout high school.

Individual results were not available for Math 12 students. Therefore it was not possible to match the students with earlier standardized test results such as the Canadian Test of Basic Skills (CTBS). This means that it was not possible to ascertain whether trends in the data were a function of individual groups. In particular, and noted several times, the results across the board in Year 5 are exceptional. With CTBS scores it would have been possible to determine whether this group of students differed significantly from the other groups. Similarly, in Year 4 all of the series plotted show a low point and CTBS scores could have been used to determine the nature of this group of students.

The Evaluation Model

This study employed one model of program evaluation, an objective based one. This was selected because of its fit with both mathematics curricula generally and with the way in which the NVSS Mathematics Program in particular was developed. This model was also able to provide the information that the stakeholders most wanted.
However, by using a different model of curriculum development and evaluation, a different picture of the program and its implementation might have emerged. If the program had been developed from the Situational Orientation, the evaluation might have focussed on process and context and could have examined the views of the students immersed in the program. If the program had been developed from the Critical Reflective Orientation, the evaluation might have focussed on what changes need to be made to the program and could have examined alternate methods of curriculum delivery.

Recommendations for Practice and Research

As the program evaluation was done in response to questions posed within the community, it is important to point out that there is a danger in interpreting the effectiveness of the NVSS Mathematics Program from too narrow a stance. The analysis made in this study shows that merely focusing on a limited view of one or two aspects of the program without evaluating the context and all the other factors which affect the success of program implementation would lead most observers to suggest that the program should not be used further. This study supports the statement that this is not the case. At worst, the NVSS Mathematics program performed no differently than the other math programs or the science courses.

In fact, it would seem that the decline in Math 12, Chemistry 12 and Physics 12 within the school and in Math 12 across the district warrants direct intervention. The NVSS Mathematics program may have helped to slow the decline and so it could be concluded that further examination of the way in which these subjects are taught is a useful exercise in improving teaching practice and student results.
Further research is needed. One particular avenue that should be followed is the matching of individual student results to scores on previous assessment tools. The correlation between CTBS scores and Math 12 statistics would be worthy of study. MacMillan (in progress) has begun examining the relationship between CTBS scores and provincial examination marks.

The NVSS Mathematics Program is still in use. The mathematics teachers continue to refine and rework the definitions within the program and the way in which material is presented to students. They have paid attention to Tyler’s advice that in any program there should be an “ongoing examination of objectives, course materials, learning experiences and student outcomes so that both the course and student learning can be improved” (1949, p. 5).
References


June 7, 1996

Ms. Lynn Maksymchak  
P.O. Box 1433  
Vanderhoof, B.C.  
V0J 3A0

Dear Lynn:

I am writing to extend support for your research work towards your Master's program at University of Northern British Columbia. I understand your research entails using archival test data on Mathematics 12, Physics 12 and Chemistry 12 provincial examination results and on the students who have taken Mathematics 12 since 1988. Anonymity of students and score results are essential in maintaining the confidentiality of the students.

I look forward to receiving a copy of your thesis findings. Best of luck in your studies.

Yours truly,

Louise Burgart  
Superintendent of Schools

LB/cp