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Andrews University
School of Education

TEACHERS’ AND STUDENTS’ PERCEPTIONS OF SEVENTH- AND EIGHTH-GRADE SCIENCE EDUCATION IN A SELECTED SEVENTH-DAY ADVENTIST UNION CONFERENCE

A Dissertation
Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

by
Marcel Andre Almont Sargeant
December 2003
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TEACHERS' AND STUDENTS' PERCEPTIONS OF SEVENTH- AND EIGHTH- GRADE SCIENCE EDUCATION IN A SELECTED SEVENTH-DAY ADVENTIST UNION CONFERENCE

A dissertation presented in partial fulfillment of the requirements for the degree Doctor of Philosophy

by

Marcel Andre Almont Sargeant

APPROVAL BY THE COMMITTEE:

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Date approved 12/1/03

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ABSTRACT

TEACHERS' AND STUDENTS' PERCEPTIONS OF SEVENTH- AND EIGHTH-GRADE SCIENCE EDUCATION IN A SELECTED SEVENTH-DAY ADVENTIST UNION CONFERENCE

by

Marcel Andre Almont Sargeant

Chair: Larry Burton
ABSTRACT OF GRADUATE STUDENT RESEARCH

Dissertation

Andrews University
School of Education

Title: TEACHERS’ AND STUDENTS’ PERCEPTIONS OF SEVENTH- AND EIGHTH-GRADE SCIENCE EDUCATION IN A SELECTED SEVENTH-DAY ADVENTIST UNION CONFERENCE

Name of researcher: Marcel Andre Almont Sargeant

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Problem

Science education has long been a great concern in the United States, where less than one-third of the students perform at or above the proficient level. The purpose of this study was to investigate the status of the science program in a selected Union Conference of the Seventh-day Adventist school system. Specifically, this study investigated the perceptions of teachers and students regarding the extent to which the science program meets the criteria of the National Commission on Mathematics and Science Teaching for the 21st century and to what extent these criteria are related to academic performance as indicated by Iowa Test of Basic Skills (ITBS) science scores.
Method

Two questionnaires designed by the researcher were used to get responses from 424 students in seventh and eighth grades and 68 teachers to see how this school system compares to the criteria of National Commission on Mathematics and Science Teaching for the 21st century. Three classroom configurations were investigated in this study, namely: (a) multigrade, (b) two-grade, and (c) single-grade. Crosstabulation, one-way analysis of variance, Kruskal-Wallis test, and linear regression were used to analyze the four research questions of this study.

Results

The single-grade classroom configuration received a better rating for the science criteria \((p < 0.01)\), and students from single-grade performed significantly better than two-grade/multigrade \((p < 0.01)\) classroom configurations on their science achievement (ITBS). There were significant relationships among science achievement and the factors that measured the criteria of the National Commission for Mathematics and Science Teaching for the 21st century.

Conclusions

The differences in teaching practices explained the discrepancies in the three classroom configurations. Schools can therefore develop policies and strategies to improve the practices in the teaching and learning process in science education that were identified as being deficient by the criteria of National Commission on Mathematics and Science Teaching for the 21st century.
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CHAPTER 1

INTRODUCTION

Recently the National Commission on Mathematics and Science Teaching (NCMST, 2000) for the 21st century released its report, Before It's Too Late. It stated:

Less than one-third of all U.S. students in grades 4, 8 and 12 performed at or above the “Proficient” achievement level in mathematics and science, where “Proficient” represents solid academic performance for each grade assessed. Perhaps even more alarming, more than one-third of U.S. students scored below the “Basic” level in these subjects, which means they lack mastery of the prerequisite knowledge and skills needed for “Proficient” at each grade. (p. 11)

Science education has long been a great concern in the United States and it has a long history of repeated reforms. Almost a hundred years ago reformers called for less attention in science programs to “fact and trivia” and more concern for problem-solving processes and applications of science to “real life.” August committees and national-level panels have called repeatedly for updating the science curriculum, more “hands-on” approaches, attention to our environment, emphasis on scientific literacy and the processes of science, and other reforms (Hurd, 1991).

About every two decades, a reform movement sparks the public interest and promotes changes in the science classroom and in how science is taught (Cheek, Briggs, & Yager, 1992). This sometimes causes an imbalance, where some aspects of the curriculum are emphasized while others are de-emphasized. The challenge has always
been to identify the appropriate balance among the various dimensions that would allow for students to excel in science (Cheek et al., 1992; NCMST, 2000).

**National Studies**

Many in the United States view American students' performance in science as unacceptable (Beaton, Mullis, Gonzalez, Kelly, & Smith, 1996; Mullis et al., 1997; NCES, 2000). Data from the National Assessment of Educational Progress (NAEP) indicated that there was no significant difference in the performance of fourth- and eighth-grade students. However, there was a significant decrease from eighth-grade to 12th grade in science scores between 1996 and 2000 based on the findings of the National Center for Education Statistics (NCES, 2000, 2001a).

It appears the longer students study science in American schools, the lower their score based on NAEP studies as noted by the NCMST (2000): “While U.S. students do, indeed, learn more each year they are in school, they are performing less well in twelfth grade than in the fourth and eight grades, compared to the standards of proficiency for those grade levels” (p. 11).

The teaching pool in science is considered to be very inadequate to meet the nation's current needs in science, in view of the fact that this subject is often taught by unqualified teachers (Darling-Hammond, 1999a; Goldhaber & Brewer, 1997; Mullis et al., 2001). Unless this achievement pattern is reversed, some argue that scientific creativity in the United States will atrophy and American innovations and technological advances will stall.
Many classes in these subjects are taught by unqualified and underqualified teachers. Our inability to attract and keep good teachers grows. As a result, newer, technologically oriented industries are having trouble finding enough qualified employees from among those teachers' students. Worse, creativity atrophies and innovation suffers. (NCMST, 2000, p. 11)

International Studies

Ten years ago President George Bush, Sr., and the nation's governors declared their intention to be first in the world in math and science by the year 2000. However, the Third International Mathematics and Science Study (TIMSS), which is a collaborative research project sponsored by the International Association for the Evaluation of Educational Achievement, has shown that the United States is far from that goal (Beaton et al., 1996; Philips, 2001; Schmidt, 2000).

Achievement in science continues to decline as time in school increases in American schools. Data from the TIMSS-1995 and TIMSS-1999 have shown that eighth-graders' performance in science can best be described as mediocre and disappointing (Martin & Kelly, 1996; Martin & Mullis, 1996; Mullis et al., 2001). Assessments in the fourth grade indicate that students in the United States do not begin school behind the children of the rest of the world, but they fall behind during their middle-school years. At fourth grade the United States is above the international mean in both math and science (Mullis et al., 1997; NCMST, 2000). The report from Michigan State University (MSU) indicated: "In science, we come close to the goals set by the nation's governors to be number 1 in mathematics and science by the year 2000. Yet in eighth grade our students are only mediocre" (TIMSS, 1997, par. 3). "U.S. students fall devastatingly far from this
goal by the time they finish high school” (NCMST, 2000, p. 10).

The United States ranks third in per-student spending among economically advanced countries, however, American students end up last or near the bottom by the end of secondary school (Paik, Wang, & Walberg, 2002).

Classic studies by Harold Stevenson of the University of Michigan and James Stigler of UCLA, showed that American schools did not fall behind because of the inferior ability of their students. American students equaled other students in first grade achievement but fell further behind with each succeeding year of school. (p. 69)

The data documenting student achievement in science and mathematics have created a situation some compare to that generated by the launching of Sputnik in 1957. However,

we did not duplicate or sustain that intensity, a lesson we have heard three times over from international assessments of science and mathematics achievement conducted since the 1960’s. Students’ grasp of science as a process of discovery, and mathematics as the language of scientific reasoning is often formulaic, fragile, or absent altogether. (NCMST, 2000, p. 10)

While “excellence” has been defined by the nation’s governors as being number one in the world in science when compared to other nations, “the unmistakable message is that our students’ performance relative to their peers in other countries—our competitors all—is disappointedly unchanged” (NCSMT, 2000, p. 10).

We are living in a global marketplace and, to remain competitive, American workers need to be the most skilled in the world. A great part of an individual’s knowledge and skill is determined by academic mastery in school. “First in the world” is not an empty slogan but it is the level of performance that American students would need in the future in order to maintain their competitive edge as a world class nation.
The United States Secretary of Education, Rod Paige, did not mince words when he delivered a stinging indictment of our science education program, and insisted that our nation can do better and every succeeding generation must be able to excel in science. Paige (2001) stated that

instead of improving our own science education, we have been relying on the education of other countries to provide their citizens. In 1999, the immigration and naturalization Service granted 115,000 H-1B visas to foreign workers. Last year to meet the demands of our high-tech industry, Congress increased that visa cap to 195,000 workers. There is nothing wrong with the H-1B program, but there is something wrong when American schools cannot produce enough good workers for valuable American jobs. There's something wrong when foreign workers are getting jobs in America because we fail to teach American graduates the skills.

(p. 1)

Criteria for Successful Science Program

The National Commission on Mathematics and Science Teaching for the 21st century established a number of criteria that are considered to be effective in science programs. These criteria lead to high-quality teaching and the evidence of high-quality teaching can be evaluated by achievement of students in national and international studies (NCMST, 2000). These criteria were derived from a number of national and international studies and are as follows:

1. science resources
2. acquisition of science skills by students
3. teaching methodologies
4. teachers' knowledge of subject being taught
5. coverage of content in science curriculum

6. students’ perception of the teaching and learning process.

Science Education in Christian Schools

Within the context of all the reforms and innovations in science education, little attention has been given to the idea of Christian schools being a model for quality programs in science.

The Catholic school system is the largest school system operated by a Christian denomination in the United States. Nicholas Wolsonovich, superintendent of the Chicago Catholic schools, indicated that science scores in the middle schools were above the national norms based on the TerraNova 11 test (Wolsonovich, 2002).

Wolsonovich (2002) noted:

Our students are learning and continually improving. There is growth at every level. An analysis of test scores for seventh grade students over a five-year period, following the same group of students, reveals that the longer pupils remain in the Archdiocesan system, the greater are their achievement results. (par. 6)

The Seventh-day Adventist Church operates the third largest denominational school system operated by a Christian denomination in the United States. The Seventh-day Adventist schools have maintained a large enrollment of over 83,000 students from kindergarten to university levels over the past 4 years based on statistics from the North American Division (NAD) of Seventh-day Adventists (NAD, n.d.). Results for students in the Seventh-day Adventist school system have shown similar trends to those of the Catholic school system. For the past 3 years between 2000 and 2002, students in this school system have been consistently performing above the national norms in science.
education on the Iowa Test of Basic Skills (ITBS), the standardized test used by this organization (NAD, n.d.).

Based on academic achievement in science, one could infer that the Seventh-day Adventist school system has a high-quality science education program. This could be inferred because the criteria recommended by NCMST are present.

At present no published studies have investigated the Seventh-day Adventist school system to see how it compares with the standards as identified by the National Commission on Mathematics and Science Teaching for the 21st century.

Since data show that science achievement in the United States declines during the middle-school years and onwards, this study focused on science education in the critical period of seventh and eighth grades in the Seventh-day Adventist school system.

**Purpose**

The purpose of this study was to investigate the status of the science program in a selected Union Conference of the Seventh-day Adventist school system. Specifically this study investigated the perceptions of teachers and students regarding the extent to which the science program meets the criteria of the National Commission on Mathematics and to what extent these criteria related to academic performance as indicated by ITBS science scores.

**Research Questions**

1. What are teachers' perceptions of practices in science education in a selected Union Conference of the Seventh-day Adventist school system?
2. What are students’ perceptions of the teaching and learning process in science education in a selected Union Conference of the Seventh-day Adventist school system?

3. As measured by the Iowa Test of Basic Skills, what is the science performance of students in a selected Union Conference of the Seventh-day Adventist school system?

4. What selected variables are related to science performance as measured by the Iowa Test of Basic Skills in a selected Union Conference of the Seventh-day Adventist school system?

Research Hypotheses

Several hypotheses were created to test each research question of this study. Question 1 generated five hypotheses for the question related to teachers’ perceptions of practices in science education in a selected Union Conference of the Seventh-day Adventist school system.

*Question 1: What are teachers’ perceptions of the practices in science education in a selected Union Conference of the Seventh-day Adventist school system?*

From this question the following hypotheses were generated:

Hypothesis 1. Among the three classroom configurations (multigrade, two-grade, and single-grade), there are significant differences in the following methodologies used by teachers: (a) hands-on approach, (b) concept attainment, (c) inquiry approach, (d) deductive reasoning, (e) learning cycle, (d) taba inductive, and (e) project-based learning in teaching science in the Seventh-day Adventist school system.

Hypothesis 2. Among the three classroom configurations, there are significant
differences in teachers’ perceptions of students’ ability to: (a) engage in systematic observation of the environment, (b) use of appropriate tools and techniques, (c) identify and clarify questions, and (d) engage in the scientific method in science education in the Seventh-day Adventist school system.

Hypothesis 3. Among the three classroom configurations, there are significant differences in the availability of science resources: (a) science laboratory, (b) movable laboratory table, (c) laboratory materials, (d) laboratory equipment, and (e) hands-on manuals for use by teachers in science education in the Seventh-day Adventist school system.

Hypothesis 4. Among the three classroom configurations, there are significant differences in teachers’ coverage of science domains: (a) earth and space science, (b) life science, (c) physical science, and (d) science and technology in science education in the Seventh-day Adventist school system.

Hypothesis 5. There are significant differences in the number of science credits completed by teachers among the three classroom configurations in the Seventh-day Adventist school system.

Question 2 generated three hypotheses for the question related to students’ perceptions of the teaching and learning process in science education in a selected Union Conference of the Seventh-day Adventist school system.

Question 2: What are students’ perceptions of the teaching and learning process in a selected Union Conference of the Seventh-day Adventist school system?

From this question the following hypotheses were generated:
Hypothesis 6. Among the three classroom configurations, there are significant differences in students' perceptions of students' factors in the teaching and learning process: (a) complete assignments, (b) encouraged by parents to succeed, (c) difficult to study at home, (d) read ahead in textbook, and (e) preparedness for test in science education in the Seventh-day Adventist school system.

Hypothesis 7. Among the three classroom configurations, there are significant differences in students' perceptions of teachers' factors in the teaching and learning process: (a) subject made interesting, (b) teacher availability, (c) teacher warm and approachable, (d) able to voice opinion in class, (e) fairness of teacher, and (f) trustworthiness in science education in the Seventh-day Adventist school system.

Hypothesis 8. Among the three classroom configurations, there are significant differences in students' perceptions of curriculum factors: (a) easy to concentrate in class, (b) textbook easy to understand, (c) amount of work given, (d) explanations given for corrected assignments, (e) content presented in an understandable manner, (f) examples given to explain difficult concepts, and (g) laboratory exercises given in science education in the Seventh-day Adventist school system.

Question 3 generated one hypothesis and sought to determine the performance of students in this selected Union Conference of the Seventh-day Adventist school system in science on the Iowa Test of Basic Skills.

*Question 3: As measured by the Iowa Test of Basic Skills, what is the performance of students in a selected Union Conference of the Seventh-day Adventist school system?*
From this question the following hypothesis was generated:

Hypothesis 9. Among the three classroom configurations, there are significant differences in students' science achievement on the ITBS in the Seventh-day Adventist school system.

Question 4 generated seven hypotheses that sought to determine the selected variables that are related to students' performance in science in this selected Union Conference of the Seventh-day Adventist school system.

Question 4: What selected variables are related to science performance as measured by the Iowa Test of Basic Skills in a selected Union Conference in the Seventh-day Adventist School system?

From this question the following hypotheses were generated:

Hypothesis 10. There are linear relationships between students' achievement as measured by their ITBS science scores (dependent variable) and the five independent variables of students' factors: (a) complete assignment, (b) encouraged by parents to succeed, (c) difficult to study at home, (d) read ahead in textbook, and (e) preparedness for test in the Seventh-day Adventist school system.

Hypothesis 11. There are linear relationships between students' achievement as measured by their ITBS science scores and the six independent variables of teachers' factors: (a) subject made interesting, (b) teacher availability, (c) teacher warm and approachable, (d) able to voice opinion in class, (e) fairness of teacher, and (f) trustworthiness in the Seventh-day Adventist school system.

Hypothesis 12. There are linear relationships between students' achievement as
measured by their ITBS science scores and the seven independent variables of curriculum factors: (a) easy to concentrate in class, (b) textbook easy to understand, (c) amount of work given, (d) explanation given for corrected assignment, (e) content presented in an understandable manner, (f) examples given to explain difficult questions, and (g) laboratory exercises given in the Seventh-day Adventist school system.

Hypothesis 13. There are linear relationships between the performance of schools as measured by their ITBS science scores and the seven independent variables in science methodologies: (a) hands-on approach, (b) concept attainment, (c) inquiry approach, (d) deductive reasoning, (c) learning cycle, (d) taba inductive, and (e) project-based learning in the Seventh-day Adventist school system.

Hypothesis 14. There are linear relationships between the performance of schools as measured by their ITBS science scores and the four independent variables of science skills acquired by students: (a) engaging in systematic observation of the environment, (b) using appropriate tool and techniques, (c) identifying and clarifying questions, and (d) engaging in the scientific method in the Seventh-day Adventist school system.

Hypothesis 15. There are linear relationships between the performance of schools as measured by their ITBS science scores and the five independent variables of science resources: (a) science laboratory, (b) movable laboratory table, (c) laboratory materials, (d) laboratory equipment, and (e) hands-on manuals in the Seventh-day Adventist school system.

Hypothesis 16. There are linear relationships between the performance of schools as measured by their ITBS science scores and the four independent variables of teachers'
coverage of science domains: (a) earth and space science, (b) life science, (c) physical science, and (d) science and technology in the Seventh-day Adventist school system.

Conceptual Framework

National and international studies in science education have helped to identify the characteristics of high-quality science programs. Experts believe that programs with these characteristics will help American students reach the goals set for them by the nation. One way to evaluate the effectiveness of high-quality science programs is through the performance and achievement of students who receive it. Programs can be evaluated by the criteria for effective science programs as defined by the National Commission on Mathematics and Science Teaching for the 21st century (NCMST, 2000).

The criteria as defined by the National Commission on Mathematics and Science Teaching for the 21st century include: (a) adequate science resources to afford students the opportunity to carry out experiments, (b) acquisition of scientific skills, (c) variety of teaching methodologies to enhance thinking, (d) teachers having a deep knowledge of subject matter being taught, (e) coverage of content important for creating high standards in students' learning, and (f) students' perceptions of the teaching and learning process.

In looking at the criteria above one realizes that there are four parts to this framework, namely: (a) students' perceptions, (b) teaching practices, (c) content, and (d) science resources. The essence of a good science program then is that of implementing teaching behavior which is congruent with objectives to be mastered (content) and students' interactions with science resources. It therefore means that there
must be a matching of students' learning behaviors, content mastery, teaching techniques, and science resources for the goal of completion (Hanson, 1989; Hanson & Silver, 1978). Silver, Hanson, Strong, and Schwartz (1996) noted:

The teaching/learning act may be defined as a series of scenes or episodes taking place over time in an environment which involves an interrelationship between teacher behavior, learner behavior, and the content to be mastered. The role of the teacher in this triangular relationship is that of decision-maker. (p. 12)

The role of the teacher is quite pivotal in this process because he or she makes the ultimate decision in terms of what the students will learn and how they are going to accomplish this learning based on the availability of science resources.

Criteria "b," "c," and "d" are connected to the choices teachers make in regard to how and what students learn. In looking at criterion "b," the emphasis teachers place on scientific skills and experiments, it was found that higher science achievement is related to increased teacher emphasis on acquisition of scientific skills and experiments (Mullis et al., 2001; NCES, 2000). The American Association for the Advancement of Science (AAAS, 1989, 1991) and the National Research Council (NRC, 1996, 1999) underscored the importance of scientific inquiry through systematic observation, using the appropriate tools and techniques to gather, analyze, and interpret scientific data. Ebenezer and Connor (1998) mentioned the need to engage in the scientific method through basic skills like observing, classifying, measuring, inferring, predicting, hypothesizing, interpreting, and investigating.

In regard to criterion "c," instructional methodologies, intellectual and communicative processes are vital for constructing and negotiating science knowledge,
seeing they create opportunities for critical thinking (Ebenezer & Connor, 1998). Joyce and Weil (1996, 2000) have also indicated the importance of methods such as concept attainment, Taba inductive, inquiry, and deductive reasoning so that students can develop thinking. “A variety of models can increase students’ ability to seek and master information, organize it, build and test hypotheses, and to apply what they are learning” (Joyce & Weil, 1996, p. viii). A number of studies (AAAS, 1993; Arends, 1994; Gibbons, 1992; Linn, 1998; Osborne & Freyberg, 1986; Rutherford & Ahlgren, 1989) indicated that students need methods that would allow them to think and be able to develop an understanding of science. In addition to the other methods mentioned before, Krajcik, Czernik, and Berger (1999) promoted a project-based approach, while Ebenezer and Connor (1998) emphasized the learning cycle. Two studies (Mullis et al., 2001; Netherlands Antilles, 2002) have shown that students who have been exposed to methods that cause them to think, perform significantly better than other students who used only the hands-on approach for learning science.

Criterion “d” addresses the importance of teachers having the knowledge of subject matter they are supposed to be teaching and students’ achievement in science. Recent studies (Goldhaber & Brewer, 1997; Mullis et al., 2001; NCES, 2000) have shown that higher achievement in science is directly associated with teachers holding bachelor’s or master’s degree in science. It was also found that 56% of students in the United States were taught by teachers who had a general education and these students performed significantly lower than other students who were taught by teachers with degrees in science areas such as biology, chemistry, and physics (Mullis et al., 2001).
Criterion “a” is related to science resources and includes materials, equipment, and laboratory facilities needed to have a successful science program. Data from TIMSS-1999 showed that students who attended schools that were well resourced had higher science achievement (TIMSS, 2001).

Among the Benchmarking participants, three-fourths or more of the students in the Academy School District, the First in the World Consortium, and Naperville were in schools where the capacity to provide science instruction was largely unaffected by shortages or inadequacies in instructional materials . . . and audio-visual resources. (Mullis et al., 2001, p. 10)

This also held true in the Netherlands Antilles where there was a direct correlation between availability of science resources and students’ performance in standardized tests (Netherlands Antilles, 2002).

According to the framework for NAEP in 1996 and 2000, the science content tested is represented as a two dimensional matrix where one dimension is the field of science and includes earth, physical (including chemistry and physics), and life sciences. The second dimension is elements of knowing and doing science and includes conceptual understanding, scientific investigation, and practical reasoning (NCES, 2000).

For the TIMSS-1999 study, investigators added environmental issues, nature of science, and use of technologies in science in test items in addition to the two dimensional matrix (Smith, Martin, Mullis, & Kelly, 2000). Other researchers (Mullis et al., 1997; Mullis et al., 2001) indicated that the content areas and performance expectations are noted as elements of knowing and doing science. Data from NAEP 1996, 2000 showed that schools that placed such emphasis on their science program did significantly better than those schools that did not (NCES, 2001a).
Students’ perceptions of the teaching and learning process play an important role in regard to how well students stay on task and accomplish all the necessary standards as required for them to do well in science educations. The teaching and learning process includes factors that are related to the students, namely: (a) student motivation, (b) parental support, and (c) safety concerns; and teachers’ quality in terms of instructional effectiveness and curriculum: (a) content and (b) availability and appropriateness of resources (NCES, 2001a; TIMSS, 2001).

Mayer, Mullens, and Moore (2000) have indicated that a safe and orderly atmosphere conducive to learning is crucial to learning and achievement, and schools with a more conducive environment perform better than schools with a less conducive learning situation. Violence in schools and the neighborhood affect students negatively because students become overly concerned with their safety, thus leading to a decrease in the academic time on task (NCES, 2001a).

Educational systems must take into consideration these factors, so that students can have the needed learning experiences to succeed in science and eventually do well in this subject. School systems need a framework that establishes what students should know and be able to do, provide a coherent direction for improving the quality of instruction. Teacher preparation, instructional materials, and other aspects of the system are then aligned to reflect the content of the frameworks in an integrated way to reinforce and sustain high-quality teaching and learning in schools and classroom. (TIMSS, 2001, p. 4)
Significance of the Study

This study is significant because educators need data to inform their judgements as to how well the science program in this school system compares to the criteria of high-quality science education as established by NCMST. These data will assist administrators and science educators develop strategic plans to change current practices or make improvements.

Results of this study will inform administrators, science educators and curriculum planners as they design appropriate staff development to meet the current needs of the school system. Results from this study will assist teacher preparations institutions in the North American Division refine their curriculum to include science courses that will help elementary education majors meet the needs of science education in the middle grades.

Definition of Terms

The following terms are defined as used in this study:

Achievement test: Iowa Test of Basic Skills (ITBS).

Conference: Governing unit of the Seventh-day Adventist Church, typically consisting of all churches and church-operated institutions in a relatively small region such as a state or a combination of two or more states.

Content: Specific areas of the science curricula for seventh and eighth grades, namely: (a) earth and space, (b) life science, (c) physical science, and (d) science and technology.

Methodologies: Teaching strategies that are noted for increasing science
achievement in students: (a) hands-on approach, (b) concept attainment, (c) inquiry approach, (d) Taba inductive, (e) project-based learning, (f) learning cycle, and (g) deductive reasoning.

**Multi-grade:** Classroom configuration where there are one to three teachers per school, with each teacher responsible for more than two grades.

**Science practices:** Criteria considered important for an outstanding science program based on the NCMST, namely: (a) adequate science resources to afford students the opportunity to carry out experiments, (b) acquisition of scientific skills, (c) variety of teaching methodologies to enhance thinking, (d) teachers having a deep knowledge of subject matter being taught, (e) coverage of content important for creating high standards in students' learning, and (f) students' perceptions of the teaching and learning process.

**Science resources:** Science facilities such as laboratory and/or movable laboratory table and laboratory equipment and materials.

**Scientific skills:** Inquiry skills that are needed for carrying out the experiments based on science curriculum: (a) systematic observation of environment, (b) using appropriate tools and techniques to gather and interpret scientific data, (c) use of identifying and clarifying questions, and (d) engaging in the scientific method.

**Single-grade:** Classroom configuration where seventh and eighth grades are taught by separate teacher per grade.

**Teaching and learning process:** All the instructional factors identified in this study that affect learning, namely: factors under the control of students (student factors), factors under the control of teachers (teachers' factors), and the curriculum that includes
content and science resources.

Two-grade: Classroom configuration where seventh and eighth grades are taught together by a single teacher.

Union Conference: Governing unit of the Seventh-day Adventist Church, which consists of a “union” of several adjacent Conferences to promote the welfare of the Church in the region covered by all member Conferences.

Delimitations of the Study

This study considered only the criteria as established by the NCMST as being the most important practices for any successful science program.

The study examined teachers’ perceptions in regard to the criteria of NCMST, including: (a) adequate science resources to afford students the opportunity to carry out experiments, (b) acquisition of scientific skills, (c) variety of teaching methodologies to enhance thinking, (d) teachers having a deep knowledge of subject matter being taught, and (e) coverage of content important for creating high standards in students’ learning.

The study looked at students’ perceptions of the teaching and learning process, namely: (a) students’ motivation and parental support, (b) teachers’ quality in terms of instructional effectiveness, and (c) the curriculum that includes content and the availability and appropriateness of resources.

This study examined science education in the middle-school grades, namely: seventh and eighth grades within one randomly selected Union Conference in the North American Division of Seventh-day Adventists.
It examined the science practices in the three classroom configurations found in the Adventist system of education: (a) multigrade where a teacher is teaching more than two grades (sixth, seventh, and eighth grades), (b) two-grade where a teacher teaches two grades maximum (namely seventh and eighth grades), and (c) single-grade where a teacher teaches either grade seven or grade eight.

Limitations of Study

This study was conducted in one Union Conference of Seventh-day Adventists. Any generalization made as a result of this study must be done in terms of the different classroom configurations represented in this study.

Organization of the Study

Chapter 1 of this study gives an introduction to the study and includes the focus and background information regarding the problem under investigation, namely, how the Seventh-day Adventist school system compares to the criteria established by NCMST.

This chapter also includes a summary of literature related to the problem under study and a conceptual framework is presented as a rationale for pursuing this study. It also addresses the delimitations and limitations of the study, where the scope of the study is outlined.

Chapter 2 of this study seeks to present appropriate literature that addresses the issues under consideration in this study. The review of literature explains theories, presents models, and presents significant research data published in the area of science education. The literature review section also looks at the historical overview of science education.
education and explains current trends related to the study.

Chapter 3 describes the sampling process, population frame, and the procedures used for developing the instruments used in this study. This methodology chapter also describes how data were collected and analyzed, thus allowing for inferences and conclusions to be made from the study.

Chapter 4 presents the results of the study based on descriptive and inferential statistical analysis. Descriptive statistics are primarily in the form of cross-tabulations. Inferential statistics are presented in the form of analysis of variance and multiple regression.

Chapter 5 seeks to integrate the results of the study with existing theory and research. This chapter gives an overview of the significant findings and considers these findings in light of existing research. This chapter presents conclusions, recommendations for practice, and recommendations for research.
CHAPTER 2

LITERATURE REVIEW

Overview of Science Education in the United States

This chapter gives a brief history of science education from its beginnings in 1860 to the second revolution that began in the 1980s to the present time, and provides current findings on science education. It examines the various psychological underpinnings related to science education and presents the Christian approach to teaching science, as well as practices conducive to science achievement. Finally it compares practices in science education between public school systems and the Seventh-day Adventist school system based on the criteria of the National Commission on Mathematics and Science Teaching (NCMST) for the 21st century.

Library research databases such as (a) EBSCO host and (b) ERIC were used. Procedures such as keywords, basic search, advanced search, publications, and subject were used using the two databases mentioned before. Keywords such as: “science achievement in middle schools,” “history of science education,” “science achievement in Christian schools,” and “science methodologies” used in the database results were examined against the research questions.

Internet search engines such as Infoseek, Google, and Refdesk were also used,
typing in keywords, phrase, or subject to get additional information regarding studies in
science education in the middle school.

**The Early Beginnings of Science Education: 1860-1920**

The era of Big Science was still in the future if one takes into consideration the early beginnings, 1860-1920. Science itself was not well established, neither was it well funded, hence little or no pressure was placed on educators to have science taught in schools. Memorization and emphasis on the three Rs was what was of most worth, based on the idealistic school of thought (Cheek et al., 1992).

The Swiss educator Pestalozzi introduced “Object Lessons” where emphasis was placed on careful observation of objects, and to some extent, on asking questions and making inferences about these objects. The actual objects were brought into the classroom for students to study and observe. This formed the basis on which our current emphasis on scientific processes and higher-order thinking eventually evolved.

Bailey, a professor of biology at Cornell University during this early period, emphasized awareness, appreciation, and conservation of nature so successfully that classical nature study became the basic science program in the United States from 1890 to 1910.

Cheek et al. (1992) indicated that though little attention was given to anything recognizable as the scientific method, students were encouraged to use their five senses, to think and come to conclusions, rather than memorizing large body of facts.

“Historically, however, it had no influence on later decisions to emphasize these aspects
of science” (Cheek et al., 1992, pp. 16-17).

As early as 1893, the beginning of a conflict in philosophy of secondary science education was already apparent. Universities viewed high schools as important institutions for preparing students academically to enter universities. A more egalitarian group viewed college-preparatory-type science courses as too specialized and not appropriate for the majority of students who would not go on to college. (McCormack, 1996, p. 17)

These events of roughly a century ago might seem distant and irrelevant to today's "high-tech" schools, but they illustrate that many of today's trends reflect the same unresolved science education issues (DeBoer, 1991).

It is hard to believe that we are still fighting the method of lecture as a primary instructional tool for our middle- and high-school science classrooms. “We are still fighting the battle begun with object teaching and the Nature-Study Movement (NSM), believing that hands-on experiences with real materials are superior to memorization and recitation of facts for science lessons” (Cheek et al., 1992, p. 17).

**Utilitarian/Textbook Period: 1920-1957**

The Utilitarian/Textbook Period was the second epoch which began in 1920 and ended in 1957. This period was characterized as one of prodigious economic and political growth driven by war, a major depression, and rapid technological advances. At the elementary level, the science curriculum developed into a “read about science” program organized by commercially prepared textbooks (Cheek et al., 1992). Gerald Craig, while at Horace Mann Laboratory School at Columbia University, was instrumental in designing a program where attention was given to the thinking processes that are involved in establishing and clarifying scientific knowledge.
Cheek et al. (1992) noted that Craig developed a scope-and-sequence curriculum designed to provide coverage of all major disciplines of scientific knowledge in a comprehensive, simple-to-complex organization. Yet the byword of the times was industrial efficiency, and it was believed that reading about science was the quickest, most efficient means to cover organized scientific information; thus discovery through hands-on learning was largely ignored. At the same time, the over-evaluation of the industrial-production model and the emphasis on the practical, everyday uses of science led to a distorted view of science that was considered far removed from the view of science held by practicing scientists. (p. 17)

Unfortunately memorization of names and facts got back into the science program and was now the primary goal for science teaching. Curricula at every level became fossilized, thus it was no surprise when only few students chose science as a career.

**First Revolution in Science Education: 1957-1978**

The first revolution in science education from 1957 to 1978 was ushered in by the unthinkable: the Russians launched Sputnik and the “best in the world” complacency of American science education was brought into serious question and Americans were spellbound. Needless to say, finger pointing and the blame game started again.

According to Collette and Chiappetta (1989), “the science groups found that school science courses and textbooks lacked rigor, were dogmatically taught, were content-oriented, lacked conceptual unity, were outdated, and had little bearing on what was really happening in the scientific disciplines” (p. 41).

In view of this state of affairs, the National Science Foundation (NSF) was established and millions of dollars were channeled into curriculum development and teacher training for about 15 years. There were three programs developed for the
Elementary Level, namely:

1. Elementary Science Study (ESS) consisted of 56 independent units where free exploration was encouraged, with little guidance by teachers in earth, life and physical science (ESS, 1970).

   Cheek et al. (1992) noted,

   ESS is characterized by low structure and maximum flexibility. Students are cast in the role of questioners and investigators of nature, while teachers are viewed as guides to learning rather than disseminators of information. Students are encouraged to play around with science, and cast off in directions tangential to unit topics, as their individual interests lead them. (p. 19)

2. Science—A Process Approach (SAPA) was focused and organized around the processes of science, and the concepts of science were introduced only as they related to the scientific processes applicable to the investigation.

   SAPA is organized around a highly structured hierarchy of behavioral objectives, each other of which fits into the development of a scientific process. Of all the elementary science programs of this era, SAPA was the most complicated, the most difficult to train teachers for, and required the largest number and most specialized of learning kits. (Cheek et al., 1992, p. 19)

3. Science Curriculum Improvement Study (SCIS) was a balanced program that made use of the rigid hierarchy of SAPA and the open system of ESS to develop scientific literacy. This program took into consideration concepts found in the learning cycle. Renner and Marek (1988) indicated this program can help students to show how each new discovery they come up with fits into an ever-expanding pattern of generalization. During this period emphasis was placed on the practical approach to teaching science utilizing the discovery teaching method (Cheek et al., 1992). Important changes during this period are summarized in Table 1.
Table 1

Changes From Early Beginning to First Science Revolution

<table>
<thead>
<tr>
<th>FROM</th>
<th>TO</th>
</tr>
</thead>
<tbody>
<tr>
<td>The textbook as the authoritative source of information</td>
<td>Laboratory data as a primary source of knowledge</td>
</tr>
<tr>
<td>Everyday technology is presented as science</td>
<td>“Pure” science is emphasized</td>
</tr>
<tr>
<td>Many science topics studied briefly</td>
<td>In-depth studies of fewer topics</td>
</tr>
<tr>
<td>Laboratory activities used to verify concepts in textbook</td>
<td>Laboratory activities used to collect data from which concepts are derived</td>
</tr>
<tr>
<td>Deductive thinking is emphasized to arrive at correct answers</td>
<td>Inductive thinking is stressed in arriving at reasonable tentative answers</td>
</tr>
<tr>
<td>Rote and receptive learning</td>
<td>Discovery and inquiry learning</td>
</tr>
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</table>

Second Revolution in Science Education: 1980-Present

The second revolution in science education evolved from a reaction to the first revolution and covered the period 1980 to the present. Critics identified problems and holes in the programs from the first revolution, namely:

1. Courses were found to be difficult for teachers to teach (could not implement program as designed to be implemented, large classes, and inadequate materials).

2. Courses appealed only to small number of students due to the courses’ overly discipline-centered content.

3. Real-world applications were excluded for theory and pure science.

4. Social, historical, and humanistic dimensions of science were perceived to be
lacking.

5. Instructional methods as inquiry and discovery were foreign to teaching and quite time-consuming, as well as difficult for students.

6. Standardized tests were not constructed based on the new program but on the classical approach to teaching science (Cheek et al., 1992; Helgeson, Blosser, & Howe, 1977; Stake & Easley, 1978; Weiss, 1987).

Despite all the advances and various approaches to teaching science, it was still evident that students were not performing well on national assessment of science, and students were still turned off from science and not selecting science as a vocation (Helgeson et al., 1977; Hurd, 1969; Weiss, 1987).

Stake and Easley (1978) conducted a nationwide study of science education and found that students still spent most of their time listening to lectures, completing worksheets, and doing verification-type laboratory exercises. The extent and use of the inquiry approach that was thought to be one of the best ways of teaching science was barely visible in science classrooms.

Not much has changed in the manner students are receiving instruction in science, and 20 years after, the National Commission on Excellence in Education still handed down a startling thumbs-down of science education in the United States. The National Science Foundation was then charged with preparing science programs with the necessary tools based on sound research to help reverse the dismal situation in science education (Cheek et al., 1992).

The Foundation provided the rationale for moving away from the pure discipline
approach to a merger with technology and societal implications of science, thus the movement Science, Technology and Society (STS) came into existence. Harms and Yager (1982) indicated that this approach encouraged students to investigate local and national issues and come up with solutions to solve these issues. It was believed that this approach would definitely be the key to improving science performance.

Studies (Bybee, 1985; Bybee, Carlson, & McCormack, 1984; Cheek et al., 1992; Ebenezer & Conner, 1998; Gabel, 2003; Linn, 1997) have indicated that STS continues to be a major thrust for instruction in science education. Gabel (2003) noted, “Students learn to analyze data and test hypotheses, use their creativity, and develop positive attitudes towards science” (p. 71). STS is an approach that allows students to explore other science courses and make them more likely to continue in this field (Cheek, 1992; McCormack, 1981, 1990; McDermott, 1984; Yager, 1987, 1996; Yager & Penick, 1986; Yager & Yager, 1985).

In the 1990s another initiative known as Project 2061 was sponsored and introduced by the American Association for the Advancement of Science (AAAS, 1989). A unique curriculum, Project 2061 is organized around three phases:

1. Phase 1: attempts to spell out the knowledge, skills, and attitudes for science programs

2. Phase 2: development of several curriculum with teachers and scientists working together to produce the most appropriately sound curriculum


Another reform was also produced by the National Association of Science
Teachers called the Project on Scope, Sequence and Coordination (SS&C), which promoted linkage and integration within and among the sciences so that students become aware of the interdependency of sciences and their place in human experiences. This project was designed as an answer to current research findings that indicated a majority of students in U.S. schools lacked basic understanding in science, technology, and mathematics (Aldridge, 1992).

The traditional view of science throughout recorded history focused on the knowledge of the universe, until 35 years ago when the focus was placed on important science processes and skills in developing new knowledge. Despite all these notable changes, students were still performing poorly in science, therefore, science processes and content were not the answer (Cheek et al., 1992).

Science education is more than skills and content, hence McCormack and Yager (1989) broadened the two domains into five domains considered vital to any good science program, which are outlined below:

**Domain I:** Knowing and Understanding (knowledge domain) where science seeks to categorize the observable universe into small unit, for example, matter, energy and plant behavior, and to describe physical and biological relationship. Students need to know facts, concepts, societal and science issues, principles or laws, existing hypotheses, and theories used by scientists. Students can therefore acquire reasonable explanations for observed relationships.

**Domain II:** Exploring and Discovering (process of science domain) where students learn how scientists think and work by using processes such as observing and
describing, organizing, charting, interpreting, constructing, and predicting.

Domain III: Imagining and Creating (creativity domain) where students’ imaginative and creative thinking are utilized to help them better understand some given body of knowledge. Human abilities noted to be valuable are: visualizing, combining objects and ideas in new ways, producing unusual uses for objects, solving problems, fantasizing, pretending, and producing unusual ideas. It is apparent that much of this domain is not incorporated into science programs, thus the creative abilities of students are suppressed or not developed.

Domain IV: Feeling and Valuing (attitudinal domain) where human feelings, decision-making skills, and value need to be brought to the forefront. Students become aware of their personal attitudes and those of classmates as they work in cooperative groups and come to consensus through the decision-making process. This domain includes but is not limited to: developing positive attitudes towards science teachers, science in school, and science in general, developing the “I can do it” attitude, exploring human emotions, expressing personal feelings in a constructive way, and making decisions about personal values.

Domain V: Using and Applying (application and connections domain) where students are sensitized to experiences in the natural world through the experiences they learned in science classes. Some characteristics of this domain include: seeing instances of scientific concepts in everyday life experiences, applying learned science concepts and skills to everyday technological problems, and making decisions relevant to health issues in one’s personal lifestyle based on scientific facts rather than myths or emotions.
McCormack and Yager (1989) noted, “Five domains of science education which are all important as we work toward helping all students attain a scientific literacy needed for living in our current society—and one needed if we are to resolve current problems thereby producing a better future” (pp. 47-48).

Criteria for High-Quality Science Programs

In order for students in the U.S. to perform at or above the proficient level in science as measured by the National Assessment of Educational Progress at the national level and at the international level by the Third International Mathematics and Science Studies, science programs must possess the criteria established by NCMST (2000). These criteria have been suggested as the means to produce high-quality science programs that cause students to perform at or above the proficient level and to be first in the world in science (AAAS, 1993; Schmidt, 2000; Singh, Granville, & Dika, 2002). The criteria for high-quality science are as follows: (a) science resources, (b) acquisition of science skills by students, (c) teaching methodologies, (d) teachers’ knowledge of subject being taught, (e) coverage of content in science curriculum, and (e) students’ perception of the teaching and learning process.

In regard to science resources, data from the NAEP 1996 and 2000 and TIMSS-1999 have indicated that students who attended schools that are well-resourced had higher science achievement than those schools that lacked such resources (Burkam, Lee, & Smerdon, 1997; Freedman, 1997; Mullis et al., 2001; NCES, 2001b; Smith et al., 2000). Schools such as Naperville, First in the World, and Academy School District were largely
unaffected by shortages or inadequacies in science resources performed above the international average and ranked among the top countries in science achievement (Mayer et al., 2000).

Science Resources included the following: (a) laboratory building to conduct science investigations, (b) laboratory equipment, (c) laboratory materials including chemical supplies, and (d) hands-on manuals that provide a number of experiments and demonstrations for teachers to use to assist students in understanding the concepts in science (AAAS, 1989; Linn, 1997; Lunnenburg & Orstein, 1996; Mayer et al., 2000; McCauley, 1995; McCormack & Yager, 1989; NRC, 1996; NSTA, 1991).

A number of studies (AAAS, 1989; NCES, 2001b; NRC, 1996; Smith et al., 2000; TIMSS, 1995) have echoed the importance of students being able to better understand science by being engaged in a number of science skills. It was found that students who were exposed to a greater degree of science skills performed better on tests that evaluated such skills as National Assessment of Educational Progress science test. Science skills considered important for students to know are as follows: (a) systematic observation of the environment, (b) using appropriate tools and techniques to gather, analyze, and interpret scientific data, (c) engaging in the scientific method in carrying out science investigations, and (d) use of clarifying and identifying questions to plan and design experiments to test hypotheses (AAAS, 1989; Ebenezer & Connor, 1998; Mullis et al., 2001; NRC, 1996; Von Secker, 2002).

In the use of instructional methodologies in science education, one needs to realize that the intellectual and communicative processes are vital for constructing and
negotiating science knowledge, seeing they create opportunities for critical thinking (Ebenezer & Connor, 1998; Glasson, 1989; Stohr-Hunt, 1996). Joyce and Weil (1996, 2000), Olson & Astington (1993), and Orlich, Harder, Callahan, and Gibson (1998) have also indicated the importance of methods such as concept attainment, Taba inductive, inquiry, and deductive reasoning so that students can develop thinking. "A variety of models can increase students' ability to seek and master information, organize it, build and test hypotheses, and to apply what they are learning" (Joyce & Weil, 1996, p. viii). A number of studies (AAAS, 1993; Anderson, 1997; Ertepinar & Geban, 1996; Linn, 1998; Osborne & Freyberg, 1986; Rutherford & Ahlgren, 1989) indicated that students need methods that would allow them to think and be able to develop an understanding of science. In addition to the other methods mentioned before, Krajcik et al. (1999) promoted the project-based approach, while Ebenezer and Connor (1998) emphasized the learning cycle. Two studies (Mullis et al., 2001; Netherlands Antilles, 2002; Von Glaserfeld, 1984) have shown that students who have been exposed to methods that cause them to think, perform significantly better than other students who used only the hands-on approach for learning science.

The importance of teachers having the knowledge of subject matter they are supposed to be teaching is directly related to students' achievement in science. Recent studies (Goldhaber & Brewer, 1997; Ingersoll, 2000; Martin & Kelly, 1996; NCES, 2001a; NRC, 2000; Stigler & Hiebert, 1999) have shown that higher achievement in science is directly associated with teachers holding a bachelor's or master's degree in science. It was also found that 56% of students in the United States were taught by
teachers who had a general education, and these students performed significantly lower than other students who were taught by teachers with degrees in science areas such as biology, chemistry, and physics (Madigan, 1997; Mullis et al., 2001). Teachers with majors in chemistry or physics were rare in the U.S. and only a few schools such as Academy School District, Naperville, and Project Smart had more than 30% of eighth-graders taught by such teachers (Mayer et al., 2000; Mullis et al., 2001).

According to the framework for NAEP 1996 and 2000, the science content tested is represented as a two-dimensional matrix where one dimension is the field of science and includes earth, physical (including chemistry and physics), and life sciences. The second dimension is elements of knowing and doing science and includes conceptual understanding, scientific investigation, and practical reasoning (NCES, 2001a).

Researchers added environmental issues, nature of science, and use of technologies in science in test items in addition to the two-dimensional matrix to the TIMSS-1999 (Smith et al., 2000; TIMSS, 2001). Other researchers (Beaton et al., 1996; Mullis et al., 1997) indicated that the content areas and performance expectations are noted as elements of knowing and doing science. Data from NAEP 1996 and 2000 showed that schools that placed such emphasis on their science program did significantly better than those schools that did not (NCES, 2001a).

The objectives that students need to know in the four content areas are explained and spelled out in curriculum framework and guides. Teachers can also draw upon the compendium of standards and benchmarks for science education from a number of sources to ensure they are addressing the content knowledge (Kendall & Marzano, 1996;
Paik, 2003; Riechard, 1994; Roth, 1995; Rozycki, 2003). These standards measure up very well with tests nationally (NAEP) and internationally (TIMSS), since they are taken into consideration when such tests are developed.

Students' perceptions of the teaching and learning process play an important role in regard to how well students stay on task and accomplish all the necessary standards as required for them to do well in science education. The teaching and learning act is considered an interrelation of the teacher's and learner's behaviors and the content to be mastered (Bruner, 1968, 1977; Kemp, Morrison, & Ross, 1998; Silver et al., 1996). In examining the teaching and learning process in science education, one would need to address how students perceive teachers' behaviors in teaching science, curriculum-related factors that affect science instruction, and students' behaviors towards science instruction to get a complete understanding of science education. It was noted that when students have positive attitudes and perceptions towards science education, their performance in science achievement increases (Fraser, Walberg, Welch, & Hattie, 1987; Hilton & Lee, 1988; Kagan, 1994; NCES, 2001a; Singh et al., 2002). Skaalvik and Rankin (1995) found that positive attitudes of students towards science education are correlated with achievement and academic performance. Banks, McQuater, and Hubbard (1978) found that when students are motivated they are more engaged in academic tasks and their performance in science increases.

Students' behaviors that have been noted to measure students' attitudes towards science education are as follows: (a) completion of assignments, (b) encouraged by parents to succeed, (c) home environment conducive to studying, (d) being prepared by
reading ahead, and (e) preparing for a major test way in advance of the test (Fortier, Valierand, & Guay, 1995; Good, 1983; Goodlad, 1998; Grolnick, Ryan, & Deci, 1991; NCES, 2001a; Reynolds & Walberg, 1992; Rudner, 1999; Saskatchewan Educational Assessment, 1993; Trachtman, 1975)

Teachers' behaviors that have been noted to affect students' attitudes towards science education are as follows: (a) teacher making subject interesting, (b) students having trust in their teacher, (c) students believing they are being graded fairly by their teachers, (d) students perceiving teachers as being warm and approachable, (e) students being able to voice their opinion in class, and (f) teachers available to assist students outside of classroom (Hanson, 1989; Helmke, 1989; Hidi, 1990; Reynolds, 1991; Saskatchewan Educational Assessment, 1993; Schiefele & Csikszentmihalyi, 1995; Snowman & Biehler, 2003).

The following curriculum factors or academic tasks have been noted to affect students' perceptions towards science education: (a) examples given to explain difficult science concepts, (b) explanations given for incorrect answers when assignments are corrected by teachers, (c) amount of work given that students can handle, (d) laboratory exercises given to further explore science, (e) textbook easy to understand, (f) students able to concentrate in class, and (g) content presented in an understandable manner to students (Dweck, 1986; Pintrich & DeGroot, 1990; Ryan, Connell, & Deci, 1985; Saskatchewan, 1993; Schiefele, 1991; Singh et al., 2002; Trachtman, 1975; Von Secker & Lissitz, 1999; Wong & Csikszentmihalyi, 1991).

Variables such as curriculum and teachers' behaviors are amenable to change, and
the sooner that schools recognize this, they can then provide students with positive academic engagement that would allow them to develop positive attitudes towards science education. Once students have positive attitudes towards their teachers and their academic tasks, they can become motivated to spend more time on this subject, thus leading to greater achievement in science (Mason & Kahle, 1989; Newman, Wehlage, & Lamborn, 1992).

**Science Performance in National and International Studies**

One could expect students in the United States to be number one in the world in science achievement with all the curricular changes and innovations in science education that have taken place over time. However, it appears that there are still challenges in science education, where the National Commission on Excellence in Education still handed down a thumbs-down to science education. The Business Coalition for Education Reform (BCER) has also painted a dismal picture of the effectiveness of science education, as is evident in students' performance in national and international studies (BCER, n.d.).

Results from the national study NAEP 1996, showed that for fourth grade, the "Below Basic" was 33%; in eighth grade it was 39% and by 12th grade it was 43%. One can get a more in-depth view of the situation by looking at Figure 1, where students' achievement is reported in four categories, namely: "Below Basic," "Basic," "Proficient," and "Advanced" (NCES, 2001b).

Results from NAEP 2000 indicated that there was no significant difference in
results for Grades 4 and 8 when compared to NAEP’s report in 1996, where in the fourth grade, the “Below Basic” was 34% in 2000 and in 1996 it was 33%; in eighth grade it was 39% (NCES, 2000). Thirty percent of fourth-graders were performing at the proficient or advanced level proficiencies, while 32% of eighth-graders were performing at the proficient or advanced proficiencies. However, 12th-graders achieved only 18% proficiencies for proficient and advanced levels. It is apparent from these results that students begin the downward slide after eighth grade. See Figure 2, for detailed results.

There was significant difference in the results of 1996 and 2000 studies for Grade 12 students. In the 1996 results, 22% of students performed at the proficient or advanced level, while in 2000 the figure dropped significantly to 18%. See Figure 3 for a comparative look at results for 12th grade (NCES, 2001b). The 12th-grade science
Figure 2. Results for science achievement 2000 for students in Grades 4, 8, and 12.

Figure 3. Comparative results for science achievement from NAEP 1996 and 2000 studies for students in 12th grade.
achievement is important because educators need to know where and when students begin to decrease in their science performance.

TIMSS is the largest study that has been done to compare students' achievement in science education on an international level.

TIMSS is a collaborative research project sponsored by the International Association for the Evaluation of Educational Achievement (IEA). In 1994-5, achievement tests in mathematics and science were administered to carefully selected samples in classrooms around the world. With more than 40 countries participating, five grades were assessed in two subjects, and more than half a million students were tested in more than 30 languages... TIMSS is the largest and most ambitious study of comparative educational achievement ever undertaken. (Beaton et al., 1996, p. 1)

International studies TIMSS 1995 and TIMSS-1999 involving 38 international nations and 27 jurisdictions across the United States have produced dismal science results as were evident in national studies. The United States as a nation has done well in science in fourth grade, but students' achievement drops when one observes eighth- and 12th-graders' performance (TIMSS, 1995, 2001). Figure 4 gives a comparative view of the United States and other nations that took part in the TIMSS.

Students in the United States scored near first in the world in science, outperformed by Korea; in eighth grade they scored slightly above the international average, outperformed by 9 nations, and in 12th grade they scored below the international average, outperformed by 11 nations and doing better than only 2 nations (Mullis et al., 1997).

The key policy implications that follow these results center on understanding the relatively weak US performance at eighth grade compared to other countries and understanding the precipitous drop in performance from the fourth grade to the eighth grade... The key to understanding U.S. performance is related to our
nation's lack of an intellectually coherent vision of what we want our children to know in mathematics and science. No such vision dominates practice in the United States. In this respect we differ from all of the top achieving countries and from most of the nations that participated. (TIMSS, 1997, par. 3-4)

![Figure 4. U.S. performance in science for Grades 4, 8, & 12 when compared with other nations in TIMSS 1995.](image)

The question can be asked, “Why are we making such a fuss?” Does it really matter whether we are achieving competencies in mathematics or science? The resounding answer is “Yes, it does matter!” There are four important reasons for students to achieve competency in science:

(1) the demands of our changing economy and workplace, (2) our democracy’s continuing need for a highly educated citizenry, (3) the vital links of mathematics and science to the nation’s national security interest, and (4) the deeper value of...
mathematical and scientific knowledge. (NCMST, 2000, pp. 11 - 12)

The message of the TIMSS 1995, 1999 studies indicates that schools can make the difference. What teachers teach and how they deliver that content to children is critical and represents the route to improving science performance (Beaton et al., 1996, Smith et al., 2000).

**Performance of Christian Schools in Science Education**

Students in the Netherlands Antilles who were taught by a Christian framework of education outperformed all other school types (Netherlands Antilles, 2002). In the United States, Catholic schools scored 13 percentile points above the population norm in science in seventh grade (Wolsonovich, 2002). Students in the Seventh-day Adventist school system scored 14 percentile, 15 percentile, and 16 percentile points above the national norms in seventh, eighth, and ninth grades respectively (NAD, n.d.).

In the Netherlands Antilles study (2002), there was significant difference ($p < 0.05$) in school performances where MAC2, a school following the Christian approach, outperformed the private schools (M1, M3, and C), using the constructivist approach. MAC2 also outperformed the Public and Magnet schools. Students in the private schools performed better than students in public schools that followed the traditional approach. Students in public schools did better than students in the Magnet schools that had no clearly defined approach (Netherlands Antilles, 2002).

There was no significant difference ($p < 0.05$) in the performances of private schools M1, M3, and C that followed the constructivist approach to teaching science.
Although the public schools were outperformed by the school types mentioned before, they still did significantly better than the Magnet schools that did not follow any clearly defined science program. Based on the results in this study, the Christian approach to teaching science gave the best results among these school types (Netherlands Antilles, 2002).

When students of MAC2 continued their science education in a school type that used the constructivist approach to teaching science, 10.0% of these students who opted to follow the science stream were subsequently asked to drop the subject after taking the qualifying exams. This is in contrast to 36.7% of students from the constructivist schools and 50% of students from the other schools.

Science achievement in the Netherlands Antilles is assessed using an external standardized science examination taken by these students, the Caribbean Examination Council (CXC). This exam is given in the months of May and June of each calendar year on specific dates and times in all Caribbean countries at the end of students high-school year. The headquarters of CXC is located in Barbados, and there are centers in three other large countries, namely: Trinidad, Jamaica, and Guyana, where objective questions are graded by computer and essay questions by experienced markers drawn from science teachers in the region.

The examination in science consists of the following components:

1. Paper 1: objective questions that test students’ knowledge and comprehension of the subject content

2. Paper 2: no more than five compulsory structured questions that test students’
knowledge/comprehension and use of knowledge (including application, analysis/interpretation, synthesis and evaluation) in science content in that subject

3. Paper 3: one compulsory data analysis and four essay-type questions grouped in pairs, where students have to answer one question from each pair and in addition to testing students’ knowledge/comprehension and use of knowledge, it also tests experimental skills as well (including observation/recording/reporting, manipulation/measuring, analysis/interpretation, and planning and designing)

4. Paper 4: school-based assessment that assesses the achievement of students in the experimental skills in laboratory and field work over a 2 year period using specified skills from CXC. Students must keep a record of laboratory work that is graded by teacher and at the end of the final year, designated sample laboratory books are sent to CXC for external moderation.

5. Paper 5: practical examination where students are given two to three investigations to carry out and they make inferences and draw conclusions based on experimentation (Caribbean Examination Council, 1996).

Each paper is given a percentage weighing depending on the science subject in question and grades are assigned. Grades I, II, and III are considered passing grades with grade I being the highest level possible and grade IV the lowest grade in the general proficiency that can be obtained. Grade equivalencies for I, II, III, and IV are A, B, C, and D in the American system respectively.

Students who experienced the Christian approach to teaching science in their middle-school years did significantly better than other students who had other approaches.
in their science program. It must be noted however that all the students who took the
external examination received a passing grade in the science subject they took.

In the United States, the Catholic school system utilizes the Terra Nova to assess
students' performance in a number of subjects offered in its academic program.

Terra Nova is used by hundreds of school systems and districts throughout the
United States, including educational systems in 29 states, all 272 U.S. Department
of Defense schools state-wide and overseas, more than 60 school districts in
Illinois and 40 participating Catholic dioceses. This is the fifth consecutive year
the Archdiocese has used the test. Terra Nova II is an updated version of
Terra Nova I and was normed in 2000. (Wolsonovich, 2002, par. 10)

The science scores for the Catholic schools were noted as follows; third-graders
scored in the 60th percentile, fifth-graders scored in the 62nd percentile, and seventh-
graders scored in the 63rd percentile. These scores are above the national norms.

Wolsonovich (2002) stated:

The third-, fifth- and seventh-grade students enrolled in the Archdiocese's
elementary schools, who took the Terro Nova II test published by CTB-McGraw
Hill (California Achievement Tests Monterey, Calif.), consistently scored well
above the 50th percentile—the national norm for the test administered in 29 state-
wide programs... We're extremely proud of these results. Whether we look at
scores for the entire system, City of Chicago, suburban or inner city, the results
indicate that our students are learning and continually improving. (par. 3-5)

Students in this Christian school system have been doing well when compared to the
national norms in this science assessment, thus the Christian approach to teaching science
in this school system is producing results.

Science scores on the ITBS for the selected Union Conference under study
showed that, over a 3-year period, students in this particular Union achieved the 62.3
percentile in seventh grade, 64.3 percentile in eighth grade, and 64.5 percentile in ninth
grade. The scores have remained consistent over a 3-year period (see Figure 5). These students at the end of sixth, seventh, and eighth grades were performing respectfully at 12.3, 14.3, and 14.5 percentiles above the national norms (based on fall norms).

The Seventh-day Adventist school system has three distinct classroom configurations in their K-12 system (see Definition of Terms, chapter 1). Data supplied by the largest Conference represented in the Union under study indicated differences in achievement between the three classroom configurations (see Figure 6). Students in seventh and eighth grades in the multigrade classroom configuration obtained scores of 58 and 57 in science respectively on the ITBS. The ITBS scores used for this Conference were Normal Curve Equivalent (NCE) as opposed to percentiles. The NCE scores have a
Two-grade Multigrade Single-grade
School Types in SDA Education System

<table>
<thead>
<tr>
<th></th>
<th>Seventh Grade</th>
<th>Eighth Grade</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multigrade</td>
<td>58</td>
<td>60</td>
<td>58</td>
</tr>
<tr>
<td>Two-grade</td>
<td>56</td>
<td>60</td>
<td>58</td>
</tr>
<tr>
<td>Single-grade</td>
<td>63</td>
<td>65</td>
<td>64</td>
</tr>
</tbody>
</table>

Figure 6. ITBS science scores for largest conference (D) in Union.

A major advantage over percentiles is that they can be averaged, allowing one to compare scores from various schools. Students in seventh and eighth grades in the two-grade classroom configuration obtained scores of 56 and 60 respectively and the scores for the single-grade classroom were 63 and 65 respectively.

When analysis of variance was conducted, significant difference was noted between the classroom configurations ($p < 0.05$), where the single-grade school did better than multigrade and two-grade schools. However, the difference between the multigrade and two-grade was not statistically significant ($p < 0.05$). This statistical difference between classroom configurations within the Seventh-day Adventist system highlights the need to more closely explore the differences using the criteria established by NCMST.
Teaching and Learning Process in Science Education

Teacher strategies are nothing new. Plato, Aristotle, and Aquinas had their own, and today educators are acquainted with Skinner, Bruner, Taba, and many others who have designed various strategies to meet the needs of students in the classroom.

It is always the hope that by using a variety of methods that matched students' needs they can excel. Silver et al. (1996) have indicated that all strategies and their related teaching styles have their place, the key to good teaching is to see how learner and strategy fit together. The strategies are ways to evoke responses in particular learning environments important to the nature of the content to be learned.

Carl Gustav Jung and Isabel Briggs Myers, both psychologists, provided a framework for analyzing and categorizing teaching and learning behaviors in four distinct styles. Jung's theory argues that the learning and teaching behavior is not random, but rather is a reflection of one's developed or accessible functions for perception. It is how these same data are judged and mentally processed by students and how they draw conclusions about the meaning and importance of specific data.

Silver et al. (1996) noted:

Jung's theory says that we tend to prefer one perception and one judgment function over their opposites. We all use all four functions, but not at the same time or with the same frequency. Preferences develop like muscles: the more they are used, the stronger they become. Preferences for perception and judgment are the comfortable behaviors we develop over time. These preferences in turn become our learning and teaching styles. (p. 9)

Silver and others (1996) identified three basic constructs for teaching science, namely:

(a) a thorough understanding of the teaching/act, an understanding of the matching process, (b) the choices available to students and teachers, and (c) the skills to carry out
the various options as outlined in the science standards.

The teaching and learning act is considered an interrelation of the teacher and learner behaviors and the content to be mastered. See Figure 7 for more details.

Figure 7. Arrow showing where learning takes place in the teaching and learning process.

Improving the quality of the teaching/learning act requires improvement in the teacher’s decision-making ability; i.e., to make the best possible matches between the students’ learning preference, the content to be taught, and the strategies to be used for students to excel in any subject (Caine & Caine, 1997; Carey, 1985; Doll, 1993; Kemp et al., 1998; Marzano et al., 1992; Paik, 2003; Silver et al., 1996; Stiggins, 1997).

Teachers must be aware of the fact that making matches requires an understanding of the three basic constructs: “(1) a thorough understanding of the teaching/learning act; (2) an understanding of the matching process; and (3) the choices available to teachers and students and the skills to carry out the available options” (Silver et al., 1996, p. 2).
Good teaching means that a teacher has to move from strategy to strategy, learner to learner, to create that conducive climate for learning to take place in science education (Hidi, 1990; Reynolds & Walberg, 1991, 1992; Rozycki, 2003; Wolf, 1989).

Teaching strategies are deliberate efforts by the teacher to vary the mode of delivery to more appropriately represent the functions of cognitive and affective domains inherent in a particular learning objective. In these teaching strategies, much effort is devoted to the learner's role. In using these strategies, teacher and student become a team with announced goals and clearly identified procedures for reaching these goals (Hanson & Silver, 1978; Silver et al., 1996).

Based on Jung's theory, there are two ways of perceiving or finding out about persons, places, or things, namely, through one's senses and, to the opposite end of the same axis, one's intuition. According to Silver and others (1996) the sensing orientation focuses on things as they appear, the sensor assumes that what his or her senses tell him or her is what exists. The intuitive orientation focuses on the inner meanings and relationships of what is occurring. Intuition therefore deals with seeing possibilities, insights, and interpretation of what might be.

Jung also indicated that there are two ways of judging one's perception, namely, thinking that is based on facts, logic, analysis, and external evidence and feeling that is based on values, personal beliefs, subjective responses, and internal evidences. The pairing of perception and judgment functions results in four different styles or types, namely, the sensing thinker (ST), sensing-feeling (SF), intuitive-thinker (NT), and intuitive-feeler (NF) (Jung, 1965; Silver et al., 1996; Spoto, 1989).
This theory is pertinent to the teaching of science seeing that students have different learning styles; hence every effort should be made to vary methodologies so students are able to deal with content in a style that is familiar to them, thus learning is achieved. Jung’s description of these four functions, and the later pairing of these functions by Briggs Myers, provides a pragmatic tool for assessing learning styles and for categorizing content to be learned in terms of cognitive and affective functions (Jung, 1971; Myers, 1975).

The use of the Hanson-Silver instruments on learning and teaching styles utilizing learned behavior description by paired functions is critical in ensuring that we are adequately catering to the needs of our students.

Silver et al. (1996) indicated,

The Jungian-based Thoughtful Education Model provides the teacher with a framework for understanding the choices available for decision-making. The framework can assist teachers in diagnosing student learning preferences, as well as, correctly categorizing the nature of the content to be learned relative to required mental operations. As a result, the teacher can select those behaviors which are most appropriate for working with an individual student or group of students, to achieve a particular objective. The essence of good teaching is implementing teaching behaviors which is congruent with the intent of the objectives to be mastered and with the student’s learning styles. (p. 15)

It has been suggested that these preferences provide teachers with clues for constructing environments that facilitate learning styles and motivate students to achieve excellence (Silver et al., 1996). Furthermore, researchers have found that students’ motivation leads to engagement in academic tasks, which ultimately is related to achievement (Banks et al., 1978; DeCharms, 1984; Dweck, 1986; Schiefele & Csikszentmihalyi, 1995).
Learning Theories Related to Science Education

This section addresses the various learning theories that have been used since the 1930s to our present time in reference to science education. The Behaviorist school of thought, Piaget's view of cognitive development, and the contributions of a number of individuals to the approach of constructivism are examined in this section.

The Behaviorist school of thought has dominated American education since the 1930s. The behaviorist espoused that learning could be studied only as a set of re-enforceable behaviors that were affected by stimulus and reward. This theory of learning as proposed by Gagne (1974) and Bloom and others (1954) maintains that teaching is a process of building hundreds of "associations" through practice and reinforcing rewards, and there are many levels in the complexity of learning knowledge and skills, so they developed taxonomies of objectives and intellectual skills.

Cheek et al. (1992) indicated that "higher-order levels of thinking needed for problem solving were relegated to lofty capstones at the top of the hierarchies that were not reachable by many students" (p. 26). There was a problem in this theory of learning science—the main focus was on memorizing knowledge that was not real or useful. It could not be applied to everyday experiences. Piaget noted there was no way the knowledge acquired by a child could be applied to genuine problems in life's experiences (Piaget, 1974).

In view of this finding, Jean Piaget and his colleagues maintained that knowledge and intelligence must be uncovered and constructed through an experiential activity of the child. Knowledge and development of thinking skills were phenomena that happened
internally and not by administering external drill and practice as propagated by the Behaviorists. Piaget saw the child as a scientist who tries to understand the world and then constructs his or her own meaning. A child's thinking process gradually shifts from concrete to abstract intellectual functioning (Snowman & Biehler, 2003).

Piaget theorized that young people have two basic strategies for interaction with the environment: (a) assimilation, which is the process whereby a person uses an existing structure or ability to handle some problems in his or her environment and (b) accommodation, which is a process where the individual modifies his or her existing cognitive structures to handle discrepant experiences (Cheek et al., 1992; Piaget, 1952, 1963, 1974).

Dembo (1994) stated that “accommodation is a process by which the individual must change in response to environment demands. This adaptation necessitates a modification or rearrangement, of the individual’s existing mental structure” (p. 355). Learning based on this theory separates and identifies stages based on age level of intellectual or cognitive development. The child’s stage of development determines the type of learning that can take place and definitely sets limits on the entire learning process.

Cheek et al. (1992) stated:

The followers of Piaget believed his theories could be widely applied to science education. Since the child’s spontaneous activity was a key to learning, students should be encouraged to design experiments to solve questions arising from personal experiences should be avoided. Piagetian proponents also argued that students needed time to develop at their own individual rates. Children followed the same stages in developmental sequence, they said, but at different paces. (p. 26)
The developmental approach to learning is quite appealing. However, if one is to apply this to science education, there would be problems in trying to develop a program that caters to both concepts and intellectual skills within the context of a philosophy that refutes all attempts to teach directly. Science educators also had difficulty in a Piagetian approach where achievement is assessed exclusively by standardized examinations.

Later research has shown that Piaget may have underestimated children's capacities. Some researchers indicate that preschoolers may have more advance cognitive abilities that Piaget proposed (Gelman & Baillargeon, 1983; Snowman & Biehler, 2003). Piaget may have overestimated adolescent capacities as it has been found that only 20 to 25% of college freshmen were able to operate at the formal operation stage (Flieller, 1999; Kamii, 1984). It also seems that the rate of development within these stages differs from culture to culture (D’Amico & Schmid, 2003; Hughes & Noppe, 1991; Leadbeater, 1991). Despite these shortcomings of Piaget's original theory, one can use the additional findings to modify instruction to meet the needs of the diverse student population found in America.

In the First Revolution of science education, much emphasis was placed on hands-on laboratory exercises and process skills, but there was no balance process and concept development. It was even more difficult to include goals from the domains of attitudes, creativity, and applications. To move beyond that, science educators were now forced to look at another framework to provide a balanced approach to science education that allowed students to excel and to apply the knowledge in everyday situations (Anderson & Smith, 1984; Cheek et al., 1992; Clewell, 1987).
Cognitive psychologists have indicated that students can use their existing knowledge base of science concepts to construct new or more accurate knowledge of a particular concept. This was certainly considered a departure from the past where the cognitive aspects of learning were not taken into consideration (McCormack & Yager, 1989; Trachtman, 1975).

The manner in which science curriculum is developed in our schools today reflects several changes in educational thinking that have occurred in recent years. These changes are most appropriately described as efforts to restructure science teaching with the overall goal of improving students’ learning as they progress throughout their school years. Constructivism in recent times has become the byword for the restructuring efforts in science education (Archer, 2002; Brooks, 1990; Brooks & Brooks, 1993; Cheek, 1992; Ebenezer & Connor, 1998; McCormack, 1990; Yager, 1991).

Constructivism offers a more definitive approach for teaching science, in that proponents built into their instructional model the major questions that have caused problems for teachers. These include how to motivate and help students to learn concepts, the sequencing of concepts for learning, where to use hands-on approach as opposed to the other learning situations, and how to assess learning (Brooks, 1990; Ebenezer & Connor, 1998; Loucks-Horsley et al., 1990).

Cheek et al. (1992) noted:

The key difference of constructivism, as compared to earlier theories of learning, is that instruction is not something done to students. Instruction is done in a way that helps the students become conscious of their own personal knowledge structure and helps them nourish, refine, modify, or replace those structures. The constructivist’s goal is to help students develop their own capacity to learn. (p. 27)
This approach to learning emphasized the personal construction of human knowledge as opposed to the transmission of knowledge from one person to the next. The current view of constructivism has a strong basis in the cognitive approach to learning and draws heavily upon the research of learning experts like Jean Piaget, Lev Vygotsky, David Ausubel, and Jerome Bruner. The contributions of these four researchers, along with the ideas of others, have laid the foundation for many of the recent changes that have occurred in science instruction (Mohn, n.d.; Snowman & Biehler, 2003).

Teachers need to be aware of the cognitive abilities of their students based on Piaget’s findings and plan instruction accordingly. Mohn (n.d.) noted that “another aspect of Piaget’s research that has been especially important to constructivism is his theory of cognitive structures and logical mathematical operations” (p. 1) and these were discussed earlier in this document.

Lev Vygotsky, a Russian psychologist, became internationally known for his explanation of cognitive development, especially in the 1980s (D’Amico & Schmid, 2003). His major contribution to the cognitive approach to learning was his description of the role of social interaction and formal instruction. Vygotsky emphasized the learner’s environment and the learner’s interactions with other people through the use of language where learners must receive information and guidance from others in order for cognitive development to occur (Mohn, n.d.).

Two important features of Vygotsky’s research are private speech and the zone of proximal development. Private speech involves a learner’s internal thought processes used to regulate problem-solving skills. The zone of proximal development includes:
(a) modeling of appropriate academic behaviors, (b) allowing for feedback between teacher and students, (c) allowing for practice so that students can internalize important skills that need to be mastered, and (d) fostering a relationship that is built on trust and mutual support between teacher and student (Snowman & Biehler, 2003).

These underpinnings of Vygotsky relate very closely to the modern framework of constructivism and emphasize the need for cooperative learning structures in order for learners to construct knowledge through interaction with their peers. Vygotsky noted that social interaction is a vital part of learning where more emphasis is placed on collaboration and interaction among budding scientists.

David Ausubel's contributions to the cognitive approach to learning focused on the conceptual rather than the operative forms of knowledge. Ausubel emphasized the importance of reception learning which is based on the idea that most of what is learned is acquired through the transmission of ideas, where connections are made between new information and pre-existing cognitive structures. It means that teachers can allow students to learn from information that has been organized by others; however, it must have meaning to the students' internal cognitive structures (Snowman & Biehler, 2003).

In light of this development, students do not have to engage in rote learning and discover all the important science information on their own but they can draw on the knowledge and research of others to increase their knowledge of the processes in science (Mohn, n.d.; Snowman & Biehler, 2003).

Jerome Bruner, a cognitive psychologist, articulated the components of discovery learning that contributed to the cognitive framework of constructivism. He stressed that
students should not be given highly structured content that leads to dependency on the teacher; rather they must be confronted with problems and given the opportunity to solve them as individuals or in groups (Bruner, 1968, 1977). Discovery teaching is a method whereby students are not asked to rediscover everything, but a means for understanding the ways that ideas connect to each other and determining how what we know is relevant to what we have learned.

D’Amico and Schmid (2003) stated:

Constructivism holds that meaningful learning occurs when people actively try to make sense of the world—when they construct an interpretation of how and why things are by filtering new information and experiences through existing knowledge structures . . . The interesting relationship between Bruner and Piaget is described from Bruner’s point of view in his autobiography (Bruner, 1983, pp. 142-143). Intellectually, the two agreed about cognitive development far more than they differed, but Bruner saw Piaget’s stages as progressive, whereas he considered the learning modalities to be cumulative; that is, resulting in a learner’s using many learning modes. (pp. 171-172)

The current views considered to be important in the constructivist approach to teaching science are based on the research of cognitive psychologists and learning theorists such as Piaget, Vygotsky, Ausubel, and Bruner. Their contributions have helped to define the roles of cognitive learning theory and constructivist thought in science education, and have provided science educators with an effective foundation on which to develop instruction so that maximum learning takes place in the science classroom.

**Constructivist Approach**

Studies have indicated that students who are taught by the constructivist approach to teaching science have observable gains over students who follow the traditional
approach of teaching science (Ebenezer & Connor, 1998; Netherlands Antilles, 2002).

Cheek et al. (1992) have long advocated using the constructivist approach to teaching science because this approach allows students to become aware of their pre-existing ideas as they interact with materials, make observations, and verbalize their existing explanations. They found that when students engage in such practices they sometimes have to modify their thinking to accommodate the most plausible solution, thus they are engaged in critical thinking. Critical thinking is very important in problem solving, and problem solving is an integral part of science education (Ebenezer & Connor, 1998; Padilla & Frye, 1996; Von Secker, 2002).

Wolfinger (2000) noted that

the science education required to prepare citizens for effective citizenship must be more than socially oriented. It must eschew contextless content in favor of instruction that addresses not only the nature, capabilities, and limitations of science but also the ways, both obvious and subtle, that science and values are related, especially policy decisions that affect individuals and society at large. (p. 19)

It means that content and process skills are very important, and the aspects of values and attitudes are becoming prominent, as science is applied more to real-life situations (Ebenezer & Connor, 1998).

Several experts (Brooks, 1990; Ebenezer & Connor, 1998; Loucks-Horsley et al., 1990) have highlighted the following principles associated with a constructivist approach to teaching science:

1. Provide an invitational/interactive phase at the beginning of new learning sequences where students identify scientific phenomenon and account for the problem
through their existing theories. Students are given the opportunity to provide alternative explanations and discussion.

2. Utilize students' conceptions and thinking to drive lessons and provide opportunity to test these ideas.

3. Alternate hands-on data and seek to answer or justify or find evidence for solution to probing questions.

4. Give students time to think and insist on predicted outcomes for investigations.

5. Be on guard for students' alternative conception and develop lessons to deal with their misconception when evident (see Figure 8).

![The Teaching Model](image)


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A major factor that determines “the teaching and learning methodologies of any philosophy of education is the goals of that philosophy and the epistemological-metaphysical framework in which those goals are couched” (Knight, 1998, p. 230). The major role of educational philosophy is to assist educators to develop a program of study that allows students to reach some desired goal based upon some philosophic position.

Philosophical beliefs or perspectives, to a large extent, determine the educational practices that are employed in the educational process. It means that one’s philosophical position will determine “teaching methodology, curricular focus, the role of teacher, the function of the school in the social order, and the nature of the learner” (Knight, 1998, p. xiii).

It has been purported by Christian educators that their educational system is built upon the reality of the Christian view of reality, which is God.

Knight (1998) stated:

Christian educational systems have been established because God exists. His existence calls for an education system in which He is the central reality that give meaning to everything else. Other educational systems have alternative foundations and cannot be substituted for Christian education. Christian education determines what shall be studied and the contextual framework in which every subject is studied. The Christian view of reality supplies the criteria for curricular selection and emphasis. All subjects are seen from in their relationship to the existence and purposes of God. Christian metaphysical presuppositions not only justify and determine the existence, curriculum, and social role of Christian education; they also explicate the nature and potential of the learner, suggest the most beneficial types of relationship between teachers and their students, and provide the criteria for the teaching methodologies. (p. 167)

The goals of Christian education focus not only on the development of cognitive knowledge, self-awareness, and coping with their environment but reconciliation and
restoring God’s image in all their students. In view of this fact students are to reflect God in every conceivable way, hence they are not a mere reflector of other men’s thoughts but are able to think reflectively for themselves (White, 1923). “The essence of Christian education is to enable students to think and act reflectively for themselves, rather than just to respond to the word or will of an authority figure” (Knight, 1998, p. 230).

Embedded within this concept is the fact that “higher than the highest human thought can reach, is God’s ideal for His children” (White, 2000, p. 12). This framework seeks to produce students who are able to reach their maximum potential, thus they will be able to perform well on science achievement tests. From this perspective, one would expect the Christian approach to science education would meet the criteria of NCMST that are essential to an outstanding science. This approach would allow for ongoing evaluations and making changes to keep up with current practices based on the evaluations (Brantley, 1999).

It can be argued that excellence has been foremost in the Judeo/Christian lifestyle. One example of excellence from the book of Daniel in the Holy Scriptures is that of Daniel, Hananiah, Mishael, and Azariah who were ten times wiser than all the scholars in the realm of Babylon. Dan 1:20 states that “in all matters of wisdom and understanding, that the king inquired of them, he found them ten times better than all the magicians and astrologers that were in his realm.”

Knight (1998) noted that “character development outside of that experience may be good humanism or even good pharisaism, but it is not congruent with the Christian model” (p. 201). It must be remembered that the search for a curriculum design that
would cure the ills of our society has been the focus of many curriculum specialists; however, it has been elusive due to the various philosophies from which educators get their underpinnings. "Mindlessness" is how Charles Silberman has described the nation’s education system, seeing that the system “has suffered too long from too many answers and few questions” (Silberman, 1970, p. 470).

Neil Postman and Charles Weingartner (1973) have indicated that we are too occupied with the “how” rather than the “why.” We are failing to ask the larger question of purpose, which we can only get from our philosophy.

Knight (1998) further noted that none of these approaches, however, have been broad enough, and their claims have usually been divisive rather than unifying. We seem to be living in a schizophrenic world in which many claim that there is no external meaning, while others base their scientific research on postulates which point to an overall meaning. Modern secular people have thrown Christianity as a unifying force and have tended to concentrate on parts of their knowledge rather than on the whole. As a result, intellectual fragmentation continues to be as large as individuals seek to determine what knowledge is of most worth. (p. 211)

There are three models to the Christian approach to education and they are:

(a) “Self-contained Subject Matter Area” (Knight, 1998, p. 214) where the Bible is seen as one of many subjects and is separate from the other secular subjects. Clarke referred to this model as a “pagan education with a chocolate coating of Christianity” (Knight, 1998, p. 214), (b) “Bible as the Whole” (Knight, 1998, p. 214) where the Bible is considered as the whole; however, the Bible is not considered to be an exhaustive source of truth, and (c) “Bible as Foundational and Contextual” (Knight, 1998, p. 214) where the Bible presents a world view that has foundation and context for all human knowledge. It gives
meaning and significance to every subject in the curriculum. Edlin (1998) referred to this model as “the permeative function of the Bible” (p. 64).

Knight (1998) reiterated that “the Bible is not a frosting on a otherwise unaltered humanist cake. It needs to be the leaven in the educational loaf, shaping the entire curriculum from its base up as it permeates the whole school program” (p. 215). It is apparent that Christian education must be built with a Christian view of reality in mind and its metaphysics provides the basis for the process of education and learning in the context of school.

Knight (1998) indicated:

Christian metaphysical presuppositions not only justify and determine the existence, curriculum, and social role of Christian education; they also explicate the nature and potential of the learner, suggest the most beneficial types of relationships between teachers and their students, and provide criteria for the selection of teaching methodologies. (p. 167)

Christian education treats all subject matter from a Christian world view, and these subjects can be fully understood only when they are “seen in their relationship to the existence and purpose of the Creator-God” (Knight, 1998, p. 167).

**Comparison of Constructivist and Christian Approaches**

The Christian’s framework of teaching science is based on the teachings of Jesus and is quite compatible with key elements of the constructivist approach.

“Notwithstanding the apparent relativism of its assumptions, many methods suggested by constructivism fit nicely with the teachings of Jesus . . . The techniques of the Master Teacher should reassure the Christian teacher that so-called constructivist methods can be

Constructivism get its assumptions from postmodern philosophers such as Immanuel Kant, David Hume, and Friedrich Nietzsche who indicated that there is no way that humans being could know things, seeing that truth is dead (relativistic assumption). In addition there is no foundation on which to base one’s beliefs, thus one has to create one’s own world and knowledge (Knight, 1998).

John Zahorik gave three propositions for constructivist teaching theory:

"knowledge is constructed by humans, knowledge is conjectural and fallible and knowledge grows through exposure” (Zahorik, 1995, pp. 11-12).

Archer (2002) stated:

Constructivism is a theoretical framework that has been widely accepted in education. Clearly, many of its proponents use premises that are incompatible with biblical principles, but its applications in the classroom are in most cases consonant with good teaching. Although Constructivism’s relativistic assumptions present problems for Christian teachers, its conclusions about what works in education can be explained by premises that are consistent with a Christian worldview. (p. 37)

Archer (2002) noted that constructivist teaching principles are in agreement with the Christian viewpoint despite the glaring difference in their assumptions. Table 2 gives a comparative overview of the Christian and constructivist approaches to education based on a philosophical point of view.

**Christian Framework**

The significance and importance of science education, based on the Christian world view, may have been revealed from the beginning of the world. In Gen 1, as
Table 2

Comparisons Between the Constructivist and Christian Views

<table>
<thead>
<tr>
<th>Issue</th>
<th>Constructivist View</th>
<th>Christian View</th>
</tr>
</thead>
<tbody>
<tr>
<td>The nature of reality</td>
<td>The world is real, but this reality is not structured or inherently meaningful</td>
<td>Reality is structured and this structure has inherent meaning. We construct reality differently due to our distorted and incomplete perspectives</td>
</tr>
<tr>
<td>The role of experience</td>
<td>Order and meaning are imposed on the world by human experience</td>
<td>Human perceptions and experience must be compared with and evaluated in terms of objective facts that describe the structure of the universe. What we perceive is a reflection of what is there and can be evaluated</td>
</tr>
<tr>
<td>The place of meaning or understanding</td>
<td>There are many ways which we may structure the world; thus, many meanings may be generated from varied perspectives</td>
<td>Each of us is unique, with different perspectives and experience. Perception varies due to imperfection brought on by sin, however there is an Ultimate Standard, God</td>
</tr>
<tr>
<td>The role of instruction</td>
<td>Instruction allows for multiple understanding, since none of these meanings is inherently correct</td>
<td>Instruction allows for multiple perspectives, not because meaning is inherently incorrect but our construct of reality is distorted and incomplete due to sin</td>
</tr>
<tr>
<td>The role of assessment</td>
<td>Authentic assessment is accomplished by multiple approaches. Assessment occurs in the midst of instruction</td>
<td>There is an absolute standard, however, there is a climate created for students to feel comfortable enough to risk failure during the teaching and learning process. Creativity is fostered and students can achieve a more broader and objective view of “truth”</td>
</tr>
</tbody>
</table>
revealed in the Holy Scriptures, one cannot help but observe how things were created in perfect order. Here we repeatedly read that "God saw it was good." Extending the Creation theme, the Psalmist, in "considering thy heavens, the works of thy fingers, the moon and the stars which thou ordained," exclaimed, "O Lord our Lord, how excellent is thy name in all the earth!" (Ps 8:1, KJV).

It was by no accident that light was created before water, then plants, followed by sea and land creatures, and finally man was created. It is no secret that plants need sunlight and water to manufacture their own food, animals need plants to get their energy, and humans get their energy from plants and animals. The natural world as created by God is full of truths that our feeble minds are limited to fully comprehend all of God's creation (Knight, 1998).

For a Christian, science can only be understood to its fullest extent when studied from a biblical perspective. "The deepest students of science are compelled to recognize in nature the working of infinite power. But to the unaided human reason, nature's teaching is contradictory and disappointing" (White, 2000, pp. 80-81). "By faith we understand" (Heb 11:3).

The Christian framework for teaching science can be seen in Figure 9. It is important to point out that the ultimate aim of this framework is to produce minds that will think, who have the needed knowledge base and scientific skills needed to solve the ills of our society through practical applications. This framework allows for cooperation among students and facilitates working together to better understand the processes involved in achieving excellence in science education.
The natural world as created by God is full of truths that our feeble minds are limited to fully comprehend all of God’s creation.

Archer (2002) noted:

At Creation, He imposed structure on the universe, replacing chaos (formless and empty) with order. Christians believe that reality is structured and that this structure has inherent meaning . . . What we perceive is a reflection of what is actually there, and can be evaluated accordingly . . . We construct reality differently, not because reality has no inherent structure, but because of our incomplete and distorted perspectives. (pp. 35-36)

At the highest point of the Christian approach is the need to study science based on the natural world through special and natural revelations. Science is an epistemological approach whereby “we acquire specific types of understanding regarding the cosmos
around us” (Land, 2002, p. 11). God has revealed himself through the Bible in a special revelation and through the world of nature in a general revelation (White, 1943), and as created beings we can get to know Him.

According to White (2000),

human beings who study most deeply into the mysteries of nature will realize most fully their own ignorance and weakness. They will realize that there are depths and heights that they cannot reach, secrets they cannot penetrate. They will be ready to say, with Newton, I seem to myself to have been like a child on the seashore finding pebbles and shells, while the great oceans of truth lay undiscovered before me. (p. 80)

Only as the higher life is brought to view, as shown in the teachings of Christ, can any learning and instruction rightly be called excellent education. Man’s study of the science of nature, unaided by the Holy Spirit, falls short of the precious things Christ desires students to learn from the things of the natural world; for they fail to be instructed in the great and important truths which concern their salvation (White, 1943). It must be remembered that the standard of our school is lowered as soon as Christ ceases to be the pattern of both students and teachers (Knight, 1998; White, 2000).

The true object of education is to fit men and women for service by developing and bringing into active exercise all their faculties for this present world and for the one to come (White, 1943). It is imperative to note that the contents of science, the methods, and the technology-based applications to real-life situations all culminate in service.

Every student should remember that the Lord requires him to make of himself all that is possible, that he may wisely teach others also (White, 1943). Knight (1998) noted that “Christian teachers will strive to enable their students to see so-called secular
occupations within the context of an individual's wider vocation as a servant of God" (p. 202).

Students in this Christian school system will tax their mental powers and strive to reach their maximum potential, based on their abilities. All who engage in the acquisition of knowledge should strive to reach the highest round of the ladder (White, 1923). Teachers will take into consideration the need to put students in cooperative learning groups where they can learn and develop the needed skills to help them succeed in class and in the world of work. God wants the youth to be helpful to each other, seeing that all youths are not able to grasp ideas quickly.

Motivation can be defined as all the forces that contribute to the selection, persistence, intensity, and continuation of a behavior that is desirable. Motivation is the willingness to put forth effort until the desired objective is attained (D’Amico & Schmid, 2003). Snowman and Biehler (2003) indicated that teachers must seek ways to arouse and sustain interest in learning by their students, and teachers must make learning relevant to everyday life. The two-headed arrows in Figure 9 indicate that the Bible helps us understand every topic in the curriculum and the topic sheds light on the meaning of the Scripture. There is therefore an interplay of the biblical perspective with the content of science and the applications to real-life situations to help solve man’s needs.

Research has indicated that students need to have intrinsic motivation to search out a reward that is related to the activity and helps them become more competent and independent in their learning experience (Snowman & Biehler, 2003). The Christian framework allows students to develop such motivation, seeing that every effort is directed
towards service. White (1943) noted: "I am instructed to say to students, in your search for knowledge climb higher than the standard set by the world; follow where Jesus has led the way" (p. 402).

The teacher in this framework plays a very important role in facilitating students’ learning by using a number of methodologies to meet the learning styles of their students. Christian teachers teaching science will continually upgrade their skills so that they can be on the cutting edge in innovative practices that work in the teaching and learning process.

Knight (1998) has indicated that teachers in this framework will also be continually growing in their own mental development. Their literary qualifications are no less important than those of their counterparts in the public sector. On the contrary, because they are inspired by broader goals and higher motives, they may even have gone beyond the average of their profession, and they will undoubtedly strive to move above the minimums established by accrediting agencies. (p. 207)

Teachers in this Christian approach view teaching as the art of loving God’s children, thus they find their job fulfilling despite their task being challenging and demanding. They actively engage students in learning science through a variety of scientific skills and methods, so that each student has the possibility to reach his or her potential. "It is a special work that takes extraordinary dedication for its successful accomplishment" (Knight, 1998, p. 209).

Perspectives on Seventh-day Adventist Education

It is apparent that the label “Christian” gives no excuse for mediocrity or shoddy work or study (Brantley, 1999). This section of the literature review provides a brief
overview of the Seventh-day Adventist school system with an emphasis on science education.

Little has been documented on the early beginnings of elementary and secondary science education in the Seventh-day Adventist system of education. However, one could look at the tertiary level and realize that as early as in the 1930s every effort was made to upgrade science facilities to meet accrediting requirements. Land (2002) noted that: “In 1933, PUC (Pacific Union College) became the first Adventist school to receive senior college accreditation and during the next several years, others followed: Walla Walla College (1935), Union College (1937), Emmanuel Missionary College (1939), Washington Missionary College (1942), and Atlantic Union College (1945)” (p. 7).

In recent developments; Loma Linda University is at the forefront in molecular and cancer research, Southwestern Adventist University is noted for its pioneering work in using global positioning satellite (GPS) to map bones from dinosaurs, and Andrews University is reaching out to high-school students in Berrien County in offering advanced science courses for college credits (NAD, n.d.).

Hayward (2002) states,

And scientists (the Seventh-day Adventist system) it now has—hundreds of them. Seventh-day Adventist colleges and universities offer training in the basic sciences from elementary through doctoral level. Adventist scientists and their students carry out extensive research, often in collaboration with colleagues at other universities. The results of this research are presented at national and international professional meetings and published in standard, peer review, scientific journals. (p. 3)

The drive to produce minds that are articulate in science and technology, especially in medicine, has played an important role in colleges and universities designing
science programs that produce scientists to meet the needs of its organization. In view of this fact, Adventist colleges and universities ensure that students have the scientific knowledge and the technical skills needed to make these students world-class. It must be recalled that “an important task of Adventist science educators at all levels is to help students understand this fact and to encourage a healthy appreciation of scientific methodology and knowledge” (Hayward, 2002, p. 3).

The North American Division of Seventh-day Adventists has developed a curriculum plan to accomplished its vision by engaging in practices such as innovative classroom instruction, diversity and multiculturalism, integrated curriculum, students’ preferred learning style, and student assessment (Brantley, 1999). The aim of Adventist education for the 21st century is to ensure that students live up to the high ideals as outlined by its philosophy of education (NAD, n.d.).

The Seventh-day Adventist educational system espouses excellence and it would be prudent to research this school system and determine if it has the catalyst for innovation, creativity, and excellence in science education.

Enrollment in the North American Division of Seventh-day Adventists school system during 2000-2001 totaled 48,245 students in Grades K-8; 15, and 20,164 students at university level. The elementary school totals as indicated above can be broken down into the following: 15,352 students in K-2; 16,373 students in Grades 3-5 and 16,521 middle-school students (Grades 6-8) for the school-year 2000/2001 (NAD, n.d.). It can be inferred from the number of students that stakeholders are satisfied with how the system is implementing the high ideals of its philosophy.
The Seventh-day Adventist system has grown considerably from its early beginnings in Battle Creek, Michigan, where Goodloe Bell started the first school in 1872. In 1891 a group of pioneers from the Seventh-day Adventist Church met at a conference in Harbor Springs, Michigan, to make concrete plans for establishing schools and colleges to meet the needs of its membership and its community. Much has happened since then.

From Harbor Springs to the present day, Adventist education has made impressive strides. In 1998, Adventist schools and colleges enrolled 961,948 students in 5,327 K-12 schools and 89 colleges and universities—a far cry from Bell’s one room school in Battle Creek. (Brantley, 1999, p. 6)
CHAPTER 3

METHODOLOGY

The purpose of this study was to investigate the status of the science program in a selected Union Conference of the Seventh-day Adventist school system. Specifically, this study investigated the perceptions of teachers and students regarding the extent to which the science program meets the criteria of the National Commission on Mathematics and Science Teaching for the 21st century and to what extent these criteria are related to academic performance as indicated by ITBS science scores.

The following areas are addressed in this chapter: (a) the research design, (b) instrumentation that includes the description and development of instruments used in this study, (c) content validity of the instruments, and (d) how data were analyzed for each research question.

Research Design

This study used the survey research design to examine the perceptions and attitudes towards science education, in which questionnaires were self-administered. Surveys are used to learn more about people’s perceptions and attitudes towards some desired characteristics. Gay (1987) indicated that in the field of education the use of survey research design is advantageous for the collection of data about schools. “Surveys
conducted by schools are usually prompted by a need for certain kind of information related to instruction, facilities, or students population” (p. 192). This study sought to gather information related to the status of science education in a selected Union Conference of Seventh-day Adventists. Surveys are used in education because pertinent and accurate information can be obtained from a small sample drawn from a large population (Fowler, 1993; McMillan & Schumacher, 1984). McMillan and Schumacher (1984) stated that “the reason why surveys are so popular is that, if they are done correctly, sound information can be collected from a small sample that can be generalized to a large population” (p. 161).

Surveys, in addition to being descriptive, can also be used to explore relationships among variables (Fowler, 1993; Gay, 1987, Howell, 1997) and research question 4 in this study sought to explore relationships among variables.

A number of studies (NCES, 2000; Netherlands Antilles, 2002; Rudner, 1999; Saskatchewan Educational Assessment, 1993; TIMSS, 2001) used the survey research design to obtain information from students in regard to the teaching and learning process in science education. In view of these findings, it was appropriate to use the survey research design to collect information for this particular study.

**Sampling Procedures and Selection of Students**

In NAEP 2000 science study, a multistage design, which consisted of the following stages: (a) selection of a geographic area (county, group of counties, or metropolitan statistical area), (b) selection of schools drawn from public and non-public
schools within the selected area, and (c) selection of students within the schools that were chosen (NCES, 2000), was used to choose the sample. This study utilized a similar approach.

This sampling approach made use of a three-stage strategy: (a) selection of a Union Conference from the nine Unions in the North American Division of Seventh-day Adventists by default, the Conferences in the selected Union were included; (b) selection of schools from each classroom configuration within each conference; and (c) selection of all students in seventh and eighth grades from the randomly selected schools. Each stage of this three-stage strategy is described in detail below.

A Union Conference was randomly selected from the nine Union Conferences in the North American Division of Seventh-day Adventists. A second Union was chosen in the event that the first randomly selected Union Conference refused to take part in this study.

The first Union Conference was contacted in November 2000 with a formal letter to the Union Education Director (see Appendix A). This letter outlined the study and sought permission to use the Union for the study. Permission was granted in March 2001 when the leadership team of the Union agreed to participate in the study. Since the first Union granted permission, the second Union Conference chosen for the study was not contacted.

There were 798 seventh- and eighth-graders enrolled in this randomly selected Union Conference in the North American Division of Seventh-day Adventists. This Union has five conferences and they were given the following labels: (a) Conference A,
(b) Conference B, (c) Conference C, (d) Conference D, and (e) Conference E to maintain the anonymity of these conferences as a pre-condition for conducting this study.

In the second stage of the sampling design, schools were selected for participation in this study. Schools in these conferences consist of the following classroom configurations; (a) multi-grade, (b) two-grade, and (c) single-grade schools. The number of schools by classroom configurations for each conference is shown in Table 3. This stage selected schools for the study by simple random sampling, without replacing the chosen school in the sample pool until the allotted quota of students was obtained.

The number of students enrolled in each type of school for each conference is shown in Table 4. For example there are 55 multigrade students in Conference A and 42 two-grade students in Conference C. The third stage of this approach selected seventh- and eighth-graders from the school selected in stage two of this multistage approach.

For the purpose of this study 50% were selected in each classroom configuration per conference. Since total enrollment was 798, 399 students were selected for this study.

To illustrate how stages two and three were done for single-grade classroom configuration to select students in Conference D, the following was done. Table 4 shows that there are 83 students in Conference D, thus one will need to select 42 students. The names of the three schools were placed in a hat, then one school was picked without replacement and the number of students was determined. For example, school A has 20 seventh- and eighth-graders. This process was repeated until the quota of students was reached.
Table 3

*Number of Schools Represented in Study by Classroom Configurations by Conferences*

<table>
<thead>
<tr>
<th>Classroom Configurations</th>
<th>Conferences</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Multigrade:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total schools</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Selected schools</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Two-grade:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total schools</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Selected schools</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Single-grade:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total schools</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Selected schools</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 4

*Breakdown of Students in Classroom Configurations Based on Selected Union*

<table>
<thead>
<tr>
<th>Classroom Configuration</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>Total</th>
<th>Total Students</th>
<th>Selected Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multigrade:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total students</td>
<td>55</td>
<td>38</td>
<td>24</td>
<td>207</td>
<td>53</td>
<td>377</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selected Students</td>
<td>28</td>
<td>19</td>
<td>12</td>
<td>104</td>
<td>27</td>
<td>190</td>
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<td></td>
</tr>
<tr>
<td>Two-grade:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total students</td>
<td>17</td>
<td>21</td>
<td>42</td>
<td>132</td>
<td>20</td>
<td>232</td>
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<td>Selected students</td>
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<td>11</td>
<td>21</td>
<td>66</td>
<td>10</td>
<td>117</td>
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<tr>
<td>Single-grade:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total students</td>
<td>40</td>
<td>0</td>
<td>56</td>
<td>83</td>
<td>0</td>
<td>179</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selected students</td>
<td>20</td>
<td>0</td>
<td>28</td>
<td>42</td>
<td>0</td>
<td>90</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Table 5 shows the number of students included in the sample based on the 50% allocation of students in the three classroom configurations per conference in this selected Union Conference of Seventh-day Adventists.

The use of random selection for choosing the Union Conference and the schools for this study ensured that the population sample selected was unbiased. Wiersma (1991) indicated that using such a sampling technique can be as simple as using a hat where each member of the population is placed inside and each has an even chance of being chosen. This sampling technique provides one with valid results from the population, since it addresses the aspect of external validity (McMillan & Schumacher, 1984).

As it was not feasible to have a list of all the names of students from all classrooms represented in the population, I decided to use intact classes of seventh- and eighth-graders from randomly chosen schools. Administrators are more likely to allow intact groups to be sampled than individual students from various groups (Fowler, 1993; Gay, 1987).

For the purpose of this study 50% of the student population was chosen. Fowler (1993) indicated that precision increases steadily from a sample size of 35 to about 200. After 300 there is only a modest gain to increasing the sample size.

Teachers in this study were selected by default. Once the classroom was chosen, the teachers were invited to participate in the study.
<table>
<thead>
<tr>
<th>Classroom Configurations</th>
<th>Conferences</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td><strong>Multigrade:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schools</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Students</td>
<td>28</td>
<td>19</td>
</tr>
<tr>
<td><strong>Two-grade:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schools</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Students</td>
<td>17</td>
<td>12</td>
</tr>
<tr>
<td><strong>Single-grade:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schools</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Students</td>
<td>27</td>
<td>0</td>
</tr>
</tbody>
</table>
Instrumentation

Two questionnaires were used in this study. They included: (a) a researcher-designed questionnaire for measuring students' perceptions of the teaching and learning process in science (see Appendix B, "How Do You Feel?"), and (b) a researcher-designed questionnaire for measuring teachers' perceptions of the criteria that have been established by the National Commission on Mathematics and Science Teaching for the 21st century (see Appendix B, "What Do I See . . . How Do I Feel?"). Students and teachers chosen for the study were given their respective questionnaire to complete.

Description of Instruments

The students' questionnaire designed by the researcher for this study consisted of a total of 27 items of which 24 provided information on students' perceptions of the teaching and learning process in science education and 3 provided demographic information related to the student. Most of the items in the instrument used a variation of the selected-response format known as the Likert scale (Wiersma, 1991). The instrument presented a set of related statements, and students were asked to choose the best response from the responses provided for them.

The teachers' questionnaire consisted of 14 selected-response (1-14) and one open response item, 15 (see Appendix B, "What Do I See . . . How Do I Feel?"). Fowler (1993) indicated that selected-response questions are usually a more satisfactory means of creating data when compared to open questions. Items 6-14 used a Likert-type format where the respondents were asked to make a choice based on an ordered response given
by the researcher.

The items in the teacher questionnaire addressed the following criteria: (a) science resources, (b) acquisition of skills by students, (c) use of teaching methods, (d) number of credits completed in science, and (e) coverage of content areas.

Development of Teachers’ Questionnaire

The following criteria were noted and defined by the National Committee of Mathematics and Science Teaching for the 21st century (NCMST, 2000):

1. Science resources—the facilities, materials, and equipment needed by teachers and students to carry out demonstrations and experiments.

2. Acquisition of skills—skills needed by students to carry out the investigations in the field of science: (a) engaging in systematic observation of the environment, (b) use of appropriate tools and techniques, (c) use of identifying and clarifying questions, and (d) use of the scientific method.

3. Effective teaching method—use of a variety of teaching methodologies to develop critical thinking in students as they study science, such as: (a) hands-on approach, (b) concept attainment, (c) inquiry approach, (d) deductive reasoning, (e) learning cycle, (d) Taba inductive, and (e) project-based learning.

4. Teacher’s knowledge of science subject—the number of college-level science credits completed.

5. Coverage of science curriculum—the extent to which objectives are covered for the following science areas: (a) earth/space science, (b) life science, (c) physical science,
and (d) science/technology.

Table 6 shows the domain-to-item matrix for the items used in the teachers' questionnaire to measure each criterion established by NCMST. The items used in the teachers' questionnaire were adapted from a number of studies: (a) NCES (2000), (b) Netherlands Antilles (2002), (c) Saskatchewan Educational Assessment (1993), (d) TIMSS (2001), and (e) North American Division of Seventh-day Adventists Profiles Studies (Brantley & Hwangbo, 2000).

In this study, the validity of the teachers' questionnaire was achieved by using items that were designed to measure the various domains related to the criteria established by NCMST (2000).

**Development of Students' Questionnaire**

The student's questionnaire sought to address students' perceptions of the teaching and learning process. The teaching and learning process is considered an interrelation of teacher and learner behaviors and curriculum (Silver et al., 1996). Studies have shown that as students' perceptions of these three variables increase, science performance increases (Silver et al., 1996; Singh et al., 2002).

Students' behaviors are defined as the variables that are outside of the school setting that are directly related to the students' attitude towards science education. These variables are: (a) completion of assignments, (b) encouraged by parents to succeed, (c) conducive to study at home, (d) read ahead in textbook, and (e) preparedness for test.
Table 6

Domain-to-Item Matrix for the Teachers' Questionnaire

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Domains</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Resources</td>
<td>Laboratory Facilities</td>
<td>Science laboratory room</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Movable laboratory table</td>
</tr>
<tr>
<td></td>
<td>Material</td>
<td>Science materials</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hands-on manuals</td>
</tr>
<tr>
<td></td>
<td>Equipment</td>
<td>Science equipment</td>
</tr>
<tr>
<td>Acquisition of Skills</td>
<td>Science Skills</td>
<td>Systematic observation of the environment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Appropriate use of tools/techniques</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use of identifying and clarifying questions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Engaging in the scientific method</td>
</tr>
<tr>
<td>Effective Teaching Methods</td>
<td>Methodologies</td>
<td>Hands-on-approach</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concept attainment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inquiry approach</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Deductive reasoning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Learning cycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Taba inductive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Project-based learning</td>
</tr>
<tr>
<td>Knowledge of Science Subject (teacher)</td>
<td>Credits in Science</td>
<td>Number of credits completed at college-level</td>
</tr>
<tr>
<td>Coverage of Science Curriculum</td>
<td>Content Areas</td>
<td>Earth/space science</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Life science</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Physical science</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Science/technology</td>
</tr>
</tbody>
</table>
Teachers’ behaviors are defined as personality traits that encourage students to be motivated to do well in science. These variables are: (a) teacher warm and approachable, (b) graded fairly by teacher, (c) subject made interesting, (d) availability to help students in science outside of classroom, (e) voice opinion in class, and (f) trustworthiness of teacher.

Curriculum factors include all the variables in the teaching and learning process that directly affect students’ learning in the classroom. These variables are: (a) easy to concentrate in class, (b) textbook easy to understand, (c) amount of work given, (d) explanation given for corrected assignments, (e) content is understandable, (f) examples given to explain difficult concepts, and (g) laboratory exercises given.

Table 7 shows the domain-to-item matrix for the items used in the students’ questionnaire to measure the criteria established by NCMST (2000). Items related to students’ perceptions of the teaching and learning process in science education were adapted from a number of studies: (a) NCES (2000), (b) Netherlands Antilles (2002), (c) Saskatchewan Educational Assessment (1993), and (d) TIMSS (2001).

In this study, the validity of the teachers’ questionnaire was achieved by using items that were designed to measure the various domains related to the criteria established by NCMST (2000).

Fraenkel and Wallen (2000) and Fowler (1993) indicated that when one develops an instrument, it is very important for the designer to pay attention to the instrument having content validity. Failure to do so results in wasted data and a study that would probably not be valid.
<table>
<thead>
<tr>
<th>Standards</th>
<th>Domains</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students’ Perceptions of</td>
<td>Students’ Behaviors</td>
<td>Completion of assignments</td>
</tr>
<tr>
<td>Teaching and Learning Process in</td>
<td></td>
<td>Encouraged by parents to succeed</td>
</tr>
<tr>
<td>Science Education</td>
<td></td>
<td>Conducive to study at home</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Read ahead in textbook</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Preparedness for test</td>
</tr>
<tr>
<td>Teachers’ Behaviors</td>
<td></td>
<td>Subject made interesting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Availability of teacher</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Warmth and approachability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>of teacher</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Able to voice opinion in class</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Graded fairly by teacher</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trustworthiness of teacher</td>
</tr>
<tr>
<td>Curriculum Factors</td>
<td></td>
<td>Easy to concentrate in class</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Textbook easy to understand</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Amount of work given</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Explanations given for corrected assignments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Content understandable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Examples given to explain difficult concepts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Laboratory exercises given</td>
</tr>
</tbody>
</table>
The two researcher-designed questionnaires were mailed to five doctoral students in the Program Evaluation class of 1998 at Andrews University in December 2000 who had completed more than 16 graduate credits in statistics and evaluation and who were involved in science education as teacher or science consultant. The questionnaires were also sent to the Chair of the Science Committee of the Atlantic Union Conference of Seventh-day Adventist to further establish content validity. Instructions were given to them to determine the appropriateness of the items as a measure of: (a) science resources, (b) acquisition of science skills by students, (c) science teaching methods, (d) depth of teachers' knowledge of science subject being taught, and (e) coverage of content in science curriculum for the teachers' questionnaire. For the students' questionnaire, they were asked to determine the appropriateness of the items as a measure of: (a) students' behaviors, (b) teachers' behaviors as perceived by students, and (c) curriculum factors in the teaching and learning process in science.

All of the doctoral students and Chair of the Science Curriculum Committee of the Atlantic Union indicated that the items indicated in the questionnaires were valid to measure the domains based on the domain-to-item matrix of the two instruments. More than half of them (67%) indicated that the following items should be added to the student questionnaire in order to provide demographic information about students' motivation: (a) Do you believe you could have obtained a better grade? and (b) Is this subject important to you to better understand the teaching and learning process in science? These items were thus added to the student questionnaire. The instruments were now ready for field testing.
The instruments were pilot tested during a Needs Assessment Study in a Union Conference of the Seventh-day Adventist church in the North American Division using a total of 250 students and 50 teachers in the three classroom configurations typically found in the Seventh-day Adventist school system. The pilot testing was done to identify any items that were not clearly phrased.

When I received the completed instruments from the pilot study, I discovered the following variables: (a) 112 (Is this subject made interesting by the teacher?), (b) 114 (Is your teacher warm and approachable?), 117 (Do you feel your work is graded fairly by teacher?), and (d) 121 (How much trust and confidence do you have in your teacher?) were removed from the students' questionnaire (see Appendix B "How Do You Feel?") by the Director of Education of that Union Conference of Seventh-day Adventists. These variables were important indicators of students' perceptions of the teaching and learning process in science education (teachers' behaviors), and the exclusion of these variables made the pilot test inadequate. Therefore a second pilot test was done in Conference D of the selected Union Conference of Seventh-day Adventists in March 2001 using the survey instrument with seventh and eighth-graders in one randomly selected school of each school configurations: (a) multigrade–10 students, (b) two-grade–20 students, (c) single-grade–28 students, and the four teachers for these classes (these participants were not members of the sample chosen for the study). Since all the students and teachers answered each item on their respective questionnaire for both pilot tests, it was apparent that the items were clear and understandable.

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Procedure

On receipt of the approval notice for the study to be done from the Union Director of Education in March 2001, letters were sent to all the Education Directors of Conferences in the selected Union Conference of Seventh-day Adventists in March 2001 (see Appendix A) in order to further outline the importance of the study for their particular Conference and to solicit their support in asking the chosen schools to supply all needed information for the study.

I coded the student questionnaire using the following color scheme for the different classroom configurations: (a) blue for schools where seventh and eighth grades were taught by a separate teacher (single-grade), (b) orange-red for schools where seventh and eighth grades were taught together by one teacher (two-grade), and (c) gold bond for multigrade schools with one to three teachers per school. The Conferences were coded by numbers; (a) Conference A, 7; (b) Conference B, 9; (c) Conference C, 11; (d) Conference D, 8; and (e) Conference E, 10. The color coding and the numbering were done to maintain anonymity and confidentiality of the respondents. Student questionnaires were placed in respective labeled envelopes with the names of the principals and school addresses based on the sampling procedure.

The teacher questionnaires were color-coded according to the same system used for student questionnaires: (a) blue for schools where seventh and eighth grades were taught by a separate teacher, (b) orange-red for schools where seventh and eighth grades were taught together by one teacher, and (c) gold bond for multi-grade schools with one to three teachers per school.
Principals were contacted individually by telephone and informed about the importance of this study to their school and for their Union Conference. The principal of each selected school was mailed a packet that contained the teacher and student questionnaires. This packet included instructions for administration of the surveys. I phoned the principals when the questionnaires were sent by registered mail and asked him/her to call when the package was received. All principals complied.

The principals or their designee (someone other than the teacher) were asked to administer the questionnaires to the students. Special instructions were included in a letter to the principals that stressed the questionnaire was related to science and no other subject (see Appendix A).

The questionnaire for teachers had a self-addressed stamped envelope. Teachers received a follow-up phone call reminder to fill out the questionnaire or to thank them for doing so. Wiersma (1991) indicated that telephone calls may be used for follow-up and a repeated follow-up mailing can be used. The percentage gain by repeated follow-ups decreases with each follow-up. Unless response rate is low or an unusually high response rate is required, repeated follow-ups are not common.

Principals were told to place completed student questionnaires in the pre-paid, pre-addressed envelopes and post them immediately. Once questionnaires were received, they were recorded and placed in a database using the Statistical Package for the Social Science (SPSS). After the data from questionnaires were entered, the instruments were organized in a storage cabinet according to classroom configurations and Conferences.
Data Analysis

This section gives the rationale for using statistical procedures, and gives directions in regard to how data were analyzed in order to answer the four research questions under investigation in this study.

Question 1: What are teachers’ perceptions of the practices in science education in a selected Union Conference of the Seventh-day Adventist school system?

For the treatment and analysis of the results for question 1, crosstabulations (descriptive statistics) were performed on each item under investigation based on the item-to-domain matrix for the five standards of NCMST as shown in Table 6. In addition to the items in the item-to-domain matrix, crosstabulations were also done on the following items: (a) received further upgrading, (b) opportunities given for upgrading in science, (c) workshops for science education, (d) use of curriculum guide, (d) working relationship with high-school science teachers, and (e) quality of textbook to get more information about the status of science education in this selected Union Conference of the Seventh-day Adventist school system.

Question 1 has five hypotheses for the question related to teachers’ perceptions of practices in science education in a selected Union Conference of the Seventh-day Adventist school system and they are as follows:

Hypothesis 1. Among the three classroom configurations (multigrade, two-grade, and single-grade), there are significant differences in the following methodologies used by teachers: (a) hands-on approach, (b) concept attainment, (c) inquiry approach, (d) deductive reasoning, (e) learning cycle, (d) taba inductive, and (e) project-based
learning in teaching science in the Seventh-day Adventist school system.

Hypothesis 2. Among the three classroom configurations, there are significant differences in teachers’ perceptions of students’ ability to: (a) engage in systematic observation of the environment, (b) use of appropriate tools and techniques, (c) identify and clarify questions, and (d) engage in the scientific method in science education in the Seventh-day Adventist school.

Hypothesis 3. Among the three classroom configurations, there are significant differences in the availability of science resources: (a) science laboratory, (b) movable laboratory table, (c) laboratory materials, (d) laboratory equipment, and (e) hands-on manuals for use by teachers in science education in the Seventh-day Adventist school system.

Hypothesis 4. Among the three classroom configurations, there are significant differences in teachers’ coverage of science domains: (a) earth and space science, (b) life science, (c) physical science, and (d) science and technology in science education in the Seventh-day Adventist school system.

Hypothesis 5. There are significant differences in the number of science credits completed by teachers among the three classroom configurations in the Seventh-day Adventist school system.

Analysis of variance was performed on hypotheses 1-4 to determine if there were significant differences among the three classroom configurations in regards to the criteria of NCMST (2000) in this selected Union Conference of the Seventh-day Adventist school system. Post hoc multiple comparisons were also performed using Student-Newman-
Keuls procedure to determine which classroom configurations are different.

For hypothesis 5, a nonparametric analysis of variance known as the Kruskal-Wallis test was done to determine if there were significant differences in the number of credits completed by teachers in the three classroom configurations. The Kruskal-Wallis test was the most appropriate statistical procedure for analyzing hypothesis 5 since classroom configurations were nominal and the number of credits was ordinal.

Question 2: What are students' perceptions of the teaching and learning process in a selected Union Conference of the Seventh-day Adventist school system?

Crosstabulations were performed on each item under investigation based on the item-to-domain matrix for the standard of students' perceptions of the teaching and learning process in science (Table 7). In addition to the items in the item-to-domain matrix, crosstabulations were also done on the following items: (a) could obtain a better grade, (b) subject important, (c) reason influencing grade, (d) have study plan, (d) follow study plan, (e) distraction from studying at home, and (f) common source of distraction in class, to get more information about the teaching and learning process in the science education in this selected Union Conference of the Seventh-day Adventist school system.

In this study one wanted to get an overview of items in the domain-to-item matrix based on the three classroom configurations, as well as a total picture of items related to science education in this selected Union Conference of Seventh-day Adventists, thus the use of crosstabulation was appropriate. Norusis (1997) indicates that crosstabulation shows the number of cases that have particular combinations of values for two or more variables and they are expressed as percentages for rows and columns, hence the use of
crosstabulations was considered to be valid for analyzing data for this study.

Question 2 has three hypotheses for the question related to students’ perceptions of the teaching and learning process in science education in a selected Union Conference of the Seventh-day Adventist school system and they are as follows:

Hypothesis 6. Among the three classroom configurations, there are significant differences in students’ perceptions of students’ factors in the teaching and learning process: (a) complete assignments, (b) encouraged by parents to succeed, (c) difficult to study at home, (d) read ahead in textbook, and (e) preparedness for test in science education in the Seventh-day Adventist school system.

Hypothesis 7. Among the three classroom configurations, there are significant differences in students’ perceptions of teacher’s factors in the teaching and process: (a) subject made interesting, (b) teacher availability, (c) teacher warm and approachable, (d) able to voice opinion in class, (e) fairness of teacher, and (f) trustworthiness in science education in the Seventh-day Adventist school system.

Hypothesis 8. Among the three classroom configurations, there are significant differences in students’ perceptions of curriculum factors: (a) easy to concentrate in class, (b) textbook easy to understand, (c) amount of work given, (d) explanations given for corrected assignments, (e) content presented in an understandable manner, (f) examples given to explain difficult concepts, and (g) laboratory exercises given in science education in the Seventh-day Adventist school system.

Analysis of variance was performed on hypotheses 6-8 to determine if there were significant differences among the three classroom configurations in students’ perceptions.
of the teaching and learning process in science education in this selected Union Conference of the Seventh-day Adventist school system. Post hoc multiple comparisons were also performed using Student-Newman-Keuls procedure to determine which classroom configurations are different.

Question 3 generated one hypothesis and sought to determine the performance of students in this selected Union Conference of the Seventh-day Adventist school system in science on the Iowa Test of Basic Skills.

Question 3: As measured by the Iowa Test of Basic Skills, what is the performance of students in a select Union Conference of the Seventh-day Adventist school system?

From this question the following hypothesis was generated:

Hypothesis 9. Among the three classroom configurations, there are significant differences in students' science achievement on the ITBS in the Seventh-day Adventist school system.

Analysis of variance was used to determine if there were significant differences in students' achievement among the three classroom configurations. Post hoc multiple comparisons were also performed using Student-Newman-Keuls procedure to determine which classroom configurations are different.

Question 4 generated seven hypotheses that sought to determine the selected variables that are related to students' performance in science in this selected Union Conference of the Seventh-day Adventist school system.

Question 4: What selected variables are related to science performance as
measured by the Iowa Test of Basic Skills in a selected Union Conference in the Seventh-day Adventist School system?

From this question the following hypotheses were generated:

Hypothesis 10. There are linear relationships between students' achievement as measured by their ITBS science scores (dependent variable) and the five independent variables of students' factors: (a) complete assignment, (b) encouraged by parents to succeed, (c) difficult to study at home, (d) read ahead in textbook, and (e) preparedness for test in the Seventh-day Adventist school system.

Hypothesis 11. There are linear relationships between students' achievement as measured by their ITBS science scores and the six independent variables of teachers' factors: (a) subject made interesting, (b) teacher availability, (c) teacher warm and approachable, (d) able to voice opinion in class, (e) fairness of teacher, and (f) trustworthiness in the Seventh-day Adventist school system.

Hypothesis 12. There are linear relationships between students' achievement as measured by their ITBS science scores and the seven independent variables of curriculum factors: (a) easy to concentrate in class, (b) textbook easy to understand, (c) amount of work given, (d) explanation given for corrected assignment, (e) content presented in an understandable manner, (f) examples given to explain difficult questions, and (g) laboratory exercises given in the Seventh-day Adventist school system.

Hypothesis 13. There are linear relationships between the performance of schools as measured by their ITBS science scores and the seven independent variables in science methodologies: (a) hands-on approach, (b) concept attainment, (c) inquiry approach,
Hypothesis 14. There are linear relationships between the performance of schools as measured by their ITBS science scores and the four independent variables of science skills acquired by students: (a) engaging in systematic observation of the environment, (b) using appropriate tool and techniques, (c) identifying and clarifying questions, and (d) engaging in the scientific method in the Seventh-day Adventist school system.

Hypothesis 15. There are linear relationships between the performance of schools as measured by their ITBS science scores and the five independent variables of science resources: (a) science laboratory, (b) movable laboratory table, (c) laboratory materials, (d) laboratory equipment, and (e) hands-on manuals in the Seventh-day Adventist school system.

Hypothesis 16. There are linear relationships between the performance of schools as measured by their ITBS science scores and the four independent variables of teachers’ coverage of science domains: (a) earth and space science, (b) life science, (c) physical science, and (d) science and technology in the Seventh-day Adventist school system.

Regression analysis making use of zero-order correlation was used to analyze the seven hypotheses that are under investigation in research question 4. "This is equivalent to testing the null hypothesis that the population slope is 0" (Norusis, 1997, p. 400). Linear regression analysis allows one to test whether there is a relationship between the independent variables (items under each domain in item-to-domain matrix) and the dependent variable (ITBS science scores). Each domain for the students’ and teachers’
questionnaires had a number of items, and one needed to determine if there were relationships between the dependent and independent variables. Gay (1987) indicated that "relationship studies are conducted in an attempt to gain insight into factors, or variables, that are related to complex variables such as academic achievement, motivation, and self-concepts" (p. 244). This analysis can therefore be considered appropriate for this study seeing the purpose of research question 4 was to determine the variables that are related to science achievement. The stepwise procedure used, was most appropriate because it is the most commonly used procedure since it removes variables in a model "whose importance diminishes as additional predictors are added or are removed" (Norusis, 1997, p. 461).

For the analysis involving the use of science achievement (ITBS), the percentile scores entered on the front of the students' questionnaire were converted by the researcher to normal curve equivalent (NCE). This was done by using the conversion table in the ITBS manual (Drahozal, 1997). Teachers reported the scored obtained by the class as a group and these percentiles were converted to NCE, so that meaningful results could be obtained for the selected Union Conference under investigation.

All hypotheses were tested at the 0.01 level. The 0.01 level was selected rather than the traditional 0.05 level to control for the inflation of the Type 1 error.
CHAPTER 4

RESULTS

Overview of Results

This chapter gives an overview of the demographic information of teachers and students in this selected Union Conference of the Seventh-day Adventist school system and presents the results of the data analysis under the four research questions in this study, using descriptive and inferential statistics.

Demographic Information of Teachers

A total of 68 teachers participated in this study, representing a return rate of 100%. Table 8 summarizes the demographic characteristics of these teachers. Almost half (48.5%) came from Conference D; most (60.3%) were teachers in the multigrade school. Almost three-quarters of the teachers (78%) had teaching experiences between 3 to 10 years and almost all (94.1%) of the teachers in this study had a bachelor’s degree.

Table 9 shows the number of credits completed by teachers by classroom configurations, where most teachers completed between 6-10 credits, with more than three-fourths of teachers in multigrade (87.8%), two-grade (80.9%), and about half (50%) of teachers in single-grade. The single-grade classroom configuration was the only one where teachers completed over 20 credits of college-level science courses, with 20% of
Table 8

*Frequency and Percentage of Selected Demographic Characteristics of Teachers in Union (N = 68)*

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teacher Type</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neophyte (0-2 years)</td>
<td>5</td>
<td>7.4</td>
</tr>
<tr>
<td>Beginning (3-5 years)</td>
<td>28</td>
<td>41.2</td>
</tr>
<tr>
<td>Experience (6-10 years)</td>
<td>25</td>
<td>36.8</td>
</tr>
<tr>
<td>Seasoned (11-25 years)</td>
<td>9</td>
<td>13.2</td>
</tr>
<tr>
<td>Veteran (over 25 years)</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Highest Degree</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bachelors</td>
<td>64</td>
<td>94.1</td>
</tr>
<tr>
<td>Masters</td>
<td>4</td>
<td>5.9</td>
</tr>
<tr>
<td><strong>Classroom Configurations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multigrade</td>
<td>41</td>
<td>60.3</td>
</tr>
<tr>
<td>Two-Grade</td>
<td>17</td>
<td>25.0</td>
</tr>
<tr>
<td>Single-Grade</td>
<td>10</td>
<td>14.7</td>
</tr>
<tr>
<td><strong>Geographic Region in Union</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conference A</td>
<td>10</td>
<td>14.7</td>
</tr>
<tr>
<td>Conference B</td>
<td>7</td>
<td>10.3</td>
</tr>
<tr>
<td>Conference C</td>
<td>10</td>
<td>14.7</td>
</tr>
<tr>
<td>Conference D</td>
<td>33</td>
<td>48.5</td>
</tr>
<tr>
<td>Conference E</td>
<td>8</td>
<td>11.8</td>
</tr>
</tbody>
</table>
Table 9

Descriptive Statistics for Number of Credits Completed by Teachers by Classroom Configurations \((N = 68)\)

<table>
<thead>
<tr>
<th>Number of Credits Completed</th>
<th>Number and (Percentages) of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6-10</td>
</tr>
<tr>
<td>Multi grade</td>
<td>36 (87.8)</td>
</tr>
<tr>
<td>Two-grade</td>
<td>14 (82.4)</td>
</tr>
<tr>
<td>Single-grade</td>
<td>5 (50.0)</td>
</tr>
</tbody>
</table>

these teachers indicating such.

Most teachers in the three classroom configurations did not receive upgrading in science education. Table 10 shows the descriptive statistics for teachers by classroom configurations where no teacher in the two-grade classroom received upgrading since his or her graduation. Less than a tenth (7.3%) of teachers in multigrade received upgrading, while more than a quarter (30%) of teachers from the single-grade classroom configuration received upgrading.

Almost all teachers in multigrade (97.6%) and two-grade (94.1%) classroom configuration were not aware of the science curriculum at the high-school level. Results for teachers in the single-grade classroom configuration were slightly better than the other two classroom configurations, where 20% of teachers in the single-grade classroom configuration were aware of the science curriculum at the high-school level (see Table 11).
### Table 10

*Descriptive Statistics for Upgrading in Science by Teachers by Classroom Configurations (N = 68)*

<table>
<thead>
<tr>
<th>Upgrading in Science</th>
<th>Number and (Percentages) of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Multigrade</td>
<td>38 (92.7)</td>
</tr>
<tr>
<td>Two-grade</td>
<td>17 (100.0)</td>
</tr>
<tr>
<td>Single-grade</td>
<td>7 (70.0)</td>
</tr>
</tbody>
</table>

### Table 11

*Descriptive Statistics for Awareness of Science Curriculum at High-School by Teachers by Classroom Configurations (N = 68)*

<table>
<thead>
<tr>
<th>Awareness of Curriculum</th>
<th>Number and (Percentages) of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Multigrade</td>
<td>40 (97.6)</td>
</tr>
<tr>
<td>Two-grade</td>
<td>16 (94.1)</td>
</tr>
<tr>
<td>Single-grade</td>
<td>8 (80.0)</td>
</tr>
</tbody>
</table>

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Table 12 shows the results for teachers wanting a close working relationship with science teachers at the high-school level by classroom configurations. Most teachers in the three classroom configurations wanted a working relationship with science teachers at the high-school level, with all (100%) from single-grade, 88.2% from two-grade, and 73.2% from multigrade classroom configurations. Only 12.2% of teachers in the multigrade classroom configuration indicated they were not sure they wanted to work with high-school science teachers.

Table 12

*Descriptive Statistics for Working Relationship With High-School Teachers by Teachers by Classroom Configurations (N = 68)*

<table>
<thead>
<tr>
<th>Working Relationship</th>
<th>Number and (Percentages) of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No (14.6)</td>
</tr>
<tr>
<td>Multigrade</td>
<td>6</td>
</tr>
<tr>
<td>Two-grade</td>
<td>2 (11.8)</td>
</tr>
<tr>
<td>Single-grade</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

More than half of teachers in the three classroom configurations used their curriculum guide to plan instruction, with 68.2% of teachers in multigrade, 64.7% from two-grade, and 80% from single-grade were noted. More teachers in the single-grade classroom configuration (80%) indicated they used their curriculum guides to plan instruction than teachers in the two other classroom configurations (see Table 13).
Table 13

Descriptive Statistics for Use of Curriculum Guide by Teachers by Classroom Configurations (N = 68)

<table>
<thead>
<tr>
<th>Use of Curriculum Guide</th>
<th>Number and (Percentages) of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No (Percentages)</td>
</tr>
<tr>
<td>Multigrade</td>
<td>13 (31.7)</td>
</tr>
<tr>
<td>Two-grade</td>
<td>6 (35.2)</td>
</tr>
<tr>
<td>Single-grade</td>
<td>2 (20.0)</td>
</tr>
</tbody>
</table>

Table 14 shows results for teachers’ rating of science textbook by classroom where most teachers rated the textbook as fair, with 87.8% from multigrade; single-grade, 80.0%; and two-grade, 58.8%. Teachers in the two-grade classroom configuration gave a better rating of the quality of science textbook as being good or excellent, with about a third (35.3%) of teachers indicating such.

Table 14

Descriptive Statistics for Quality of Textbook by Teachers by Classroom Configurations (N = 68)

<table>
<thead>
<tr>
<th>Quality of Textbook</th>
<th>Number and (Percentages) of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poor (Percentages)</td>
</tr>
<tr>
<td>Multigrade</td>
<td>2 (4.9)</td>
</tr>
<tr>
<td>Two-grade</td>
<td>1 (5.9)</td>
</tr>
<tr>
<td>Single-grade</td>
<td>0 (0.0)</td>
</tr>
</tbody>
</table>

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Demographic Information of Students

A total of 422 students participated in this study, representing a return rate of 97.9%. Table 15 summarizes the demographic characteristics of these students, where the number of males (50.7%) and females (49.3%) was about the same. The 13-14 age group was the largest (60.4%). More than half (53%) of students came from Conference D; most students (40.3%) were enrolled in the multigrade schools.

Table 15

Frequency and Percentage of Selected Demographic Characteristics of Students in Union (N = 422)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>208</td>
<td>49.3</td>
</tr>
<tr>
<td>Male</td>
<td>214</td>
<td>50.7</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-12 years</td>
<td>159</td>
<td>37.7</td>
</tr>
<tr>
<td>13-14 years</td>
<td>255</td>
<td>60.4</td>
</tr>
<tr>
<td>over 14 years</td>
<td>8</td>
<td>1.9</td>
</tr>
<tr>
<td>Classroom Configurations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multigrade</td>
<td>170</td>
<td>40.3</td>
</tr>
<tr>
<td>Two-Grade</td>
<td>129</td>
<td>30.6</td>
</tr>
<tr>
<td>Single-Grade</td>
<td>123</td>
<td>29.1</td>
</tr>
<tr>
<td>Geographic Region in Union</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conference A</td>
<td>64</td>
<td>15.2</td>
</tr>
<tr>
<td>Conference B</td>
<td>29</td>
<td>6.9</td>
</tr>
<tr>
<td>Conference C</td>
<td>67</td>
<td>15.9</td>
</tr>
<tr>
<td>Conference D</td>
<td>224</td>
<td>53.0</td>
</tr>
<tr>
<td>Conference E</td>
<td>38</td>
<td>9.0</td>
</tr>
</tbody>
</table>

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Table 16 presents results for students' perceptions of science subject being important by classroom configuration. More than half of students in each classroom configuration indicated science was important to them, with 62.4% from multigrade, 71.3% from two-grade, and 76.4% from single-grade. More students (37.7%) in the multigrade classroom configuration indicated they did not know or were not sure this subject was important to them.

Table 16

Descriptive Statistics for Subject Being Important by Students by Classroom Configurations (N = 421)

<table>
<thead>
<tr>
<th>Subject Important</th>
<th>Number and (Percentages) of Responses</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>15.3</td>
<td></td>
</tr>
<tr>
<td>Multigrade</td>
<td>38 (22.4)</td>
<td></td>
<td>106 (62.4)</td>
</tr>
<tr>
<td>Two-grade</td>
<td>19 (14.7)</td>
<td>17 (13.2)</td>
<td>92 (71.3)</td>
</tr>
<tr>
<td>Single-grade</td>
<td>13 (10.6)</td>
<td>16 (3.8)</td>
<td>94 (76.4)</td>
</tr>
</tbody>
</table>

* Due to non-response of 1 student in two-grade classroom percentages do not add up to 100.

Table 17 presents the results for students having a study plan by classroom configurations. More than half of all students in the three classroom configurations indicated that they had a study plan, with 57.7% students from single-grade, 57.1% from multigrade, and 55.8% from two-grade.

Table 18 presents the responses of students who indicated that they had a study plan by classroom configurations. About half of all students in the three classroom configurations indicated they had a study plan, with 57.7% students from single-grade, 57.1% from multigrade, and 55.8% from two-grade.

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Table 17

Descriptive Statistics for Have a Study Plan by Students by Classroom Configurations (N = 422)

<table>
<thead>
<tr>
<th>Have a Study Plan</th>
<th>Number and (Percentages) of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Multigrade</td>
<td>73 (42.9)</td>
</tr>
<tr>
<td>Two-grade</td>
<td>57 (44.2)</td>
</tr>
<tr>
<td>Single-grade</td>
<td>52 (42.3)</td>
</tr>
</tbody>
</table>

configurations seldom or never followed their study plan, with 63.9% from multigrade, 61.1% from single-grade, and 48.6% from two-grade. More students (51.4%) in the two-grade classroom configuration indicated they sometimes or always followed their study plan than students in the other two classroom configurations.

Table 18

Descriptive Statistics for Following Study Plan by Students by Classroom Configurations (N = 241)

<table>
<thead>
<tr>
<th>Follow Study Plan</th>
<th>Number and (Percentages) of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Never</td>
</tr>
<tr>
<td>Multigrade</td>
<td>29 (29.9)</td>
</tr>
<tr>
<td>Two-grade</td>
<td>9 (12.5)</td>
</tr>
<tr>
<td>Single-grade</td>
<td>16 (22.2)</td>
</tr>
</tbody>
</table>
Table 19 presents the results of the common sources of distraction from studying at home by students in the three classroom configurations. The most important reason given by students for not studying at home was television viewing, with more than half of students in each classroom configurations indicating such; (a) multigrade (65.9%), (b) single-grade (52.8%), and (c) two-grade (50.4). More students in multigrade indicated television distracted them from studying than the other two classroom configurations.

Table 19

*The Relationship Between Distraction From Study by Students by Classroom Configurations (N = 422)*

<table>
<thead>
<tr>
<th>Distraction From Study</th>
<th>Single-Grade</th>
<th>Multigrade</th>
<th>Two-Grade</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
<td>n %</td>
</tr>
<tr>
<td>Television</td>
<td>65 52.8</td>
<td>112 65.9</td>
<td>65 50.4</td>
<td>242 57.3</td>
</tr>
<tr>
<td>Sport/Clubs</td>
<td>17 13.8</td>
<td>20 11.8</td>
<td>24 18.6</td>
<td>61 14.5</td>
</tr>
<tr>
<td>Social Clubs/Church</td>
<td>8 6.5</td>
<td>10 7.6</td>
<td>9 17.1</td>
<td>27 10.2</td>
</tr>
<tr>
<td>Coping Siblings</td>
<td>8 6.5</td>
<td>13 5.9</td>
<td>22 7.0</td>
<td>43 6.4</td>
</tr>
<tr>
<td>Family Problems</td>
<td>12 9.8</td>
<td>2 1.2</td>
<td>0 0.0</td>
<td>14 3.3</td>
</tr>
<tr>
<td>Emotional Problems</td>
<td>6 4.9</td>
<td>9 5.3</td>
<td>6 4.7</td>
<td>21 5.0</td>
</tr>
<tr>
<td>Other</td>
<td>7 5.7</td>
<td>4 2.4</td>
<td>3 2.3</td>
<td>14 3.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>123 100.0</strong></td>
<td><strong>170 100.0</strong></td>
<td><strong>129 100.0</strong></td>
<td><strong>422 100.0</strong></td>
</tr>
</tbody>
</table>

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More than two-thirds of students in each classroom configuration indicated they could have received a better grade, with the following responses noted: (a) 82.9% from multigrade, (b) 77.2% from single-grade, and (c) 66.7% from two-grade. It was noted that more students in the multigrade classroom indicated they could have received a better grade by classroom configurations. About a third (33.3%) of students in the two-grade did not know or were not sure they could have received a better grade in this subject (see Table 20).

Table 20

*Descriptive Statistics for Better Grade in Subject by Students by Classroom Configurations (N = 422)*

<table>
<thead>
<tr>
<th>Better Grade</th>
<th>Number and (Percentages) of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>Multigrade</td>
<td>20 (11.8)</td>
</tr>
<tr>
<td>Two-grade</td>
<td>9 (7.0)</td>
</tr>
<tr>
<td>Single-grade</td>
<td>9 (7.3)</td>
</tr>
</tbody>
</table>

Table 21 presents the results for the reasons given by students for the grade they received by classroom configurations. Three important reasons given by students for the grade they received in science were: (a) difficult content, (b) subject boring, and (c) not prepared for exam.
Table 21

*Frequency Distribution for Reasons for Grade by Students by Classroom Configurations (N = 422)*

<table>
<thead>
<tr>
<th>Reasons for Grade</th>
<th>Single-Grade</th>
<th>Multigrade</th>
<th>Two-Grade</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Difficult Content</td>
<td>34</td>
<td>27.6</td>
<td>55</td>
<td>32.4</td>
</tr>
<tr>
<td>Subject Boring</td>
<td>36</td>
<td>29.3</td>
<td>52</td>
<td>30.6</td>
</tr>
<tr>
<td>Not Prepared for Exam</td>
<td>22</td>
<td>17.9</td>
<td>33</td>
<td>19.4</td>
</tr>
<tr>
<td>Items on Test Not Covered</td>
<td>5</td>
<td>4.1</td>
<td>5</td>
<td>2.9</td>
</tr>
<tr>
<td>Dislike Subject</td>
<td>7</td>
<td>5.7</td>
<td>11</td>
<td>6.5</td>
</tr>
<tr>
<td>Dislike Teacher</td>
<td>5</td>
<td>4.1</td>
<td>8</td>
<td>4.7</td>
</tr>
<tr>
<td>Physically Ill</td>
<td>1</td>
<td>0.8</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Social Problems</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Emotional Problems</td>
<td>5</td>
<td>4.1</td>
<td>3</td>
<td>1.8</td>
</tr>
<tr>
<td>Other</td>
<td>8</td>
<td>6.5</td>
<td>3</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>123</td>
<td>100.0</td>
<td>170</td>
<td>100.0</td>
</tr>
</tbody>
</table>
For single-grade classroom configuration, the following were noted: (a) 29.3% of students indicated subject boring as the number one reason for grade, (b) 27.6% of students indicated difficulty of content as second most important reason for their grade, and (c) 17.9% of students indicated not prepared as the number three reason for their grade. For multigrade classroom configuration, the following were noted: (a) number one reason given by students (32.4%) was subject difficult, (b) number two reason given by students (30.6%) was subject was boring, and (c) third reason given by students (19.4%) was not prepared for exam. For two-grade classroom configuration the following were noted: (a) number one reason given by students (34.1%) was difficult content, (b) number two reason given by students (24.8%) was not prepared for exam, and (c) third reason given by students (17.8%) was subject boring.

Table 22 presents the results for the common source of distraction in science class by students by classroom configurations. The main reasons given by students in the three classroom configurations were: (a) noisy classroom, (b) uninteresting lessons, and (c) conversation with friends. For multigrade classroom configuration the following were noted: (a) uninteresting lessons was the number one reason given by students (47.6%), (b) conversation with friends was the number two reason given by students (21.2%), and (c) third reason given by students (18.2%) was noisy classroom. For two-grade classroom configuration the following were noted: (a) uninteresting lesson was the number one reason given by students (40.3%), (b) conversation with friends was the second reason given by students (33.3%), and (c) the third reason given by students (12.4%) was noisy classroom.
Table 22

*Frequency Distribution for Common Sources of Distraction in School by Students by Classroom Configurations (N = 422)*

<table>
<thead>
<tr>
<th>Common Source of Distraction</th>
<th>Single-Grade</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Noisy Classroom</td>
<td>52</td>
<td>42.3</td>
<td>31</td>
<td>18.2</td>
<td>16</td>
<td>12.4</td>
</tr>
<tr>
<td>Uninteresting Lesson</td>
<td>43</td>
<td>35.0</td>
<td>81</td>
<td>47.6</td>
<td>52</td>
<td>40.3</td>
</tr>
<tr>
<td>Personal Problems</td>
<td>6</td>
<td>4.9</td>
<td>15</td>
<td>8.8</td>
<td>8</td>
<td>6.2</td>
</tr>
<tr>
<td>Conversation With Friends</td>
<td>20</td>
<td>16.3</td>
<td>36</td>
<td>21.2</td>
<td>43</td>
<td>33.3</td>
</tr>
<tr>
<td>Emotional Problems</td>
<td>2</td>
<td>1.6</td>
<td>7</td>
<td>4.1</td>
<td>10</td>
<td>7.8</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>123</td>
<td>100.0</td>
<td>170</td>
<td>100.0</td>
<td>129</td>
<td>100.0</td>
</tr>
</tbody>
</table>

For single-grade classroom configuration, the following were noted for common source of distraction in science classroom: (a) noisy classroom was the number one reason given by students (42.3%), (b) second reason given by students (35.0%) was uninteresting lesson, and (c) the third reason given by students (16.3%) was conversation with friends.
Testing the Hypotheses

**Research Question 1:** What are teachers' perceptions of the practices in science education in a selected Union Conference of the Seventh-day Adventist school system?

Table 23 presents the use of methodologies by teachers, where hands-on approach had the largest mean ($M = 3.12, SD = 0.64$) with more than half (73.5%) of teachers implementing or just started implementing this methodology in science classes. The least used methodology was learning cycle ($M = 1.29, SD = 0.46$) and about a quarter (29.4%) of teachers had just starting implementing this methodology. Teachers' use of methodologies that develop thinking were just about the same where no teachers indicated they were proficient.

### Table 23

*Descriptive Statistics for Methodologies by Teachers (N = 68)*

<table>
<thead>
<tr>
<th>Methodologies</th>
<th>Number and (Percentages) of Responses</th>
<th>$M$</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Hands-on Approach</td>
<td>0</td>
<td>10 (14.7)</td>
<td>40 (58.8)</td>
</tr>
<tr>
<td>Concept Attainment</td>
<td>6</td>
<td>58 (85.3)</td>
<td>4 (5.9)</td>
</tr>
<tr>
<td>Inquiry Approach</td>
<td>0</td>
<td>54 (79.4)</td>
<td>14 (20.6)</td>
</tr>
<tr>
<td>Deductive Reasoning</td>
<td>6</td>
<td>41 (60.3)</td>
<td>20 (29.4)</td>
</tr>
<tr>
<td>Learning Cycle</td>
<td>48</td>
<td>20 (29.4)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Taba Inductive</td>
<td>11</td>
<td>57 (83.8)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Project-based Learning</td>
<td>0</td>
<td>39 (57.4)</td>
<td>25 (36.8)</td>
</tr>
</tbody>
</table>

*Note.* 1=Not Using, 2=Started Implementing, 3=Implementing, 4=Proficient User.
Most teachers indicated they were just starting or are implementing such methodologies as: (a) concept attainment ($M = 1.97, SD = 0.39$), (b) inquiry approach ($M = 2.21, SD = 0.41$), deductive reasoning ($M = 2.24, SD = 0.63$), and Taba inductive ($M = 1.84, SD = 0.37$).

Null Hypothesis 1. There are no differences among the three classroom configurations (multigrade, two-grade, and single-grade) by teachers’ use of the following methodologies: (a) hands-on approach, (b) concept attainment, (c) inquiry approach, (d) deductive reasoning, (e) learning cycle, (d) Taba inductive, and (e) project-based learning in teaching science in the Seventh-day Adventist school system. Table 24 shows the means and standard deviations by classroom configuration and analysis of variance results for use of methodologies by teachers. Post Hoc multiple comparisons using Student-Newman-Keuls were done in order to determine statistical differences among the three classroom configurations. The following results were noted:

1. There are no differences among the three classroom configurations by teachers’ use of hands-on approach. The null hypothesis was retained.

2. There are differences among the three classroom configurations by teachers’ use of concept attainment. Teachers in the multigrade or two-grade classroom configurations are more likely to have started implementing concept attainment than are teachers in single-grade classroom configurations. The null hypothesis was rejected.

3. There are no differences among the three classroom configurations by teachers’ use of the inquiry approach. The null hypothesis was retained.
Table 24

*Means and Standard Deviations for Methodologies by Classroom Configurations with Analysis of Variance Results (N =68)*

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Classroom Configurations</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Multigrade (n=41)</td>
<td>Two-grade (n=17)</td>
<td>Single-grade (n=10)</td>
<td>F</td>
<td>p</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Hands-on Approach</td>
<td></td>
<td>3.05</td>
<td>0.59</td>
<td>3.06</td>
<td>0.66</td>
<td>3.50</td>
</tr>
<tr>
<td>Concept Attainment</td>
<td></td>
<td>2.07</td>
<td>0.26</td>
<td>1.94</td>
<td>0.43</td>
<td>1.60</td>
</tr>
<tr>
<td>Inquiry Approach</td>
<td></td>
<td>2.12</td>
<td>0.33</td>
<td>2.24</td>
<td>0.44</td>
<td>2.50</td>
</tr>
<tr>
<td>Deductive Reasoning</td>
<td></td>
<td>2.10</td>
<td>0.62</td>
<td>2.35</td>
<td>0.61</td>
<td>2.60</td>
</tr>
<tr>
<td>Learning Cycle</td>
<td></td>
<td>1.15</td>
<td>0.36</td>
<td>1.47</td>
<td>0.51</td>
<td>1.60</td>
</tr>
<tr>
<td>Taba Inductive</td>
<td></td>
<td>1.78</td>
<td>0.42</td>
<td>1.94</td>
<td>0.24</td>
<td>1.90</td>
</tr>
<tr>
<td>Project-based Learning</td>
<td></td>
<td>2.10</td>
<td>0.40</td>
<td>2.88</td>
<td>0.60</td>
<td>3.00</td>
</tr>
</tbody>
</table>

* Denotes $p < 0.01$, $df = 2, 65$.
4. There are no differences among the three classroom configurations by teachers' use of deductive reasoning. The null hypothesis was retained.

5. There are differences among the three classroom configurations by teachers' use of the learning cycle. Teachers in the single-grade classroom configuration, while similar to two-grade, are more likely to have started implementing the learning cycle than multigrade classroom configuration. However, there was no difference in teachers' use of methodology between the two-grade and multigrade classroom configuration. The null hypothesis was rejected.

6. There are no differences among the three classroom configurations by teachers' use of Taba inductive reasoning. The null hypothesis was retained.

7. There are differences among the three classroom configurations by teachers' use of project-based learning. Teachers in single-grade and two-grade classroom configurations are more likely to have been implementing project-based learning than teachers in the multigrade classroom configuration. The null hypothesis was rejected.

Table 25 presents the results for teachers' perceptions of the extent to which students acquired science skills. Almost half (48.5%) of teachers indicated students did not meet the skill for use of appropriate tools and techniques. For the use of identifying and clarifying questions, about 70.2% of teachers indicated students did not meet or did not meet the skill too well. More than half (58.8%) of the teachers indicated that the skill scientific method was not met very well by students. On average, teachers indicated that the science skills were not met very well.
Table 25

**Descriptive Statistics for Students’ Acquisition of Science Skills by Teachers (N = 68)**

<table>
<thead>
<tr>
<th>Science Skills</th>
<th>Number and (Percentages) of Responses</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Systematic Observation</td>
<td>20 (29.4)</td>
<td>31 (45.6)</td>
<td>15 (22.1)</td>
</tr>
<tr>
<td>Use of Tools/Techniques</td>
<td>33 (48.5)</td>
<td>21 (30.9)</td>
<td>11 (16.2)</td>
</tr>
<tr>
<td>Identifying/Clarifying</td>
<td>12 (17.6)</td>
<td>29 (42.6)</td>
<td>20 (29.4)</td>
</tr>
<tr>
<td>Scientific Method</td>
<td>10 (14.7)</td>
<td>40 (58.8)</td>
<td>15 (22.1)</td>
</tr>
</tbody>
</table>

*Note. 1=Not Met at All, 2=Not Met Too Well, 3=Generally Met Well, 4=Met Very Well.*

Null Hypothesis 2. Among the three classroom configurations, there are no differences by teachers’ perceptions of students’ ability to: (a) engage in systematic observation of the environment, (b) use of appropriate tools and techniques, (c) identify and clarify questions, and (d) engage in the scientific method in science education in the Seventh-day Adventist school system.

Table 26 shows the means and standard deviations by classroom configurations and analysis of variance results for teachers’ perceptions of science skills acquired by students.

Post Hoc multiple comparisons using Student-Newman-Keuls were done in order to determine statistical differences among the three classroom configurations. The following results were noted:
Table 26

Means and Standard Deviations for Science Skills by Classroom Configurations with Analysis of Variance Results ($N = 68$)

<table>
<thead>
<tr>
<th>Classroom Configurations</th>
<th>Multigrade ($n=41$)</th>
<th>Two-grade ($n=17$)</th>
<th>Single-grade ($n=10$)</th>
<th>$F$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
</tr>
<tr>
<td>Observation of Environment</td>
<td>1.56</td>
<td>0.59</td>
<td>2.29</td>
<td>0.47</td>
<td>3.20</td>
</tr>
<tr>
<td>Gathering Tools/Techniques</td>
<td>1.27</td>
<td>0.44</td>
<td>2.12</td>
<td>0.78</td>
<td>3.20</td>
</tr>
<tr>
<td>Identifying/Clarifying</td>
<td>1.90</td>
<td>0.70</td>
<td>3.12</td>
<td>0.78</td>
<td>2.70</td>
</tr>
<tr>
<td>Scientific Method</td>
<td>1.83</td>
<td>0.54</td>
<td>2.65</td>
<td>0.61</td>
<td>2.70</td>
</tr>
</tbody>
</table>

* Denotes $p < 0.01$, $df = 2, 65$.  

1. There are differences among the three classroom configurations by students' ability to engage in systematic observation of the environment. Teachers in the single-grade classroom configuration are more likely to engage students in systematic observation of the environment than teachers in two-grade and multigrade classroom configurations. Teachers in a two-grade classroom configuration are more likely to engage students in the systematic observation of the environment than teachers in the multigrade classroom configuration. The null hypothesis was rejected.
2. There are differences among the three classroom configurations by students’ ability to use gathering tools and techniques. Teachers in the single-grade classroom configuration are more likely to engage students in the use of tools and techniques in science investigation than teachers in two-grade and multigrade classroom configurations. Teachers in a two-grade classroom configuration are more likely to engage students in the use of tools and techniques in science investigations than teachers in the multigrade classroom configuration. The null hypothesis was rejected.

3. There are differences among the three classroom configurations by students’ ability to use identifying and clarifying questions. Teachers in the two-grade and single-grade classroom configurations are more likely to have students use identifying and clarifying questions in science investigations than teachers in the multigrade classroom configuration. The null hypothesis was rejected.

4. There are differences among the three classroom configurations by students’ ability to engage in the scientific method. Teachers in the two-grade and single grade classroom configurations are more likely to have students engage in the use of the scientific method in science investigations than teachers in the multigrade classroom configuration. The null hypothesis was rejected.

Table 27 shows that almost all (97.1%) teachers strongly disagreed that a science laboratory was available for use in science education. There were no movable laboratory tables available for use in the three classroom configurations. Only 2.9% of teachers strongly agreed that laboratory materials and equipment were readily available for them to use. More than three-fourths (79.1%) of teachers agreed or strongly agreed that hands-on
manuals were available for them to use.

Null Hypothesis 3. Among the three classroom configurations, there are no differences by the availability of science resources for use by teachers: (a) science laboratory, (b) movable laboratory table, (c) laboratory materials, (d) laboratory equipment, and (e) hands-on manuals for use by teachers in science education in the Seventh-day Adventist school system.

Table 27

*Descriptive Statistics for Science Resources by Teachers (N = 68)*

<table>
<thead>
<tr>
<th>Science Resources</th>
<th>Number and (Percentages) of Responses</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1  2  3  4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory Room</td>
<td>66 (97.1) 0 (0.0) 0 (0.0) 2 (2.9)</td>
<td>1.09</td>
<td>0.51</td>
</tr>
<tr>
<td>Movable Table</td>
<td>0 (0.0) 0 (0.0) 0 (0.0) 0 (0.0)</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Laboratory Materials</td>
<td>30 (44.1) 36 (52.9) 0 (0.0) 2 (2.9)</td>
<td>1.62</td>
<td>0.65</td>
</tr>
<tr>
<td>Laboratory Equipment</td>
<td>35 (51.0) 31 (45.6) 0 (0.0) 2 (2.9)</td>
<td>1.54</td>
<td>0.66</td>
</tr>
<tr>
<td>Hands-on Manual</td>
<td>1 (1.5) 13 (19.1) 41 (60.3) 13 (19.1)</td>
<td>2.97</td>
<td>0.67</td>
</tr>
</tbody>
</table>

*Note.* 1=Strongly Disagree, 2=Disagree, 3=Agree, 4=Strongly Agree.

Table 28 shows the means and standard deviations by classroom configurations and analysis of variance results for science resources available for use by teachers in the three classroom configurations.
Table 28

Means and Standard Deviations for Science Resources by Classroom Configurations with Analysis of Variance Results (N = 68)

<table>
<thead>
<tr>
<th>Classroom Configurations</th>
<th>Multigrade (n=41)</th>
<th>Two-grade (n=17)</th>
<th>Single-grade (n=10)</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab. Room</td>
<td>1.00 0.00</td>
<td>1.00 0.00</td>
<td>1.60 1.26</td>
<td>6.93</td>
<td>0.002*</td>
</tr>
<tr>
<td>Materials</td>
<td>1.49 0.51</td>
<td>1.47 0.51</td>
<td>2.40 0.84</td>
<td>11.18</td>
<td>0.000*</td>
</tr>
<tr>
<td>Equipment</td>
<td>1.37 0.49</td>
<td>1.65 0.49</td>
<td>2.10 1.10</td>
<td>61.20</td>
<td>0.004*</td>
</tr>
<tr>
<td>Hands-on Manual</td>
<td>2.83 0.70</td>
<td>3.00 0.50</td>
<td>3.50 0.53</td>
<td>4.49</td>
<td>0.015</td>
</tr>
</tbody>
</table>

* Denotes $p < 0.01$, $df = 2, 65.$

When Post Hoc multiple comparisons using Student-Newman-Keuls were done in order to determine statistical differences among the three classroom configurations, the following results were noted:

1. There are differences among the three classroom configurations by the availability of science laboratory for use by teachers. Teachers in the single-grade classroom configuration are more likely to have a science laboratory available for them to use in science education than teachers in two-grade and multigrade classroom.
configurations. The null hypothesis was rejected.

2. There are differences among the three classroom configurations by the availability of laboratory materials for use by teachers. Teachers in the single-grade classroom configuration are more likely to have science materials available for them to use in science education than teachers in two-grade and multigrade classroom configurations. The null hypothesis was rejected.

3. There are differences among the three classroom configurations by the availability of laboratory equipment for use by teachers. Teachers in a single-grade classroom configuration, while similar to two-grade classroom configuration, are more likely to have laboratory equipment available for them to use than teachers in the multigrade classroom configuration. However, there were no differences between two-grade and multigrade classroom configurations and the availability of laboratory equipment for use by teachers. The null hypothesis was rejected.

4. There are no differences among the three classroom configurations by the use of a hands-on manual by teachers. The null hypothesis was retained.

Table 29 shows that the physical science content area ($M = 1.87, SD = 0.75$) was not met very well. Only 2.9% of teachers indicated this area was met very well. However, the earth/space science ($M = 2.91, SD = 0.54$) and, to some extent, life science ($M = 2.66, SD = 0.54$) areas were generally met well. More than three-fourths (83.8%) of teachers indicated that the content area of science/technology was not met very well.

Null Hypothesis 4. Among the three classroom configurations, there are no differences in teachers' coverage of science domains: (a) earth and space science,
Table 29

*Descriptive Statistics for Coverage of Science Content Areas by Teachers (N = 68)*

<table>
<thead>
<tr>
<th>Content Areas</th>
<th>Number and (Percentages) of Responses</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1  2  3  4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earth/Space</td>
<td>0 (0.0) 13 (19.1) 48 (70.6) 7 (10.3)</td>
<td>2.91</td>
<td>0.54</td>
</tr>
<tr>
<td>Life Science</td>
<td>1 (1.5) 22 (32.4) 44 (64.7) 1 (1.5)</td>
<td>2.66</td>
<td>0.54</td>
</tr>
<tr>
<td>Physical Science</td>
<td>22 (32.4) 35 (51.5) 9 (13.2) 2 (2.9)</td>
<td>1.87</td>
<td>0.75</td>
</tr>
<tr>
<td>Science/Technology</td>
<td>0 (0.0) 57 (83.8) 10 (14.7) 1 (1.5)</td>
<td>2.17</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Note. 1=Not Met at All, 2=Not Met Too Well, 3=Generally Well Met, 4=Met Very Well.

(b) life science, (c) physical science, and (d) science and technology in science education in the Seventh-day Adventist school system.

Table 30 shows the means and standard deviations by classroom configurations and analysis of variance results for the coverage of science content areas by teachers in the three classroom configurations.

Post Hoc multiple comparisons using Student-Newman-Keuls were done in order to determine statistical differences among the three classroom configurations. The following results were noted:

1. There are no differences among the three classroom configurations in teachers' coverage of earth/space science. The null hypothesis was retained.

2. There are no differences among the three classroom configurations in teachers’
Table 30

Means and Standard Deviations for Coverage of Content Areas by Classroom Configurations with Analysis of Variance Results (N = 68)

<table>
<thead>
<tr>
<th>Classroom Configurations</th>
<th>Multigrade (n=41)</th>
<th>Two-grade (n=17)</th>
<th>Single-grade (n=10)</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Content Areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earth/Space</td>
<td>2.88</td>
<td>0.56</td>
<td>2.88</td>
<td>0.49</td>
<td>3.10</td>
</tr>
<tr>
<td>Life Science</td>
<td>2.78</td>
<td>0.48</td>
<td>2.53</td>
<td>0.51</td>
<td>2.40</td>
</tr>
<tr>
<td>Physical Science</td>
<td>1.68</td>
<td>0.57</td>
<td>1.71</td>
<td>0.59</td>
<td>2.90</td>
</tr>
<tr>
<td>Science/Technology</td>
<td>2.10</td>
<td>0.30</td>
<td>2.29</td>
<td>0.47</td>
<td>2.30</td>
</tr>
</tbody>
</table>

* Denotes p < 0.01, df = 2, 65.

coverage of life science. The null hypothesis was retained.

3. There are no differences among the three classroom configurations in teachers' coverage of physical science. Teachers in the single-grade classroom configuration were more likely to cover content in physical science than teachers in the two-grade and multigrade classroom configurations. The null hypothesis was rejected.

4. There are no differences among the three classroom configurations in teachers' coverage of science/technology. The null hypothesis was retained.
Null Hypothesis 5. There are no differences among the three classroom configurations in the number of science credits completed by teachers in the Seventh-day Adventist school system.

When the Kruskal-Wallis test was performed, there were differences among the three classroom configurations in the number of credits completed in science by teachers. Teachers in the single-grade classroom configuration were more likely to have completed more credits in college-level science courses than teachers in the two-grade and multigrade classroom configurations (see Table 31). The null hypothesis was rejected.

Table 31

Kruskal-Wallis Test of Science Credits Completed by Teachers and Classroom Configurations (N = 68)

<table>
<thead>
<tr>
<th>Variable Credits Completed</th>
<th>N</th>
<th>Mean Rank</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multigrade</td>
<td>41</td>
<td>32.04</td>
<td>.013*</td>
</tr>
<tr>
<td>Two-grade</td>
<td>17</td>
<td>33.65</td>
<td></td>
</tr>
<tr>
<td>Single-grade</td>
<td>10</td>
<td>46.05</td>
<td></td>
</tr>
</tbody>
</table>

* Significant at $p < 0.01$ level, $df = 2, 67$. 

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Question 2: What are students' perceptions of the teaching and learning process in a selected Union Conference of the Seventh-day Adventist school system?

Table 32 shows students encouraged by parents to succeed in this subject had the smallest mean ($M = 1.74$, $SD = 0.87$), where only 16.8% of students were sometimes or always encouraged by parents. About half (48.8%) of students sometimes or always completed their assignments. Less than half (47.7%) of students prepared for their test at least 2 days before the test. More than half (53%) of students seldom or never found home a conducive place to study. Just about a quarter (27.2%) of students sometimes or always read ahead in their textbook.

Table 32

Descriptive Statistics for Students' Behaviors by Students ($N = 422$)

<table>
<thead>
<tr>
<th>Students' Behaviors</th>
<th>Number and (Percentages) of Responses</th>
<th>$M$</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Never</td>
<td>Seldom</td>
<td>Sometimes</td>
</tr>
<tr>
<td>Complete Assignments</td>
<td>44 (10.4)</td>
<td>172 (40.8)</td>
<td>132 (31.3)</td>
</tr>
<tr>
<td>Encourage by Parents</td>
<td>206 (48.8)</td>
<td>145 (34.4)</td>
<td>47 (11.1)</td>
</tr>
<tr>
<td>Conducive to Study/Home</td>
<td>31 (7.3)</td>
<td>193 (45.7)</td>
<td>96 (22.7)</td>
</tr>
<tr>
<td>Read Ahead in Text</td>
<td>140 (33.2)</td>
<td>167 (39.6)</td>
<td>104 (24.6)</td>
</tr>
<tr>
<td>Preparedness for Test</td>
<td>50 (11.8)</td>
<td>171 (40.5)</td>
<td>120 (28.4)</td>
</tr>
</tbody>
</table>

Note. 1=Never, 2=Seldom, 3=Sometimes, 4=Always.
Null Hypothesis 6. Among the three classroom configurations, there are no differences in students’ perceptions of students’ variables in the teaching and learning process: (a) complete assignments, (b) encouraged by parents to succeed, (c) conducive to study at home, (d) read ahead in textbook, and (e) preparedness for test in science education in the Seventh-day Adventist school system.

Table 33 shows the means and standard deviations by classroom configurations and analysis of variance results for students’ perceptions of students’ behaviors in the teaching and learning process in science education.

When Post Hoc multiple comparisons using Student-Newman-Keuls were done in order to determine statistical differences among the three classroom configurations, the following results were noted:

1. There are differences among the three classroom configurations in students’ ability to complete assignment. Students in the single-grade classroom are more likely to complete their assignments than students in the two-grade and multigrade classroom configurations. Students in the two-grade classroom configuration are more likely to complete their assignments than students in the multi-grade classroom configuration. The null hypothesis was rejected.

2. There are differences among the three classroom configurations in students being encouraged by parents to succeed. Students in the two-grade classroom configurations are more likely to be encouraged by their parents to succeed in science than students in the multi-grade and single-grade classroom configurations. The null hypothesis was rejected.
Table 33

*Means and Standard Deviations for Students' Behaviors by Classroom Configurations with Analysis of Variance Results (N = 422)*

<table>
<thead>
<tr>
<th>Classroom Configurations</th>
<th>Multigrade (n=170)</th>
<th>Two-grade (n=129)</th>
<th>Single-grade (n=123)</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Students' Behaviors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completion of Assignment</td>
<td>2.16 0.69</td>
<td>2.70 0.96</td>
<td>2.96 0.87</td>
<td>34.96</td>
<td>0.000*</td>
</tr>
<tr>
<td>Encouraged by Parents</td>
<td>1.66 0.85</td>
<td>1.95 0.82</td>
<td>1.63 0.92</td>
<td>5.50</td>
<td>0.004*</td>
</tr>
<tr>
<td>Study at Home</td>
<td>2.89 0.84</td>
<td>2.47 0.89</td>
<td>2.46 1.01</td>
<td>11.40</td>
<td>0.000*</td>
</tr>
<tr>
<td>Read Ahead in Textbook</td>
<td>1.97 0.73</td>
<td>1.95 0.87</td>
<td>1.98 0.90</td>
<td>0.025</td>
<td>0.975</td>
</tr>
<tr>
<td>Preparedness for Test</td>
<td>2.62 0.96</td>
<td>2.27 0.85</td>
<td>2.75 0.92</td>
<td>9.33</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

* Denotes $p < 0.01$, df = 2, 419.

3. There are differences among the three classroom configurations in students' ability to study at home. Students in the multigrade classroom configuration are more likely to be able to study at home than students in the two-grade and single-grade classroom configurations. The null hypothesis was rejected.

4. There are no differences among the three classroom configurations in students' ability to read ahead in textbook. The null hypothesis was retained.
5. There are differences among the three classroom configurations in students’ ability to prepare for tests. Students in single-grade and multigrade classroom configurations are more likely to prepare for their test ahead of time than students in the two-grade classroom configuration. The null hypothesis was rejected. Table 34 shows the highest means obtained were students being able to voice their opinion in class \((M = 2.84, SD = 0.74)\) and teachers grading students’ work fairly \((M = 2.84, SD = 0.84)\). About a fourth (26.3\%) of teachers sometimes or always had interesting lessons. About half (53.1\%) of teachers were sometimes or always available outside of class to help students. More than half (69\%) were warm and approachable. A large percentage (65.9\%) of students indicated that teachers were sometimes or always trustworthy.

Null Hypothesis 7. Among the three classroom configurations, there are no differences in students’ perceptions of teachers’ variables in the teaching and learning process in science education: (a) subject made interesting, (b) teacher availability, (c) teacher warm and approachable, (d) able to voice opinion in class, (e) fairness of teacher, and (f) trustworthiness in science education in the Seventh-day Adventist school system.

Table 35 shows the means and standard deviations by classroom configurations and analysis of variance results for students’ perceptions of teachers’ variables in the teaching and learning process in science education.

When Post Hoc multiple comparisons using Student-Newman-Keuls were done in order to determine statistical differences among the three classroom configurations, the following results were noted:
Table 34

Descriptive Statistics for Students’ Perceptions of Teachers’ Behaviors by Students
(N = 422)

<table>
<thead>
<tr>
<th>Teachers’ Behaviors</th>
<th>Number and (Percentages) of Responses</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Never</td>
<td>Seldom</td>
<td>Sometimes</td>
</tr>
<tr>
<td>Subject Interesting</td>
<td>89 (21.1)</td>
<td>222 (52.6)</td>
<td>102 (24.2)</td>
</tr>
<tr>
<td>Teacher Availability</td>
<td>50 (11.8)</td>
<td>148 (35.1)</td>
<td>205 (48.6)</td>
</tr>
<tr>
<td>Warm and Approachable</td>
<td>28 (6.6)</td>
<td>103 (24.4)</td>
<td>245 (58.1)</td>
</tr>
<tr>
<td>Able to Voice Opinion</td>
<td>25 (5.9)</td>
<td>93 (22.0)</td>
<td>229 (54.3)</td>
</tr>
<tr>
<td>Graded Fairly</td>
<td>31 (7.3)</td>
<td>94 (22.3)</td>
<td>208 (49.3)</td>
</tr>
<tr>
<td>Trustworthiness</td>
<td>31 (7.3)</td>
<td>113 (26.8)</td>
<td>211 (50.0)</td>
</tr>
</tbody>
</table>

Note. 1=Never, 2=Seldom, 3=Sometimes, 4=Always.

1. There are differences among the three classroom configurations in students’ perceptions of teachers making the subject interesting. Students in the single-grade classroom configuration are similar to the two-grade classroom configuration and are more likely to perceive teachers making science interesting than students in multigrade classroom configurations. There was no difference between students in the multigrade and two-grade classroom configurations and their perception of teachers making science interesting. The null hypothesis was rejected.

2. There are differences among the three classroom configurations in students’ perceptions of teacher being warm and approachable. Students in the multigrade and single-grade classroom configurations are more likely to perceive teachers as warm and
Table 35

Means and Standard Deviations for Students’ Perceptions of Teachers’ Behaviors by Classroom Configurations with Analysis of Variance Results (N = 422)

<table>
<thead>
<tr>
<th>Teachers’ Behaviors</th>
<th>Multigrade (n=170)</th>
<th>Two-grade (n=129)</th>
<th>Single-grade (n=123)</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Subject made Interesting</td>
<td>1.94</td>
<td>0.70</td>
<td>2.08</td>
<td>0.63</td>
<td>2.26</td>
</tr>
<tr>
<td>Availability of Teacher</td>
<td>2.64</td>
<td>0.55</td>
<td>2.32</td>
<td>0.72</td>
<td>2.35</td>
</tr>
<tr>
<td>Warm and Approachable</td>
<td>2.87</td>
<td>0.62</td>
<td>2.49</td>
<td>0.74</td>
<td>2.80</td>
</tr>
<tr>
<td>Voice Opinion</td>
<td>2.91</td>
<td>0.62</td>
<td>2.60</td>
<td>0.87</td>
<td>2.98</td>
</tr>
<tr>
<td>Graded Fairly</td>
<td>2.81</td>
<td>0.70</td>
<td>2.57</td>
<td>0.85</td>
<td>3.16</td>
</tr>
<tr>
<td>Trustworthiness</td>
<td>2.90</td>
<td>0.62</td>
<td>2.55</td>
<td>0.94</td>
<td>2.73</td>
</tr>
</tbody>
</table>

* Denotes p < 0.01, df = 2, 419.
approachable than students in the two-grade classroom configuration. The null hypothesis was rejected.

3. There are differences among the three classroom configurations in students being able to voice an opinion in class. Students in the multigrade and single-grade classroom configurations are more likely to be allowed to voice their opinion in class than students in the two-grade classroom configuration. The null hypothesis was rejected.

4. There are differences among the three classroom configurations in students' perceptions of being graded fairly by teachers. Students in the single-grade classroom configuration are more likely to perceive being graded fairly by their teachers than students in the two-grade and multigrade classroom configurations. The null hypothesis was rejected.

5. There are differences among the three classroom configurations in students having trust and confidence in teachers. Students in the multigrade classroom configuration are similar to the single-grade classroom configuration and are more likely to have more trust and confidence in their teachers than two-grade classroom configuration. There are no differences between the two-grade and single-grade classroom configurations by students' having trust and confidence in their teachers. The null hypothesis was rejected.

Table 36 shows that more than three-fourths (82.4%) of the students indicated that laboratory exercises were seldom or never used in schools. About half (55.7%) of the students indicated that it was easy to concentrate in class; 50.2% of students noted that
Table 36

Descriptive Statistics for Curriculum Variables by Students (N = 422)

<table>
<thead>
<tr>
<th>Curriculum Factors</th>
<th>Number and (Percentages) of Response</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Never</td>
<td>Seldom</td>
<td>Sometimes</td>
</tr>
<tr>
<td>Easy to Concentrate</td>
<td>14 (3.3)</td>
<td>153 (36.3)</td>
<td>235 (55.7)</td>
</tr>
<tr>
<td>Textbook Understandable</td>
<td>72 (17.1)</td>
<td>212 (50.2)</td>
<td>102 (24.2)</td>
</tr>
<tr>
<td>Too Much Work</td>
<td>13 (3.1)</td>
<td>25 (29.6)</td>
<td>157 (37.2)</td>
</tr>
<tr>
<td>Corrected Assignments</td>
<td>68 (16.1)</td>
<td>185 (43.8)</td>
<td>150 (35.5)</td>
</tr>
<tr>
<td>Content Understandable</td>
<td>68 (16.1)</td>
<td>198 (46.9)</td>
<td>146 (34.6)</td>
</tr>
<tr>
<td>Difficult Concepts</td>
<td>59 (14.0)</td>
<td>212 (50.2)</td>
<td>140 (33.2)</td>
</tr>
<tr>
<td>Laboratory Exercises</td>
<td>112 (26.5)</td>
<td>236 (55.9)</td>
<td>60 (14.2)</td>
</tr>
</tbody>
</table>

Note. 1=Never, 2=Seldom, 3=Sometimes, 4=Always.

content in textbook seldom was understandable, as well as examples given to explain difficult concepts. About two-thirds (67.3%) of students indicated that too much work was sometimes or always given. More than half (63.0%) of students noted that content was seldom or never understandable, and 59.9% of students indicated that explanations were seldom or never given for corrected assignments.

Null Hypothesis 8. Among the three classroom configurations, there are no differences in students' perceptions of curriculum variables in the teaching and learning process in science education: (a) easy to concentrate in class, (b) textbook easy to understand, (c) amount of work given, (d) explanations given for corrected assignments, (e) content presented in an understandable manner, (f) examples given to explain difficult concepts, and (g) laboratory exercises given in science education in the Seventh-day...
Adventist school system.

Table 37 shows the means and standard deviations by classroom configurations and analysis of variance results for students' perceptions of curriculum variables in the teaching and learning process in science education.

When Post Hoc multiple comparisons using Student-Newman-Keuls were done to determine statistical differences among the three classroom configurations, the following results were obtained:

1. There are differences among the three classroom configurations in students' ability to concentrate in science class. Students in the multigrade classroom configurations are more likely to be able to concentrate in science class than students in the single-grade and two-grade classroom configurations. The null hypothesis was rejected.

2. There are differences among the three classroom configurations in students' ability to understand the science textbook. Students in the single-grade classroom configuration are more likely to understand their science textbook than students in the two-grade and multigrade classroom configurations. The null hypothesis was rejected.

3. There are no differences in the three classroom configurations in students perceiving that too much work is given. The null hypothesis was retained.

4. There are differences in the three classroom configurations in students' perceptions of teachers giving explanations and correcting assignments. Students in the single-grade classroom configuration are more likely to have teachers give explanations for corrected assignments than students in the two-grade and multigrade classroom configurations.
Table 37

Means and Standard Deviations for Curriculum Variables by Classroom Configurations with Analysis of Variance Results (N = 422)

<table>
<thead>
<tr>
<th>Curriculum Variables</th>
<th>Multigrade (n=170)</th>
<th>Two-grade (n=129)</th>
<th>Single-grade (n=123)</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentrate in Class</td>
<td>2.76 0.66</td>
<td>2.51 0.60</td>
<td>2.53 0.58</td>
<td>7.92</td>
<td>0.000*</td>
</tr>
<tr>
<td>Textbook Easy to Understand</td>
<td>2.02 0.70</td>
<td>2.25 0.81</td>
<td>2.54 0.94</td>
<td>14.34</td>
<td>0.000*</td>
</tr>
<tr>
<td>Too Much Work</td>
<td>1.98 0.82</td>
<td>2.16 0.77</td>
<td>2.06 0.95</td>
<td>1.53</td>
<td>0.219</td>
</tr>
<tr>
<td>Explanations/Assignments</td>
<td>2.08 0.63</td>
<td>2.24 0.76</td>
<td>2.62 0.89</td>
<td>18.69</td>
<td>0.000*</td>
</tr>
<tr>
<td>Content Understandable</td>
<td>2.02 0.64</td>
<td>2.20 0.75</td>
<td>2.55 0.75</td>
<td>20.02</td>
<td>0.000*</td>
</tr>
<tr>
<td>Examples Given</td>
<td>2.04 0.64</td>
<td>2.29 0.65</td>
<td>2.48 0.81</td>
<td>14.46</td>
<td>0.000*</td>
</tr>
<tr>
<td>Laboratory Exercises Given</td>
<td>1.67 0.54</td>
<td>2.03 1.88</td>
<td>2.37 0.84</td>
<td>12.71</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

* Denotes $p < 0.01$, df = 2, 419.
configurations. The null hypothesis was rejected.

5. There are differences among the three classroom configurations in students' ability to understand the content. Students in the single-grade classroom configuration are more likely to find content understandable than students in the two-grade and multigrade classroom configurations. The null hypothesis was rejected.

*Question 3: As measured by the Iowa Test of Basic Skills, what is the performance of students in a selected Union Conference of the Seventh-day Adventist school system?*

Table 38 shows the descriptive statistics for science performance of students on ITBS (NCE) by classroom configurations. More than half of the students in the three classroom configurations obtained a score between 51-60, with multigrade scoring 58.2%, two-grade scoring 67.4%, and single-grade scoring 54.5%. About a third (33.6%) of students in the single-grade classroom configuration obtained a score higher than 61. About a quarter of students in the multigrade (28.8%) and two-grade (27.2%) classroom configurations obtained a score of less than 50.

Null Hypothesis 9. There are no differences among the three classroom configurations in students' science performance on the ITBS in the Seventh-day Adventist school system.

Table 39 shows the mean and standard deviations by classroom configurations and analysis of variance results for students' science. When Post Hoc multiple comparisons using Student-Newman-Keuls were done, the following was noted:
Table 38

*Descriptive Statistics by Classroom Configurations for Students’ ITBS (NCE) Science Scores (N = 422)*

<table>
<thead>
<tr>
<th>Subject Important</th>
<th>Number and (Percentages) of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Less than 50</td>
</tr>
<tr>
<td>Multigrade</td>
<td>49 (28.8)</td>
</tr>
<tr>
<td>Two-grade</td>
<td>35 (27.1)</td>
</tr>
<tr>
<td>Single-grade</td>
<td>11 (8.9)</td>
</tr>
</tbody>
</table>

Table 39

*Means and Standard Deviations for Students’ ITBS Science Scores by Classroom Configurations with Analysis of Variance Results (N = 422)*

<table>
<thead>
<tr>
<th>Classroom Configurations</th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multigrade</td>
<td>170</td>
<td>53.12</td>
<td>6.75</td>
<td>48.43</td>
<td>0.000*</td>
</tr>
<tr>
<td>Two-grade</td>
<td>129</td>
<td>54.17</td>
<td>4.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single-grade</td>
<td>123</td>
<td>60.48</td>
<td>7.86</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Denotes significance at 0.01 level, df = 2, 419.
There are differences among the three classroom configurations and students' performance on science scores. Students in the single-grade classroom configuration are more likely to do better than students in the two-grade and multigrade classroom configurations. The null hypothesis was rejected.

*Question 4: What selected variables are related to science performance as measured by the Iowa Test of Basic Skills in a selected Union Conference of the Seventh-day Adventist school system?*

Null Hypothesis 10. There are no linear relationships between students' achievement as measured by their ITBS science scores (dependent variable) and the five independent variables of students' variables: (a) complete assignment, (b) encouraged by parents to succeed, (c) difficult to study at home, (d) read ahead in textbook, and (e) preparedness for test in the Seventh-day Adventist school system.

Table 40 shows the correlations between the five student variables and students' achievement on their ITBS scores. Assignment completed by students showed a moderate correlation, while the other variables, with the exception of encouraged by parents to succeed, had minimal correlations.

Table 41 shows the results of regression analysis for the students' variables and science achievement using the stepwise variable selection method. As a set the four student variables account for 31% of the variance in the ITBS science scores. This is significant at the 0.01 level. The best predictor is completion of assignments ($\beta = 0.48$). Since $\beta$ were significant, the null hypothesis was rejected.
Table 40

Means, Standard Deviations, and Correlations Between Students’ ITBS Science Scores and Students’ Perception of Students’ Behaviors (N = 422)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ITBS Science Score</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Assignment Completed</td>
<td>.50**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Encouraged by Parents</td>
<td>.02</td>
<td>.01</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Conducive to Study</td>
<td>.18**</td>
<td>-.01</td>
<td>.03</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Read Ahead</td>
<td>.18**</td>
<td>.11**</td>
<td>-.19**</td>
<td>-.01</td>
<td>1.00</td>
</tr>
<tr>
<td>6</td>
<td>Preparation for Test</td>
<td>.18**</td>
<td>.08</td>
<td>.07</td>
<td>.056</td>
<td>.10*</td>
</tr>
</tbody>
</table>

Mean 55.59 2.56 1.74 2.64 1.97 2.55

Standard Deviations 7.32 .90 .87 .93 .83 .93

*Significant at 0.05. ** Significant at 0.01.

Table 41

Linear Regression Results for Students’ ITBS Science Scores and Students’ Perceptions of Students’ Behaviors (N = 422)

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>37.52</td>
<td>1.53</td>
<td></td>
<td>24.59</td>
<td>0.000</td>
</tr>
<tr>
<td>Completion of Assignment</td>
<td>3.87</td>
<td>0.33</td>
<td>0.48</td>
<td>11.59</td>
<td>0.000</td>
</tr>
<tr>
<td>Conducive to Study</td>
<td>1.42</td>
<td>0.32</td>
<td>0.18</td>
<td>4.42</td>
<td>0.000</td>
</tr>
<tr>
<td>Preparation for Test</td>
<td>0.99</td>
<td>0.32</td>
<td>0.13</td>
<td>3.07</td>
<td>0.002</td>
</tr>
<tr>
<td>Read Ahead In Text</td>
<td>0.96</td>
<td>0.36</td>
<td>0.11</td>
<td>2.65</td>
<td>0.008</td>
</tr>
</tbody>
</table>

Note. $R^2 = 0.31$, $F_{(6,417)} = 47.14$, $p = 0.000$.

Null Hypothesis 11. There are no linear relationships between students’ achievement as measured by their ITBS science scores and the six independent variables of teachers’ variables: (a) subject made interesting, (b) teacher availability, (c) teacher
warm and approachable, (d) able to voice opinion in class, (e) fairness of teacher, and (f) trustworthiness in the Seventh-day Adventist school system.

Table 42 shows the correlations between the six teacher variables and students' achievement on their ITBS scores. Subject made interesting and students' assignments graded fairly showed moderate correlations. All the other correlations, with the exception of teacher availability, were minimal.

Table 42

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ITBS Science Score</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Subject Interesting</td>
<td>.44**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Teacher Available</td>
<td>.03</td>
<td>.09*</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Teacher Warmth</td>
<td>.33**</td>
<td>.33**</td>
<td>.31**</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Voice Opinion</td>
<td>.37**</td>
<td>.20**</td>
<td>.11*</td>
<td>.35**</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Graded Fairly</td>
<td>.44**</td>
<td>.24**</td>
<td>.08**</td>
<td>.29**</td>
<td>.22**</td>
<td>1.00</td>
</tr>
<tr>
<td>7</td>
<td>Trustworthiness</td>
<td>.21**</td>
<td>.20**</td>
<td>.21**</td>
<td>.37**</td>
<td>.20**</td>
<td>.25**</td>
</tr>
</tbody>
</table>

Mean 55.59 2.07 2.48 2.73 2.84 2.84 2.74
Standard Deviations 7.32 .73 .73 .76 .74 .84 .81

* Significant at 0.05. ** Significant at 0.01.

Table 43 shows the results of regression analysis for the teachers' variables and science achievement using the stepwise variable selection method. As a set, the three teachers' variables account for 37% of the variance in the ITBS science scores. This is
Table 43

*Linear Regression Results for Students' ITBS Science Scores and Students' Perceptions of Teachers' Behaviors (N = 422)*

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>34.76</td>
<td>1.39</td>
<td>24.94</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Subject Made Interesting</td>
<td>3.25</td>
<td>0.41</td>
<td>0.33</td>
<td>8.03</td>
<td>0.000</td>
</tr>
<tr>
<td>Graded Fairly</td>
<td>2.68</td>
<td>0.36</td>
<td>0.31</td>
<td>7.54</td>
<td>0.000</td>
</tr>
<tr>
<td>Voice Opinion</td>
<td>2.28</td>
<td>0.38</td>
<td>0.24</td>
<td>6.04</td>
<td>0.000</td>
</tr>
</tbody>
</table>

*Note. R² = 0.37, F(3, 418) = 81.68, p = 0.000.*

significant at the 0.01 level. The best predictor is subject made interesting (β = 0.33).

Since β were significant, the null hypothesis was rejected.

Null Hypothesis 12. There are no linear relationships between students' achievement as measured by their ITBS science scores and the seven independent variables of curriculum factors: (a) easy to concentrate in class, (b) textbook easy to understand, (c) amount of work given, (d) explanation given for corrected assignment, (e) content presented in an understandable manner, (f) examples given to explain difficult questions, and (g) laboratory exercises given in the Seventh-day Adventist school system.

Table 44 shows the correlations between the seven curriculum variables and students' achievement on their ITBS scores. Content understandable, explanations given for difficult concepts, and assignments corrected were the three moderate correlations. All the other correlations, with the exception of too much work given were minimal.
Table 44

Mean, Standard Deviations, and Correlations Between Students' ITBS Science Scores and Students' Perceptions of Curriculum Variables (N = 422)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ITBS Science Scores</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Laboratory Room</td>
<td>.26**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Explanation Given</td>
<td>.44**</td>
<td>.11**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Content Understandable</td>
<td>.50**</td>
<td>.11**</td>
<td>.37**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Assignments Corrected</td>
<td>.44**</td>
<td>.18**</td>
<td>.34**</td>
<td>.38</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Too Much Work</td>
<td>.07</td>
<td>.02</td>
<td>.02</td>
<td>.08*</td>
<td>.07</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Textbook Difficult</td>
<td>.36**</td>
<td>.48**</td>
<td>.03</td>
<td>.23**</td>
<td>.29**</td>
<td>.17**</td>
<td>1.00</td>
</tr>
<tr>
<td>8</td>
<td>Easy to Concentrate</td>
<td>.27**</td>
<td>.13**</td>
<td>.09*</td>
<td>.11**</td>
<td>.12**</td>
<td>-.04</td>
<td>.06</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>55.59</td>
<td>1.99</td>
<td>2.24</td>
<td>2.23</td>
<td>2.28</td>
<td>2.05</td>
<td>2.24</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>7.32</td>
<td>1.22</td>
<td>.72</td>
<td>.74</td>
<td>.79</td>
<td>.85</td>
<td>.83</td>
<td>.63</td>
</tr>
</tbody>
</table>

* Significant at 0.05. ** Significant at 0.01.

Table 45 shows the results of regression analysis for the curriculum variables and science achievement using the stepwise variable selection method. As a set, the six curriculum variables account for 46% of the variance in the ITBS science scores. This is significant at the 0.01 level. The best predictor is Content presented by teacher is understandable (β = 0.27). Since β were significant, the null hypothesis was rejected.

Null Hypothesis 13. There are no linear relationships between the performance of schools as measured by their ITBS science scores and the seven independent variables in science methodologies: (a) hands-on approach, (b) concept attainment, (c) inquiry approach, (d) deductive reasoning, (c) learning cycle, (d) Taba inductive, and (e) project-based learning in the Seventh-day Adventist school system.
Table 45

Linear Regression Results for Students' ITBS Science Scores and Students' Perceptions of Curriculum Variables (N = 422)

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>30.44</td>
<td>1.51</td>
<td>20.13</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Content Understandable</td>
<td>2.64</td>
<td>0.41</td>
<td>0.27</td>
<td>6.40</td>
<td>0.000</td>
</tr>
<tr>
<td>Examples Given to Explain</td>
<td>2.00</td>
<td>0.41</td>
<td>0.20</td>
<td>4.84</td>
<td>0.000</td>
</tr>
<tr>
<td>Difficult Concepts</td>
<td>1.80</td>
<td>0.38</td>
<td>0.19</td>
<td>4.75</td>
<td>0.000</td>
</tr>
<tr>
<td>Explanations Given for Corrected Assignments</td>
<td>2.03</td>
<td>0.43</td>
<td>0.17</td>
<td>4.74</td>
<td>0.000</td>
</tr>
<tr>
<td>Easy to Concentrate in Class</td>
<td>1.65</td>
<td>0.34</td>
<td>0.19</td>
<td>4.93</td>
<td>0.000</td>
</tr>
<tr>
<td>Textbook Easy to Understand</td>
<td>0.82</td>
<td>0.22</td>
<td>0.14</td>
<td>3.67</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Note. $R^2 = 0.46$, $F(6, 415) = 58.06$, $p = 0.000$.

Table 46 shows the correlations between the seven methodologies variables and schools' ITBS. Deductive reasoning and hands-on approach were the two moderate correlations. All the other correlations, with the exception of concept attainment, were minimal.

Table 47 shows the results of regression analysis for the methodologies variables and science achievement using the stepwise variable selection method. As a set, the two methodology variables account for 30% of the variance in the ITBS science scores. This is significant at the 0.01 level. The best predictor is deductive reasoning ($\beta = 0.43$). Since $\beta$ were significant, the null hypothesis was rejected.
Table 46

Mean, Standard Deviations, and Correlations Between Schools' ITBS Science Scores and Teachers' Perceptions of Methodologies Variables (N = 68)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ITBS Science Scores</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Hand-on-Approach</td>
<td>.44**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Concept Attainment</td>
<td>.01</td>
<td>-.23*</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Inquiry Approach</td>
<td>.33**</td>
<td>.37**</td>
<td>-.25*</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Deductive Reasoning</td>
<td>.48**</td>
<td>.45**</td>
<td>-.34**</td>
<td>.51**</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Learning Cycle</td>
<td>.26*</td>
<td>-.02</td>
<td>-.12</td>
<td>.23*</td>
<td>.17</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Taba Inductive</td>
<td>.31**</td>
<td>.40**</td>
<td>-.03</td>
<td>.12</td>
<td>.23*</td>
<td>-.07</td>
<td>1.00</td>
</tr>
<tr>
<td>8</td>
<td>Project-based Learning</td>
<td>.35**</td>
<td>.04</td>
<td>.06</td>
<td>.01</td>
<td>.20*</td>
<td>.49**</td>
<td>.22**</td>
</tr>
<tr>
<td>Mean</td>
<td>54.85</td>
<td>3.11</td>
<td>1.97</td>
<td>2.21</td>
<td>2.23</td>
<td>1.23</td>
<td>1.83</td>
<td>2.49</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>7.32</td>
<td>0.64</td>
<td>0.38</td>
<td>0.41</td>
<td>0.63</td>
<td>0.46</td>
<td>0.37</td>
<td>0.61</td>
</tr>
</tbody>
</table>

* Significant at 0.05. ** Significant at 0.01.

Table 47

Linear Regression Results for Schools' ITBS Science Scores and Teachers' Perceptions of Methodologies Variables (N = 68)

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>35.67</td>
<td>3.87</td>
<td></td>
<td>14.28</td>
<td>0.000</td>
</tr>
<tr>
<td>Deductive Reasoning</td>
<td>5.02</td>
<td>1.25</td>
<td>0.43</td>
<td>4.01</td>
<td>0.000</td>
</tr>
<tr>
<td>Project-based Learning</td>
<td>3.20</td>
<td>1.28</td>
<td>0.27</td>
<td>2.49</td>
<td>0.015</td>
</tr>
</tbody>
</table>

Note. $R^2 = 0.33$, $F_{(2, 65)} = 13.75$, $p = 0.000$. 

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Null Hypothesis 14. There are no linear relationships between the performance of schools as measured by their ITBS science scores and the four independent variables of science skills acquired by students: (a) engaging in systematic observation of the environment, (b) using appropriate tool and techniques, (c) identifying and clarifying questions, and (d) engaging in the scientific method in the Seventh-day Adventist school system.

Table 48 shows the correlations between the four science skills variables and schools’ ITBS science scores. Engaging in the scientific method, systematic observation of the environment, using techniques and tools in science investigations, and the use of clarifying and identifying questions were the four moderate correlations.

Table 48

Means, Standard Deviations, and Correlations Between Schools’ ITBS Science Scores by Teachers’ Perceptions of Students’ Acquisition of Science Skills (N = 68)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ITBS Science Score</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Techniques/Tools</td>
<td>.45**</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Identifying/Clarifying</td>
<td>.43**</td>
<td>.36**</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Scientific Method</td>
<td>.58**</td>
<td>.62**</td>
<td>.54**</td>
<td>1.00</td>
</tr>
<tr>
<td>5</td>
<td>Environmental Observation</td>
<td>.50**</td>
<td>.71**</td>
<td>.49**</td>
<td>.49**</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>54.85</td>
<td>1.76</td>
<td>2.32</td>
<td>2.16</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td>7.38</td>
<td>.88</td>
<td>.89</td>
<td>.73</td>
</tr>
</tbody>
</table>

* Significant at 0.05. ** Significant at 0.01.
Table 49 shows the results of regression analysis for the science skills variables and science achievement using the stepwise variable selection method. As a set, the two science skills variables account for 40% of the variance in the ITBS science scores. This is significant at the 0.01 level. The best predictor is engaging in the scientific method in science investigations ($\beta = 0.44$). Since $\beta$ were significant, the null hypothesis was rejected.

Table 49

<table>
<thead>
<tr>
<th></th>
<th>$B$</th>
<th>$SE$</th>
<th>$\beta$</th>
<th>$t$</th>
<th>$p$</th>
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</thead>
<tbody>
<tr>
<td>Constant</td>
<td>40.00</td>
<td>2.39</td>
<td></td>
<td>16.77</td>
<td>0.000</td>
</tr>
<tr>
<td>Engaging in Scientific Method</td>
<td>4.52</td>
<td>1.13</td>
<td>0.44</td>
<td>4.01</td>
<td>0.000</td>
</tr>
<tr>
<td>Systematic Observation of Environment</td>
<td>2.55</td>
<td>1.02</td>
<td>0.28</td>
<td>2.50</td>
<td>0.015</td>
</tr>
</tbody>
</table>

*Note. $R^2 = 0.40$, $F_{(2, 65)} = 21.26$, $p = 0.000$.*

Null Hypothesis 15. There is no linear relationship between the performance of schools as measured by their ITBS science scores and the five independent variables of science resources: (a) science laboratory, (b) movable laboratory table, (c) laboratory materials, (d) laboratory equipment, and (e) hands-on manuals in the Seventh-day Adventist school system.

Table 50 shows the correlations between the four science resources variables and
schools' ITBS science scores. Hands-on manual was the strongest correlation. Laboratory equipment, laboratory room, and laboratory materials were the three moderate correlations.

Table 50

Means, Standard Deviations, and Correlations Between Schools’ ITBS Science Scores and Teachers’ Perceptions of Science Resources (N = 68)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ITBS Science Score</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Laboratory Room</td>
<td>.50**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Movable Table</td>
<td>.</td>
<td>.</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Laboratory Materials</td>
<td>.49**</td>
<td>.65**</td>
<td>.</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Hands-on Manuals</td>
<td>.85**</td>
<td>.27*</td>
<td>.39**</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Laboratory Equipment</td>
<td>.56**</td>
<td>.66**</td>
<td>.57**</td>
<td>.45**</td>
<td>1.00</td>
</tr>
<tr>
<td>Mean</td>
<td>54.85</td>
<td>1.09</td>
<td>1.00</td>
<td>1.61</td>
<td>2.97</td>
<td>1.54</td>
</tr>
<tr>
<td>SD</td>
<td>7.38</td>
<td>.51</td>
<td>.00</td>
<td>.65</td>
<td>.67</td>
<td>.66</td>
</tr>
</tbody>
</table>

* Significant at 0.05. ** Significant at 0.01.

Table 51 shows the results of regression analysis for the availability of science resources variables and science achievement using the stepwise variable selection method. As a set, the two science resources variables account for 80% of the variance in the ITBS science scores. This is significant at the 0.01 level. The best predictor is hands-on manual (β = 0.77). Since β were significant, the null hypothesis was rejected.
Table 51

*Linear Regression Results for Schools' ITBS Science Scores and Teachers' Perceptions of Science Resources (N = 68)*

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>24.98</td>
<td>1.90</td>
<td>13.12</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Hands-on-Manual</td>
<td>8.51</td>
<td>0.64</td>
<td>0.77</td>
<td>13.40</td>
<td>0.000</td>
</tr>
<tr>
<td>Laboratory Room</td>
<td>4.21</td>
<td>0.83</td>
<td>0.29</td>
<td>5.06</td>
<td>0.000</td>
</tr>
</tbody>
</table>

*Note. R² = 0.80, F(2, 65) = 130.33, p = 0.000.*

Null Hypothesis 16. There are no linear relationships between the performance of schools as measured by their ITBS science scores and the four independent variables of teachers' coverage of science domains: (a) earth and space science, (b) life science, (c) physical science, and (d) science and technology in the Seventh-day Adventist school system.

Table 52 shows the correlations between the four coverage-of-science-content variables and schools' ITBS science scores. Earth/Space science content area and science/technology science content area were two moderate correlations.

Table 53 shows the results of regression analysis for the coverage of science content area variables and science achievement using the stepwise variable selection method. As a set, the three science content area variables account for 56% of the variance in the ITBS science scores. This is significant at 0.01 level. The best predictor is earth/space science (β = 0.57). Since β were significant, the null hypothesis was rejected.
Table 52

*Means, Standard Deviations, and Correlations Between Schools' ITBS Science Scores and Teachers' Perceptions of Coverage of Science Content Areas (N = 68)*

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ITBS Science Score</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Earth and Space</td>
<td>.68**</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Life Science</td>
<td>.16</td>
<td>.10</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Physical Science</td>
<td>.37**</td>
<td>.19</td>
<td>-.01</td>
<td>1.00</td>
</tr>
<tr>
<td>5</td>
<td>Science/Technology</td>
<td>.43**</td>
<td>.33**</td>
<td>.20*</td>
<td>.17</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>54.85</td>
<td>2.91</td>
<td>2.67</td>
<td>1.87</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td>7.38</td>
<td>.54</td>
<td>.54</td>
<td>.75</td>
</tr>
</tbody>
</table>

* * Significant at 0.05. ** Significant at 0.01.

Table 53

*Linear Regression Results for Schools' ITBS Science Scores and Teachers' Perceptions of Coverage of Science Content Areas (N = 68)*

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>20.35</td>
<td>4.08</td>
<td>4.98</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Earth/Space Science</td>
<td>7.75</td>
<td>1.22</td>
<td>0.57</td>
<td>6.34</td>
<td>0.000</td>
</tr>
<tr>
<td>Physical Science</td>
<td>2.26</td>
<td>0.84</td>
<td>0.23</td>
<td>2.70</td>
<td>0.009</td>
</tr>
<tr>
<td>Science/Technology</td>
<td>3.55</td>
<td>1.56</td>
<td>0.20</td>
<td>2.28</td>
<td>0.026</td>
</tr>
</tbody>
</table>

*Note. $R^2 = 0.56$, $F_{(3, 64)} = 26.70$, $p = 0.000$. Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.*
Summary of Major Findings

Research question 1 addressed teachers' perceptions of a number of criteria established by the National Commission on Mathematics and Science Teaching for the 21st century. The following were noted:

1. The hands-on approach is the most widely used methodology in science education. Teachers in the single-grade classroom configuration indicated greater use of learning cycle and project-based learning than teachers in the two-grade and multigrade classroom configurations.

2. Approximately 20-40% of teachers indicated that students generally met or met very well the science skills needed for students to develop inquiry abilities in science education. Teachers in the single-grade classroom configuration indicated a higher acquisition of science skills by students than students in the two-grade and multigrade classroom configurations.

3. Hands-on manual is the most widely available science resources to teachers for science education. Science resources such as laboratory equipment, materials, and room were generally not available for teachers to use in science education. Teachers in the single-grade classroom configuration indicated greater availability of science resources (with the exception of movable lab table) than the two-grade and multigrade classroom configurations.

4. Teachers reported that they covered life science and earth/space science content areas; however, physical science and science/technology areas were not covered too well where approximately 16% of teachers indicated these content areas were generally well
met or met very well. Teachers in the single-grade classroom configurations indicated a better coverage of the physical science content area than two-grade and multigrade classroom configurations.

5. Teachers in the single-grade classroom configuration completed more credits in college-level science courses than teachers in the two-grade and multigrade classroom configurations.

In looking at students' perceptions of the teaching and learning process in science education in this selected Union Conference of Seventh-day Adventists, the following were noted:

1. The student variable with the lowest rating was Encouraged by parents to succeed in science. Approximately 52-73% of students never or seldom gave the other student variables a positive rating.

2. With the exception of one teacher variable (subject not made interesting by teacher), all the other teacher variables received a positive rating by students.

3. Students' on average perceived the curriculum variables very negatively. More than half of students never or seldom had a positive rating of these variables.

4. Students in the single-grade classroom configuration on average gave a better rating of variables in the teaching and learning process in science education.

In looking at research question 3, more than half (60%) of students obtained between 51-60 on their ITBS (NCE) science score. Students in the single-grade classroom configurations obtained better ITBS science scores than students in the two-grade and multigrade classroom configurations. However, all classroom configurations scored
above the national norms.

Research question 4 looked at relationships among the criteria established by NCMST (2000) and science achievement and the following were noted:

1. With the exception of students being encouraged by teachers, as a set, students' variables accounted for 31% of the variance in students' achievement. The students' variable that best predicts science achievement was completion of assignment ($\beta = 0.48$).

2. With the exception of the teachers' variables, Available to help students outside of class and Trust/confidence in teacher, as a set teacher variables accounted for 37% of the variance in students' achievement. The teachers' variable that best predicts science achievement was Subject made interesting ($\beta = 0.33$).

3. With the exception of the curriculum variable Too much work given by teachers, as a set, curriculum variables accounted for 46% of the variance in students' achievement. The curriculum variable that best predicts science achievement was Presentation of content by teacher is understandable ($\beta = 0.27$).

4. The two methodologies variables, deductive reasoning and project-based learning, as a set accounted for 30% of the variance in science achievement. The methodology variable with the best predictor was deductive reasoning ($\beta = 0.43$).

5. The two science skills variables, engaging in the scientific method and systematic observation of the environment, as a set science skills variables accounted for 40% of the variance in science achievement. The science skill variable with the best predictor was engaging in the scientific method ($\beta = 0.44$).

6. The two science resources variables, hands-on manual and laboratory room, as
a set accounted for 80% of the variance in science achievement. The science resources variable with the best predictor of science achievement was hands-on manuals ($\beta = 0.77$).

7. With the exception of life science content area, as a set, content area variables accounted for 30% of the variance in science achievement. The content area variable with the best predictor of science achievement was earth/space science ($\beta = 0.57$).
CHAPTER 5

DISCUSSION AND CONCLUSION

Overview of Study

This study investigated the status of the middle-school science program in a selected Union Conference of the Seventh-day Adventist school system. Specifically this study investigated the perceptions of teachers and students regarding the extent to which the science program meets the criteria of the National Commission on Mathematics and Science Teaching for the 21st century and to what extent these criteria are related to academic performance as indicated by ITBS science scores.

Overview of Literature

Science education has been of great concern from its earliest beginning in the 1860s, when the Swiss educator Pestalozzi introduced “Object Lessons” that focused on careful observation of objects, and to some extent, on asking questions and making inferences. Over time, practices in science education have been refined. We now find ourselves in the era of constructivism that expects students to become aware of their preexisting ideas as they interact with materials, observe, and verbalize their existing explanations even as they develop new understandings (Brooks, 1990; Cheek et al., 1992; Ebenezer & Conner, 1998; Hurd, 1991; Loucks-Horsley et al., 1990).

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Many innovations have been attempted during the history of science education in the United States, such as: (a) Nature-Study Movement (NSM), (b) Elementary Science Study (ESS), (c) Science A Process Approach (SAPA), (d) Science Curriculum Improvement Study (SCIS), and (e) Science, Technology and Society (STS). However the appropriate balance among the various dimensions that would allow students to excel in science was still missing (Cheek et al., 1992; Ebenezer & Connor, 1998; Krajcik et al., 1999; Wolfinger, 2000).

In spite of all these innovations, many in the United States viewed American students' performance in science as unacceptable. Some have argued that science achievement in schools has reached the point where one cannot help but draw the disturbing conclusion that students are losing ground in science achievement and the situation seems hopeless (NCES, 2000; NCMST, 2000). These beliefs have been substantiated by national and international studies where less than one-third of American students in Grades 4, 8, and 12 were performing at or above the proficient level in science. Students' performance in these studies fall devastatingly far from the national goal of being number one in the world by the time they finish high school (NCES, 2000; Paik et al., 2002; TIMSS, 1995, 2001).

Within the context of all reforms and innovations in science education, little attention has been given to the idea of Christian schools being a model for quality programs in science (Archer, 2002; Brantley, 1999; Land, 2002). Students' science achievement in the Archdiocesan school system in Chicago increased as they progressed during their years in school (Wolsonovich, 2002). For the past 3 years, students in the...
Seventh-day Adventist school system have been consistently performing above the national norms in science education (NAD, n.d.).

On close examination of the philosophy of Christian schools, excellence is the goal, and embedded within this philosophy is the belief that “higher than the highest human thought can reach, is God’s ideal for His children” (White, 2000, p. 12). This framework seeks to produce students who are able to reach their maximum potential, thus they will perform to the best of their abilities on their science achievement (Knight, 1998; White, 1923).

It can be argued that excellence has been foremost in the Judeo/Christian lifestyle. One example of excellence from the book of Daniel in the Holy Scriptures is that of Daniel, Hananiah, Mishael, and Azariah who were 10 times wiser than all the scholars in the realm of Babylon. Dan 1:20 states that “in all matters of wisdom and understanding, that the king inquired of them, he found them ten times better than all the magicians and astrologers that were in his realm.”

Recent studies (AAAS, 1993; Ebenezer & Connor, 1998; Goldhaber & Brewer, 1997; Krajcik et al., 1999; Mullis et al., 1997, 2001; NCES, 2001a, Netherlands Antilles, 2002; NRC, 1996; Silver et al., 1996; TIMSS, 2001) have identified a number of criteria that NCMST has considered vital to improving science programs in American schools, and these practices are found in the Christian framework of teaching science (Archer, 2002; Knight, 1998; Land, 2002; White, 1923, 1943). These criteria are indicated below:

1. methodologies

2. teachers’ knowledge of subject being taught
3. coverage of content in science curriculum
4. scientific skills
5. laboratory facilities
6. science material and equipment
7. students' perceptions of the teaching and learning process.

Methodology

A survey research method was used in this study to learn more about students' and teachers' attitudes and perceptions towards the practices of science education in this selected Union Conference of the Seventh-day Adventist church. A researcher-designed questionnaire was self administered by students and teachers chosen by the three-step multistage sampling procedure.

The students' questionnaire designed by the researcher for this study consisted of a total of 27 items of which 24 provided information on students' perceptions of the teaching and learning process in science education, and three items provided demographic information related to the student. Most of the items in the instrument used a variation of the selected-response format known as the Likert scale (Wiersma, 1991). The instrument presented a set of related statements, and students were asked to choose the best response from the responses provided for them.

A domain-to-item matrix was developed for the items used in the students' questionnaire to measure the criteria established by NCMST (2000). Items related to students' perceptions of the teaching and learning process in science education were
adapted from a number of studies: (a) NCES (2000), (b) Netherlands Antilles (2002), (c) Saskatchewan Educational Assessment (1993), and (d) TIMSS (2001).

The teachers' questionnaire consisted of 14 selected-response (1-14) and one open response item 15 (see Appendix B, What Do I See ... How Do I Feel?). Items 6-14 used a Likert-type format where the respondents were asked to make a choice based on an ordered response given by the researcher.

The items in the teacher questionnaire addressed the following criteria: (a) science resources, (b) acquisition of skills by students, (c) use of teaching methods, (d) number of credits completed in science, and (e) coverage of content areas. A domain-to-item matrix was designed for the items used in the teachers' questionnaire to measure each criterion established by NCMST. The items used in the teachers' questionnaire were adapted from a number of studies: (a) NCES (2000), (b) Netherlands Antilles (2002), (c) Saskatchewan Educational Assessment (1993), (d) TIMSS (2001), and (e) North American Division of Seventh-day Adventist Profiles Studies (Brantley & Hwangbo, 2000).

In this study, the content validity of the questionnaires was ensured by using items that were designed to measure the various domains related to the criteria established by NCMST (2000). The two questionnaires were mailed to five doctoral students in the Program Evaluation class of 1998 at Andrews University in December 2000 who had completed more than 16 graduate credits in statistics and evaluation and who were involved in science education as teachers or science consultants. The questionnaires were also sent to the Chair of the Science Committee of the Atlantic Union Conference of
Seventh-day Adventists. Instructions were given to them to determine the appropriateness of the items as measure of the criteria of NCMST (2000).

Comments from the expert reviewers indicated the items on the questionnaires were a valid measure of the criteria of NCMST, the instruments were pilot-tested to see whether any items were not phrased clearly. Since all the students and teachers answered each item on their respective questionnaire for the pilot-test, it was apparent that the items were clear and understandable. No respondents chose to write in comments on the instruments indicating unclear items.

Questionnaires were then coded by color and numbers to identify classroom configuration and conference, since I wanted to maintain confidentiality and anonymity of participants. These questionnaires were mailed to principals of selected schools with detailed instructions on how the questionnaires were to be administered. Teachers' questionnaire had a self-addressed stamped envelope so that teachers could mail back the completed questionnaires, while the principals of selected school were provided with prepaid envelopes so that they could return the completed student questionnaires.

Questionnaires were entered into a database using the SPSS software and then placed in a secure cabinet.

Descriptive statistics were used to describe the results, and inferential statistics in terms of (a) analysis of variance, (b) Kruskal-Wallis test, and (c) linear regression analysis were used to test the hypotheses generated for this study by the four research questions.
Population/Sample

The sample population consisted of 798 seventh- and eighth-graders in a selected Union Conference of the Seventh-day Adventist school system in the North American Division of Seventh-day Adventists. Four hundred and thirty-nine seventh- and eighth-graders were chosen by multi-stage sampling that ensured students from the five conferences and the three classroom configurations were included in this sample. Teachers of the students chosen for the sample were included in the study by default, and this amounted to 68, coming from 63 schools.

Findings/Discussions

Teachers’ Perceptions of Science Practices and Their Relationship to Academic Performance

Recent studies (Anderson, 1997; Ebenezer & Connor, 1998; Ertepinar & Geban, 1996; Glasson, 1989; Joyce & Weil, 2000; Krajcik et al., 1999; Netherlands Antilles, 2002; Stohr-Hunt, 1996; Von Secker, 2002; Von Secker & Lissitz, 1999) have provided empirical and theoretical evidence that hands-on-approach, inquiry, deductive reasoning, Taba inductive, concept attainment, project based learning, and learning cycle contribute significantly to students’ achievement in science.

Teachers in this selected Union Conference of the Seventh-day Adventist school system predominantly used the hands-on approach and project-based learning, and most teachers had just started implementing the methodologies that are considered significant for increased science performance (see Table 23). Teachers in the single-school
configuration had greater means for the use of methodologies that were statistically significant (concept attainment, inquiry approach, and learning cycle) and schools in the single-grade classroom configuration did significantly better \( (p < 0.01) \) on the ITBS science scores than schools in the multigrade and two-grade classroom configurations.

It is obvious one or two methodologies like hands-on-approach and project-based learning are not sufficient for students to excel in science education, but teachers need to use a variety of methodologies to match students' learning styles. There was a significant relationship at the 0.01 level between use of methodologies and schools' ITBS science scores (Table 46). The results in this study confirm results from other studies (Cheek et al., 1992; Glasson, 1989; Von Glaserfeld, 1984) where it was found that teachers who used a variety of methodologies noted increased science performance on science achievement tests, especially when methods allowed for critical thinking in the content area. The variable under methodologies that best predicts science achievement in this selected Union was deductive reasoning \((\beta = 0.43)\). These results are consistent with the descriptive statistics obtained for this study (see Table 23).

The results of this study also noted that only 2.4% of students always thought content was presented in a manner that was understandable, thus it can be inferred that teachers need to use a variety of methodologies so that students could have a better opportunity to understand, and thus do better in science education in this selected Union Conference of the Seventh-day Adventist school system. These findings can be added to the body of knowledge seeing that no empirical evidence was available in the present literature to show how students’ achievement in science is affected by classroom
configurations.

A number of studies (Beaton et al., 1996; Clabaugh, 2003; NCES, 2000; TIMSS, 2001) have shown that teachers who completed only a few credits in science were less prepared to teach science, and students’ achievement in science was significantly lower than teachers who had a major in science or a minor in science. Most teachers (50-80.9%) completed, on average, 6 -10 credits in science education. There was significant difference at the $p < 0.01$ level between the three classroom configurations where teachers in a single-grade classroom configuration completed more credits in science than the other two configurations, and schools from the single-grade classroom configuration obtained a higher mean score of 46.05 on the science achievement test (see Table 31).

Despite the low number of science credits completed by most teachers in this selected Union Conference of the Seventh-day Adventist school system, not much upgrading was done to improve science education. More than half (70-100%) of teachers indicated they did not receive upgrading in science and those who indicated “yes” came predominantly from the single-grade classroom configuration. It is apparent that teachers’ quality in science education is not being maintained by professional development in this selected Union Conference. Another factor to take into consideration is that almost half (48.6%) of teachers in this study were neophyte or beginning teachers, therefore they would need support, since they lacked the knowledge and experience in the classroom. Recent studies (Darling-Hammond, 1999b; Glidden, 1999; NCMST, 2000) have indicated that students’ achievement can be increased only when there is ongoing professional development in science education and when teachers take more science
courses in various content areas.

In relation to the number of credits completed in science by teachers in this selected Union Conference of Seventh-day Adventists is the aspect of content covered by these teachers. Teachers in this study generally covered well two subject areas, earth/space and life science; however, 16.2% of them indicated that physical science and science/technology content areas were generally met well or met very well (Table 29). It is evident that these teachers did a poor job at covering these content areas because they lacked the preparation to teach chemistry, physics, and science and technology as indicated in the number of credits they completed in science. Studies (Martin & Kelly, 1996; NCES, 2000; Von Secker, 2002) have indicated that students’ achievement in science increases when teachers have the knowledge of the content required and impart that knowledge to the students.

There is also no substitute for a deep knowledge in the subject area (Ingersoll, 2000; NRC, 2000; Stigler & Hiebert, 1999) and teachers in this selected Union Conference of the Seventh-day Adventist school system need to acquire that depth of knowledge in their teacher preparation programs or professional development workshops. These changes will help teachers do a better job in preparing their students to increase their performance on science achievement tests. This fact was affirmed in this study where there was a significant relationship between teachers’ coverage of science content variables and schools’ science achievement on the ITBS at the 0.01 level (see Table 51). The content area variable with the best predictor of science achievement was earth/space science ($\beta = 0.57$).
Teachers' coverage of content areas in this selected Union Conference of the Seventh-day Adventist school system is further compounded by the following: (a) 16.2% of teachers rated the textbook as good or excellent, (b) the number one reason given by students for their grade was Content difficult to understand, (c) 2.6% of students indicated that explanations were given to explain difficult concepts, and (d) 37% of students indicated content presented by teacher was sometimes or always understandable.

There is good news in the area of science collaboration in this selected Union Conference of the Seventh-day Adventist school system, where 73-100% of teachers indicated a willingness to have a working relationship with high-school science teachers. Teachers can therefore receive additional knowledge and techniques needed to prepare their students to perform well in middle-school, and for them to continue such performance in high-school. Research studies have shown that when students feel inadequate in their middle school years in science, they will not do well in science in their high school years (NCES, 2001a; TIMSS, 1995, 2001). A working relationship between middle-school and high-school teachers can increase awareness of the high-school curriculum. This has potential to help students feel more adequate to continue their studies in science education in high school. The teachers in this selected Union Conference of Seventh-day Adventists have a long way to go, given that 80-98% of teachers were not aware of the science program in the high school.

An important aspect of teaching science is the emphasis placed on scientific investigations. Studies done so far have validated the fact that when students get a better understanding of science by engaging in science investigations, their achievement in
science ultimately increases (NCES, 2000; TIMSS, 2001; Von Secker, 2002; Von Secker & Lissitz, 1999). In this selected Union Conference of the Seventh-day Adventist school system, 26.1% of teachers indicated that the skills of identifying and clarifying, environmental observations, scientific method, and gathering tool/techniques were generally met well or met very well. From these results, one can say that teachers need to begin teaching these skills to their students so they can improve in their science achievement. It was noted that teachers perceived students in the single-grade classroom configuration acquired more skills and did significantly better ($p < 0.01$) than students in the two-grade and multigrade classroom configurations on their science achievement test. There were significant relationships at the 0.01 level among science skills and science achievement (see Table 48), with engaging in the scientific method being the best predictor ($\beta = 0.44$). This school system needs to address this criterion immediately due to the far-reaching consequences of decreased science achievement for students not possessing these skills.

Recent studies (Burkam et al., 1997; Freedman, 1997; NCES, 2001b; Netherlands Antilles, 2002; TIMSS, 2001) indicated schools need to have institutional support in terms of science resources so that students can acquire the needed skills to increase their achievement in science. In this selected Union Conference of the Seventh-day Adventist school system, only 2.9% of teachers agreed or strongly agreed that science materials, equipment, and laboratory were available at their fingertips for use in their science program.

Students in this selected Union Conference of the Seventh-day Adventist school
system confirmed the rating of the science resources by teachers, where students reported that only 3.1% of teachers always conducted laboratory exercises. It was noted from the results that schools with more science resources did better on the science achievement test than schools that lacked these resources. In this study, the single-grade classroom configuration had significantly more science resources and it did better than the other two classroom configurations on their science achievement ($p < 0.01$). There were significant relationships at the 0.01 level among science resource factors (with the exception of movable laboratory table, which no school had) and science achievement (see Table 50). The science resource with the best predictor of science achievement was Hands-on manuals ($\beta = 0.77$).

There is room for improvement in most of the practices in science education as established by NCMST in this selected Union Conference of the Seventh-day Adventist school system. The number of credits completed in science by teachers is limiting the amount of content covered, as well as the use of a variety of methods to deliver the content. Teachers are hampered severely by the lack of science that limits the extent to which teachers can impart the needed inquiry skills to their students. The results from the various correlations further confirmed these observations, where there were significant relationship between schools' performance on the science achievement test and the variables in the following practices: (a) acquisition of skills by students, (b) the use of a variety of methodologies, (c) science resources, and (d) coverage of content areas.

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Students' Perceptions and Their Relationships to Academic Performance

This section of the findings and discussion addresses students' perceptions of the teaching and learning process and the extent to which these variables are related to science achievement.

Students' attitudes and perceptions have been found by researchers to be adequate predictors of students' achievement in science. Students' positive attitudes and perceptions resulted in positive effects on science achievement (Fraser et al., 1987; Reynolds, 1991; Reynolds & Walberg, 1992). In this study the students tended to give the teaching factors the highest rating; however, much needs to be done for the curriculum and students' factors so that they (students) can have a better perception of the teaching and learning process in science education.

Two variables in this study gave a preliminary overview of students' motivation, and these variables received positive responses from students in this selected Union Conferences, where 69.2% of students indicated this subject was important and 76.3% of them noted they could have received a better grade. However, these positive responses were not substantiated by other indicators where only 39.2% of these students indicated they followed their study plan, and television viewing (57.3%) and involvement in clubs/sports (14.5%) are main sources of distraction from studying. These findings are in agreement with previous studies (NCES, 2000; Rudner, 1999; Singh et al., 2002).

Researchers (Fraser et al., 1987) found that home environment and motivation affect science achievement. Students (3.9%) in this selected Union Conference of the
Conference of the Seventh-day Adventist school system indicated that they were encouraged by their parents to succeed in this subject. Students noted that involvement in sports (14.5%), social clubs/church (10.2%), and coping with siblings (6.4%) detracted from their studies. It is apparent that parents need to encourage their children to succeed in science, since studies have shown that increase parental support leads to increased motivation (Singh et al., 2002).

Students who are motivated and academically engaged performed significantly better on science achievement tests than others who are not motivated and academically engaged (Banks et al., 1978; Hidi, 1990; Newmann et al., 1992). In this selected Union Conference of the Seventh-day Adventist school system, there are some disturbing findings where: (a) only 2.6% of students always read ahead in their textbook, (b) less than a tenth (8.5%) of students find the textbook easy to understand, (c) more than half (52.3%) prepared for their test just before or night before a test, and (d) only 3.9% completed their assignments, indicating that students were not academically engaged.

Hidi (1990) and Schiefele and Csikszentmihalyi (1995) found that there is an increase in students’ motivation to learning science when the lesson is made interesting. However, 41.7% of students in this selected Union Conference of Seventh-day Adventists indicated that uninteresting science lessons were the main reason for the common source of distraction in science classes and only 2.1% of students thought the subject was made interesting by the teachers. These findings are cause for concern in this school system because accumulated research studies have substantiated the fact that motivation, attitudes, interest, and academic engagement are important constructs related
to learning (DeCharms, 1984; Dweck, 1986; Hidi, 1990; Singh et al., 2002). These findings were further confirmed by this study, where students in the single-grade classroom configuration were more academically engaged and performed better than students in the two-grade and multigrade classroom configurations. The students' variables that were included in this study were valid because there were significant relationships among these variables and science achievement, with the exception of parents encouraging their children to succeed in science (see Table 40). The students' variable that best predicts science achievement was completion of assignment ($\beta = 0.48$).

A number of researchers (Singh et al., 2002) found that school-related factors are crucial in making meaningful changes in curricular issues that will eventually lead to greater performance by students. Schools have more control over these variables than other variables such as the home situation. In looking at the results from this study, there are serious shortcomings in the following curriculum variables: (a) assignments were always corrected and explanations given, (b) content was always presented in an understandable manner, (c) explanations are always given to explain difficult concepts, (d) laboratory exercises are always given, and (e) it is always easy to concentrate in this class. When classroom configurations were examined, the students in single-grade classroom configuration reported significantly more positive perceptions ($p < 0.01$) in regard to these curriculum factors, and their science performance was better than students in the two-grade and multigrade classroom configurations. These results are in keeping with other studies that emphasized the need to engage students academically (NCES, 2000; Singh et al., 2002; TIMSS, 2001). Results from this study show that there were
significant relationships among curriculum variables and science achievement (see Table 45), with content understandable being the best predictor ($\beta = 27$), further validating the importance of providing the most conducive learning environment so that students can have the opportunity to excel in science education.

In regard to the teachers' variables, students had a positive rating for teachers with the exception of the variable Subject not interesting. However, there are a number of variables including unavailability of science resources that probably caused this factor to receive a negative rating by students. The overall results for this variable were a high point for this selected Union Conference of the Seventh-day Adventist school system and congratulations are in order. It must be noted that there were significant relationships among teachers' variables and science achievement (see Table 42), with Teacher making subject interesting as the best predictor ($\beta = 0.33$).

As students' attitudes and perceptions of the science program at this selected Union Conference of Seventh-day Adventists increased, their science achievement also increased significantly. These findings are very important because they establish the need to include variables related to students, teachers, and the curriculum in order to accurately measure students' attitudes and perceptions of any science program (Singh et al., 2002).

These findings also validated the use of items in the students' questionnaires that included student, teacher, and curriculum factors, seeing there were significant relationships among these factors and science achievement.
Conclusion

While students are performing above national norms, based on this study this selected Union Conference of the Seventh-day Adventist school system is not fully putting into practice its philosophy of education in its science program. This is consistent with an earlier finding showing only 16.0% of elementary teachers in the North American Division of the Seventh-day Adventist school system strongly agreed their schools were putting their philosophy into practice (Brantley & Hwangbo, 2000). The results obtained from this selected Union Conference of Seventh-day Adventists using the established criteria of NCMST indicated that this school system is falling short of its high ideal of excellence.

This study provided some ideas for educational reform such as designing curricular strategies to enhance students’ attitudes and perceptions of the teaching and learning process in science education. School-related factors are in the control of schools, thus much can be done to enhance students’ motivation, interest, and academic engagement in this subject. “Researchers have suggested that student’s motivation to learn science can be increased and improved when teachers create a curriculum that focuses on conceptualizing and creating meaning and relevance” (Singh et al., 2002, p. 7).

The differences in teaching practices explained the discrepancies in classroom configurations, since there were significant differences among classroom configurations, with single-grade schools obtaining a significantly better rating on most of the established criteria of NCMST (2000) used for evaluating the science program of this school system, and this resulted in better performance on the science achievement test by students.
Schools can therefore develop policies and strategies to improve the practices in the teaching and learning process in science education that were identified by this study being deficient.

There is room for improvement in most of the criteria established by NCMST in this selected Union Conference of Seventh-day Adventists and special attention needs to be given to the multigrade and two-grade classroom configurations, since their science achievement, though above national norms, was significantly lower than the single-grade classroom configuration.

**Recommendations for Practice**

There needs to be ongoing evaluation of science education in the various classroom configurations, so that changes can be documented over time and necessary innovations introduced so the quality of the science program in the Seventh-day Adventist school system can be increased. There are a number of evaluation models that can be used; however, I will recommend a cyclic model because it has evaluation built in at every step and it is very simple to follow.

There is need for teacher education programs in the Seventh-day Adventist colleges and universities to increase the number of science courses needed for teachers to be certified to teach in elementary schools. They can also require courses in certain science content areas, such as physical science and science/technology. Schools in the Seventh-day Adventist school system should institute departmentalization in seventh and eighth grades so that students can be taught by teachers who have majors in science.
education; however, this can cause problems for multigrade schools where the enrollment is usually small. Teachers in this classroom configuration can continue to have upgrading in science content during the summers until they have acquired the needed content to teach the required curriculum.

Schools in this system should take part in national studies such as NAEP, so that educators could get a better picture of students' achievement at the national level. This information would be crucial in designing a science program that measures up to national standards.

Every effort must be made to have the required science resources in these schools so that students can have the opportunity to practice and investigate science processes. One is well aware of the cost involved in building laboratories, but the investment is needed to help motivate students so they can perform better on their science achievement tests. Small schools can invest in movable laboratory tables that are efficient for students to conduct experiments and are very mobile. Other teachers can use them as well. Schools can seek school-business partnerships where businesses in the community can make significant contributions to purchase this equipment.

**Recommendations for Research**

The findings of this study have practical and theoretical significance because no other study has been done to determine the status of the science program in this selected Union Conference of the Seventh-day Adventist school system based on the criteria established by NCMST. It therefore builds on and adds to the current body of literature in
regard to evaluation of science programs in science education in general and more specifically in the middle school, seeing that empirical research in science education in middle schools is limited (Singh et al., 2002).

Results obtained from this study were consistent with studies done by other investigators (Beaton et al., 1996; Clabaugh, 2003; Darling-Hammond, 1999a; Freedman, 1997; Gabel, 2003; Glidden, 1999; Martin & Mullis, 1996; NCES, 2001a; Netherlands Antilles, 2002; NRC, 2000; Reynolds & Walberg, 1992; Robitaille & Garden, 1996; Singh et al., 2002; Stigler & Hiebert, 1999; TIMSS, 1995, 2001; Von Seeker, 2002) and provides a foundation for future studies in science education in the middle-school system, since research in this area is lacking (Singh et al., 2002).

The results obtained from this study further confirm the use of these criteria by NCMST (2000) as appropriate measures for evaluating any science program in middle schools, since they accurately predicted students’ science achievement in this school system. By examining differences in the three classroom configurations by the criteria of NCMST, one was able to identify specific practices that needed to be addressed in this selected Union Conference of the Seventh-day Adventist school system.

Studies similar to this one should be conducted in all nine Union Conferences of Seventh-day Adventists so that stakeholders can get an overall status of the science program in the North American Division of the Seventh-day Adventist school system. One should also investigate the Conferences within the Unions under study, using the same classroom configurations to discover any significant differences between Conferences in terms of science achievement, and teachers’ and students’ ratings of the
criteria established by NCMST.

Further studies should be done to investigate parents' and administrators' perceptions of the science program in the Seventh-day Adventist school system. One can use selected items from the researcher-designed questionnaires that were found to be valid for assessing the criteria established by NCMST (2000) for science programs.
APPENDIX A

LETTERS
Dear Director,

I am a doctoral student at Andrews University in Berrien Springs, Michigan and I am desirous in conducting my research in your Union Conference of Seventh-day Adventist. My study will look at the status of Science Program in the Middle School, using the standards as established by the National Commission on Mathematics and Science Teaching for the 21st century.

This study calls for the sampling of at least half of the seventh and eighth-graders attending school in the three classroom configurations: (1) multigrade (single teacher for more than two grades), (2) two-grade (one teacher teaching seventh and eighth grades), single-grade (single teacher per grade), in the five conferences that are found in this Union Conference of Seventh-day Adventist.

This study calls for the use of two questionnaires, one for the teacher of the seventh and eighth-graders and one for the seventh and eighth-graders. I will ensure the confidentiality and anonymity of all participants in this study, seeing that participants will not be writing their names on the questionnaires, and the name of the name of your Union will not be mentioned in the study.

I have enclosed copies of questionnaires and the research proposal that will give you more information on the actual study. In the event you need further information please contact me at tel: 630-323-9211 or email: marcel_s.3@hotmail.com.

Respectfully,

Marcel Sargeant (Researcher).
603 The Lane,
Hinsdale, IL 60521

Superintendent of Schools
XXXXXXXXXXX (Conference Address)

Dear Superintendent,

Please find enclosed the schools that have been chosen for my research study that was approved by the Education of XXX Union Conference of Seventh-day Adventist. I have enclosed the copy of the letter I sent to the principals of the schools participating in this study.

I am soliciting your support in explaining the importance of this study for your Conference and science education in this Union. I have enclosed the approval letter from the Union Director of Education.

You can contact me at tel: 630-323-9211 or email: marcel_s_3@hotmail.com if you need additional information. Thank you.

Names of Schools:
(list of schools)

Respectfully,

Marcel Sargeant (Researcher)
Principal
XXXXX (Address of School).

Dear Principal,

Please find enclosed in the package the following:

- science questionnaires for students in the seventh and eighth-grades
- science questionnaires for teachers of the seventh and eighth-grade classes.

You or someone else besides the teacher of the class can administer the students’ questionnaire entitled “How Do You Feel.” Ensure that students write the correct ITBS science score in the box at the top of the questionnaire. Teachers need to indicate the overall ITBS science score (percentile) for that class in the top right hand corner of the questionnaire.

The teachers’ questionnaires have self-addressed stamped envelopes, so kindly ask them to mail questionnaire. I have attached a copy of the approval letter from the Union Director. Thank you very much for your cooperation as we strive to improve science education in seventh and eighth grades.

Please feel free to contact me at tel: 630-323-9211 or email: marcel_s_3@hotmail.com after you have mailed the completed students’ questionnaires back to me in the prepaid priority box.

Respectfully,

Marcel Sargeant
WHAT DO I SEE...... HOW DO I FEEL?
ELEMENTARY SCHOOL SCIENCE CURRICULUM

What are your views about Science Education in your Elementary School? Information from this questionnaire would help determine the direction of Curriculum Development at the Elementary level. All individual responses and comments would be kept in confidence. Please do not write your name anywhere on this questionnaire.

Check (√) the most appropriate indicated below:

1. Teaching Experience?
   a. Number of years in education
      () 0-2 years
      () 3-5 years
      () 6-10 years
      () 11-25 years
      () over 25 years

   b. Number of years at present location
      () 0-2 years
      () 3-5 years
      () 6-10 years
      () 11-25 years
      () over 25 years

2. Highest degree completed?
   () Certificate
   () Bachelors
   () Masters
   () Specialist
   () Doctorate

3. Number of credits completed in Science Education at Certificate/Bachelors level?
   () 5-10
   () 11-15
   () 16-20
   () over 20

4. Have received further upgrading in Science Education after graduation?
   () YES
   () NO
5. Opportunities are always given by administration for upgrading in Science Education?

() YES  () NO  () NOT SURE

6. Innovative Educational Practices. Where are you in the following innovations? Check (✓) in the appropriate space beneath the innovation.

**Hands-on Approach in Science:**
()- not using  () started implementing  () implementing  () proficient user

**Concept Attainment:**
()- not using  () started implementing  () implementing  () proficient user

**Inquiry Approach:**
()- not using  () started implementing  () implementing  () proficient user

**Deductive Reasoning:**
()- not using  () started implementing  () implementing  () proficient user

**Learning Cycle:**
()- not using  () started implementing  () implementing  () proficient user

**Taba Inductive:**
()- not using  () started implementing  () implementing  () proficient user

**Project Based Learning in Science:**
()- not using  () started implementing  () implementing  () proficient user

7. Do you think workshops should be held by administration to upgrade your skills in Science Education?

() YES  () NO  () NOT SURE

8. Assessment of Curriculum Guides.

Did you use your Science Curriculum Guide at the beginning of the year to plan your course outline?

() YES  () NO

If NO, why not?

()- did not have a copy  () guide too cumbersome
()- guide did not match textbook  () guide did not fit teaching plan
()- other reason for non-use _______________________________
9. How effective is your School Curriculum in ensuring that students achieve the following skills in Science? Circle a numeral on a scale from 1 “Not met at all” to 7 “Met very well”.

a. Engaging in scientific inquiry through systematic observation of the environment
Not met at all  1  2  3  4  5  6  7 Met very well

b. Using appropriate tools and techniques to gather, analyze and interpret scientific data
Not met at all  1  2  3  4  5  6  7 Met very well

c. Identifying and clarifying questions of scientific importance
Not met at all  1  2  3  4  5  6  7 Met very well

d. Engaging in the scientific method
Not met at all  1  2  3  4  5  6  7 Met very well

10. The following are at your “fingertips” for use in the teaching of Science at my school? Check (✓) all that apply:

a. Science laboratory  () strongly agree  () agree  () disagree  () strongly disagree
b. Movable lab. table  () strongly agree  () agree  () disagree  () strongly disagree
c. Lab. materials () strongly agree  () agree  () disagree  () strongly disagree
d. Lab. equipment  () strongly agree  () agree  () disagree  () strongly disagree
e. Hands on manuals () strongly agree  () agree  () disagree  () strongly disagree

11. Are you aware of the Science Curriculum or programs at the High School?
   () YES  () NO

12. Would a close working relationship with the High School Science teachers be beneficial to you as you plan for the smooth transition of students into Secondary School?
   () YES  () NO  () NOT SURE
13. Place a tick (√) in the column that best expresses your coverage of objectives indicated in grid.

**Objective Attainment**

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>Met very well</th>
<th>Generally well met</th>
<th>Not met too well</th>
<th>Not met at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Earth and Space: understand the basic structure and processes, and the essential ideas about the structure and composition of the earth.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Life Science: know about the diversity and unity that characterize life based on the genetic transfer of characteristics from generation to generation. Understand the cycling of matter and flow of energy through the living environment. Understand the basic concepts of the evolution of species.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Physical Science: understand the basic concepts about the structure and properties of matter. Understand energy types, sources, and conversion and their relationship to temperature. Basic principles of motion.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Science and Technology: understand the nature of scientific knowledge, inquiry and enterprise and interaction of science, technology and society.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

14. Please rate the quality of textbook you are using based on the above-mentioned objectives?

Title of textbook__________________________________________

a. excellent     b. good     c. fair     d. poor
15. You may write any comments related to Science Education at your school in the space provided below:

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Thank you for your time. Place the completed questionnaire in the attached envelope and mail.
HOW DO YOU FEEL?

An Assessment of Factors Affecting the Performance of Students in Science

Instructions: Please put a tick () in the space provided to indicate your honest response to the questions below. Do not write your name on this questionnaire.

DEMOGRAPHICS

SEX: () male
() female

AGE: () 11-12 years
() 13-14 years
() over 14 years

COUNTRY OF BIRTH: ____________________________

1. Do you believe that you could have obtained a better grade in this subject?
   () YES
   () NO
   () NOT SURE

2. Is this subject important to you as a student?
   () YES
   () NO
   () NOT SURE

3. Indicate the most important reason influencing your grade?
   () Subject matter is difficult to understand
   () Subject is boring
   () Exam included items that were not covered during classes
   () Did not adequately prepare for the exam
   () Dislike the subject
   () Dislike the teacher
   () Physically ill
   () Social problems
   () Emotional problems
   () Not Applicable (got B+ or better)
   () Other ____________________
4. How often do you complete your assignment?
   () ALWAYS
   () SOMETIMES
   () SELDOM
   () NEVER

5. Is it easy to concentrate in the classroom during classes?
   () ALWAYS
   () SOMETIMES
   () SELDOM
   () NEVER

6. How often are you encouraged to your parents to succeed in this subject?
   () ALWAYS
   () SOMETIMES
   () SELDOM
   () NEVER

7. Do you have a study plan?
   () YES
   () NO (If yes, answer part II)

8. How often do you follow your study plan?
   () ALWAYS
   () SOMETIMES
   () SELDOM
   () NEVER

9. What distracts you the most from studying?
   () Television
   () Involvement in sports/computer games
   () Social activities (Church clubs, Service clubs)
   () Coping with brothers and sisters
   () Family problems
   () Emotional problems
   () Not Distracted
   () Other ________________________
10. Do you read the chapter in your textbook before it is taught?
   0 ALWAYS
   0 SOMETIMES
   0 SELDOM
   0 NEVER

11. Is your textbook difficult to understand?
   0 NEVER
   0 SELDOM
   0 SOMETIMES
   0 ALWAYS

12. Is this subject made interesting by the teacher?
   0 ALWAYS
   0 SOMETIMES
   0 SELDOM
   0 NEVER

13. Is your teacher available outside of class to help you with problems in this subject?
   0 ALWAYS
   0 SOMETIMES
   0 SELDOM
   0 NEVER

14. Is your teacher warm and approachable?
   0 ALWAYS
   0 SOMETIMES
   0 SELDOM
   0 NEVER

15. Are you able to voice your opinion in this class?
   0 ALWAYS
   0 SOMETIMES
   0 SELDOM
   0 NEVER

16. Is too much work given by the teacher than you can handle?
   0 NEVER
   0 SELDOM
   0 SOMETIMES
   0 ALWAYS
17. Do you feel your work is graded fairly by your teacher?
   () ALWAYS
   () SOMETIMES
   () NEVER

18. Are assignments corrected and explanations given to incorrect responses?
   () ALWAYS
   () SOMETIMES
   () NEVER

19. Is the content presented in a manner that you can understand?
   () ALWAYS
   () SOMETIMES
   () NEVER

20. Are everyday examples given by teachers to explain various concepts?
   () ALWAYS
   () SOMETIMES
   () NEVER

21. How much confidence and trust do you have in your teacher?
   () A GREAT DEAL
   () QUITE A BIT
   () SOME
   () VERY LITTLE

22. When do you usually prepare for a test?
   () MORE THAN TWO DAYS
   () TWO DAYS BEFORE
   () NIGHT BEFORE
   () JUST BEFORE
23. What is the most common source of distraction to you in this class?
   0 NOISY CLASSROOM
   0 UNINTERESTING LESSON
   0 PERSONAL PROBLEMS
   0 CONVERSATION WITH OTHER STUDENTS
   0 EMOTIONAL PROBLEMS
   0 NOT DISTRACTED
   0 OTHER ________________________

24. Does your teacher use laboratory exercises to explain difficult subject matter?
   0 ALWAYS
   0 SOMETIMES
   0 SELDOM
   0 NEVER

THANK YOU FOR LETTING US KNOW HOW YOU FEEL
REFERENCE LIST


Drahoszal, E. (1997). *Validity information for the Iowa Test of Basic Skills (ITBS) and Iowa Test of Educational Development (ITED)*. Itasca, IL: Riverside Publishing Company.


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VITA

Name: Marcel A. A. Sargeant

Undergraduate and Graduate Schools Attended:

Andrews University
University of Guyana

Degrees Awarded:

2003 Doctor of Philosophy (Curriculum and Instruction)
Andrews University

1997 Drs. in Pedagogical Science (School management)
Department van Onderwijs

1995 Master of Arts (Education)
Andrews University

1987 Bachelor of Science (Biology)
University of Guyana

Professional Experiences:

2002-present Assistant Professor of Education and Psychology
Southwestern Adventist University, TX

1999-2002 Science Teacher
Hinsdale Adventist Academy, IL

1997-1999 Subject Consultant/Trainer
Federal Dept. of Education, Netherlands Antilles

1994-1999 Curriculum and Evaluation Specialist
SMA, St. Maarten, Netherlands Antilles

1992-1997 Math/Science Instructor
University of St. Martin, Netherlands Antilles

1988-1994 Chair of Science Dept./Science Teacher
SMA, St. Maarten, Netherlands Antilles