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States and nine other countries: Three considerations**

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San Jose State University, 1992

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SELECTED INFLUENCES ON ACHIEVEMENT IN SCIENCE
IN THE UNITED STATES AND NINE OTHER COUNTRIES:
THREE CONSIDERATIONS

A Thesis
Presented to
The Faculty of the
Department of Secondary Education
San Jose State University

In partial Fulfillment
of the Requirements for the Degree
Master of Arts

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August, 1992

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ABSTRACT

SELECTED INFLUENCES ON ACHIEVEMENT IN SCIENCE IN THE UNITED STATES AND NINE OTHER COUNTRIES: THREE CONSIDERATIONS

by Lynn Donnelly Stephens

Students from the United States scored below the mean or near the bottom on international science tests when scores earned by similar students in a number of other countries were examined (Eichinger, 1990). The ten countries which participated in the Second International Science Study (SISS) and were examined in this study were Australia, Canada, England, Finland, Hungary, Japan, Norway, Poland, Sweden, and the United States. Each of these countries tested students at the fifth and ninth grade levels, and students in their last year of secondary school taking advanced science. According to an examination of the results of the SISS, the amount of class time and the amount of emphasis placed on science education positively influence achievement on international science tests. Integration of the major fields of science in the curriculum does not, of itself, improve success on international science tests.

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for also making sacrifices
so that I could earn this degree.

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for all their support and encouragement
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CHAPTER ONE
INTERNATIONAL SCIENCE SCORES FOR THE UNITED STATES
AND NINE OTHER COUNTRIES

Introduction

The poor performance in science by students from the United States both on international and national tests has been the basis for much of the publicity about science education. Using data from the International Association for the Evaluation of Educational Achievement (IEA), Eichinger (1990) reported that students from the United States scored below the mean or near the bottom when scores earned by similar students in a number of other countries were examined. Students in the United States scored their highest in comparisons with other nations at the fifth grade level, placing eighth out of 15 participating countries. They ranked 14th out of 17 countries at the ninth grade level, last in biology, eleventh in chemistry, and ninth in physics at the twelfth grade level (International Association for the Evaluation of Educational Achievement, 1988).

In addition to the international tests, American students have showed a decline on national examinations as well. On most standardized tests American students are averaging lower scores than they did 26 years ago (Kurian, 1988). According to 1986 data reported by the National

Assessment of Educational Progress (NAEP), students in the United States have showed a decline in proficiency or achievement in five content areas of science (Mullis & Jenkins, 1988).

The Scholastic Aptitude Test, or SAT, scores for college bound students have also been declining (National Science Foundation, 1985). All students have shown a decline on the verbal scores from 1966 through 1991, though the math scores showed slight increases from 1981 through 1986 (College Entrance Examination Board, 1991; Snyder & Hoffman, 1991). According to Kurian (1988) the quantity of superior ratings, 650 or better out of a possible 800, on the SATs has also decreased (Kurian, 1988).

The NAEP study also noted that enrollment in high school science courses is low, and few students are taking the advanced science classes. According to a 1987 High School Transcript Study reported by the NAEP, approximately 90 percent of the American high school graduates had completed at least one year of biology, 45 percent had completed one or more years of chemistry, and only 20 percent had studied a full year of physics. Only six percent of the high school students in the United States took an advanced biology course (Mullis & Jenkins, 1988), less than four percent completed a second year of chemistry, and less than two percent completed a second year of physics

(Brown, personal communication, March 18, 1992).

It is important to examine science programs both in the United States and other countries to look for some variables that might give the teaching profession some clues about performance and explain the rankings. According to the 1986 NAEP study there is little time spent teaching science in the United States, particularly at the elementary grades. Approximately one half of the third-grade teachers surveyed claimed to spend one to two hours each week in science instruction; one fourth spent less than one hour per week teaching science, and about half of the seventh and eleventh grade teachers reported spending three hours or less each week in actual science instruction (Mullis & Jenkins, 1988). Many students leave high school without sufficient preparation in science and require remedial education at colleges and on the job (NSF, 1985). This study focuses on identifying variables relating to (a) the amount of time spent teaching science, (b) the emphasis placed on science education, and (c) the type of science curriculum.

Test results are a complex subject, even within a country, because of the number of variables involving culture, class, and curriculum.

Problem Statement

Students from the United States have performed poorly on national and international science tests. To improve

these scores, teachers need to find reasons for the poor performance.

Purpose Statement

The purpose of this study was to determine whether there is a relationship between test results and differences in science education programs, compared in terms of (a) the class time allocated to science, measured in years of schooling requiring science, and (b) the curriculum organization used in the ten nations selected for this study. The nine other countries selected for this study tested better than the United States on one or more science tests conducted by the IEA. The ten countries examined in this study were Australia, Canada, England, Finland, Hungary, Japan, Norway, Poland, Sweden, and the United States.

Research Questions

Data provided by the international science test scores were used to examine three possible variables:

1. Is there a relationship between the time spent teaching science and success on science achievement tests?
2. Is there a relationship between the emphasis placed on science education and success on science achievement tests?
3. Is there a relationship between integrating the fields of science in the curriculum and success on science

achievement tests?

Focus Statements

The following positions further guided the development of this study and provided a focus for the examination of the international tests.

1. The total amount of class time that a student is exposed to science per day, per week, or per year influences achievement on international science tests; the more exposure, the greater the achievement.

2. The greater the emphasis placed on science education throughout the period of schooling, grades one through twelve, the greater the achievement on international science tests.

3. Integration of the major fields of science in the curriculum does not, of itself, improve success on international science achievement tests.

Operational Definitions

achievement - A level of success or accomplishment as determined by performance on standardized international science tests in this paper.

anchor items - Identical questions on tests for different populations, thus allowing comparisons of improvement between the ninth and twelfth grades for example.

bridge items - Identical questions which were on the first and the second IEA studies, thereby making comparisons

between the two studies possible.

centralized control - A term which refers to one national agency or governing body which manages educational issues and curriculums for an entire country.

comprehensive system - Schools which include both general and specialized courses of study.

compulsory education - Schooling which is required by law.

curriculum - The course of study only.

emphasis - importance placed on science in terms of science requirements such as years of required science or minutes per day of science instruction.

FISS - First International Science Study done in 1970 by the International Association for the Evaluation of Educational Achievement.

horizontal - Type of curriculum as in the United States where one subject area of science is studied for a year and a different science the next year. For example, biology is usually studied in tenth grade and chemistry in eleventh grade.

IEA - International Association for the Evaluation of Educational Achievement, incorporated in 1967 as an international association of research centers from which the individual centers decide whether or not to participate in specific international studies (IEA, 1988).

integrated - Refers to a combination of sciences taught in a given time frame - sometimes two or more sciences taught together; sometimes merely two classes of one science taught per week and two classes of another science taught per week. This paper cannot establish finite information on the type of integration since it was not available.

layer cake - This term is used interchangeably in the literature with horizontal where each area of science is studied separately for a year at a time.

opportunity to learn - This is a term which refers to time that a student is exposed to a topic and, therefore, has the possibility of learning the material.

parallel - This is a term which describes the science curriculum in many European countries where several science subjects are taught over a period of several years, and the course may just be called "science" each year. For example, in Hungary physics is taught for two to three periods each week over an interval of four years in secondary school; chemistry is taught from two to four periods per week for three years, and biology is taught for two to four periods per week for two years.

poor performance - This term refers to achievement below the mean, specifically test scores below the average scores

earned by students in an international science study.

population 1, 2, 3 - This term identifies the group of students tested in the SISS; 10-year-olds, 14-year-olds, and 17-year-olds respectively. In the FISS they were Population I, II, and IV. In this country students would be fifth graders, ninth graders, and high school seniors.

proficiency - A term which refers to the mastery of knowledge and process skills as indicated by performance on specific tests, achievement.

selective system - A type of school system which is common in parts of Europe where there is organizational differentiation at early levels. The students are grouped at different types of schools often with selective admission requirements for academic schools and vocational schools. It frequently results in a high drop out rate of students not completing the entire school program, an aspect of emphasis in this study.

Singapore - A designation used in the SISS which refers to the Republic of Singapore and includes the capital, also named Singapore, and 40 islets.

SISS - Second International Science Study done in 1986 by the International Association for the Evaluation of Educational Achievement.

time - amount of class time spent in science instruction per day, week, or year.

Assumptions

It was assumed that not all schools within a country taught science in precisely the same way; therefore the data collected was considered representative of schools in that country, and the sample of students tested represented an "average" school. In other words, most schools in that country would be similar in curricula, hours of instruction, amount of science required, and other characteristics.

The sources of data were also believed to be accurate for the time that they were collected and reported and would yield approximately the same results regardless of the number participating.

Limitations

This study was limited to the data collected for the United States and nine nations that had published scores higher than those for the United States on one or more international science achievement tests, and that tested the same populations of elementary and secondary students in science. The data from the following nations--Australia, Canada, England, Finland, Hungary, Japan, Norway, Poland, Sweden, and the United States--were considered in this study. The study is further limited to data accessible at the time of this paper.

Delimitations

The study was limited to an examination of international test results, not to test questions. However, for those interested, sample questions may be found in Appendix B.

This study did not consider a number of factors which might also have affected science achievement on national and international achievement tests. For example, laboratory facilities and equipment, amount of money spent on education, teaching methods, student motivation, computer use in the classroom, class size, teacher training, adequate number of qualified teachers, teacher class loads, out of school science experience, home environment, social attitudes, and the amount of homework were not addressed in this study.

Statement of Significance

This study can provide a basis for rethinking the amount of time and the emphasis placed on science education in the United States, as well as a global perspective of the effects of parallel and layer cake science curricula.

Document Organization

The organization for the remaining chapters deviates somewhat from that of a traditional thesis in order to accommodate the nature of this study. Chapter two provides a review of the international tests and sources of

information about curriculum programs in each country rather than a review of the literature. Chapter three (a) focuses on test populations and test questions, (b) describes the research method, and (c) reviews related studies by other researchers. Chapter four analyzes the currently available test data and related studies presented in chapter three; and chapter five includes conclusions and recommendations, and presents further questions for consideration.

CHAPTER TWO

REVIEW OF INTERNATIONAL TESTS AND SCIENCE PROGRAMS

Introduction

The purpose of this chapter is to review available data on international testing and to give a brief description of the science programs in each of the countries involved in this study.

The three focus statements of this study (Chapter one, p. 5) relate to two of the five aims of the SISS: to (a) assess the present state of science education across the world by means of large-scale survey methods, and (b) focus on the function of science curriculum as the SISS identifies components that justify differences in the results of science education programs within systems and across educational systems. The remaining three aims of the SISS relate to (a) an examination of how science education has changed since the early 1970's, (b) an investigation of these changes from the 1970's to the 1980's, and (c) assistance to participating countries to perform associated national studies of science education and investigate areas of particular interest in their own systems (Rosier, 1987).

The data come primarily from the SISS, although some data are also used from the FISS as well as research relating to both studies. The compilation of this information is used to determine if there is any

relationship between class time spent on science, emphasis placed on science, and the science curriculum and success on science achievement tests for the ten countries involved in this study: Australia, Canada, England, Finland, Hungary, Japan, Norway, Poland, Sweden, and the United States.

This chapter will be subdivided into review of international testing, and science programs for nations in this study. Section one has six additional subdivisions; history of international IEA tests, preparation for testing, test content, populations tested, first international science study--FISS, and second international science study--SISS. Section two is further divided by country.

Review of International Testing

History of international IEA tests

The purpose of the Second International Science Study (SISS) was to evaluate international science achievement using a similar format as that used in the First International Science Study (FISS) (Anderson, 1989) to provide an overview of science education across the world (Rosier, 1987). The FISS and the SISS were both sponsored by the International Association for the Evaluation of Educational Achievement, IEA (Anderson, 1989). The individual research centers decided whether or not to participate in the studies; IEA did not select countries for participation. Nineteen countries participated in the FISS

which took place in 1970. Twenty-four countries participated in the SISS which was begun in 1980 with the actual testing done in 1986. Ten countries participated in both of the studies (IEA, 1988) but not necessarily in all areas of the science study. Though this study is limited to ten nations in the SISS, all of the participating countries worked together to produce test questions. These questions represented the curricula in all of the countries, and each country agreed upon common procedures for data collection and testing (Anderson, 1989).

Preparation for testing

For both the FISS and the SISS, curriculum was defined as learning experiences which were planned and arranged by the school and was further divided into three sequential stages: the intended curriculum, the implemented curriculum, and the achieved curriculum. The international science achievement tests which resulted from the FISS and the SISS examined the achieved curriculum. The implemented curriculum was determined through teacher surveys, particularly their estimates of the opportunity to learn each topic, and involved the individual teacher's interpretation, presentation, and implementation of the curriculum. The results of the achieved curriculum, or degree to which students internalized the curriculum, was measured, at least in part, by the results of the science

achievement tests. The intended curriculum was used in the process of selecting a consensus curriculum from which the test questions were formed. In order to be part of the consensus curriculum, the topic had to be considered important through the survey ratings by a majority of the school systems. In addition, the test items needed to include the three levels of knowledge, comprehension, and application (Rosier, 1987).

The ten nations had the option of using a combination of international and national science test questions, thereby allowing comparisons between countries as well as an assessment of topics that received greater emphasis in a country's educational system. Known differences in curriculum could aid in interpreting differences in achievement on the science achievement tests (Rosier, 1987).

Test content

The basic science content areas used in the FISS and the SISS were biology, chemistry, physics, earth science, and other science content. The other science content included technology, rural science, and health science. Each category was assigned a numerical rating which indicated the amount of coverage for each topic (Rosier, 1987).

Topics which were covered in the SISS chemistry achievement test were theoretical chemistry, energy,

solutions, acids and bases, reactions, oxidation-reduction, organic chemistry, and nuclear chemistry. Thirty percent of the questions dealt with the topic of reactions (Ferko, 1989).

Approximately forty percent of the questions on the physics test dealt with the topic of mechanics; other topics included heat, optics, electromagnetism, and modern physics (Ferko, 1989).

The main survey of the FISS and the SISS included the following parts: a school questionnaire, a teacher questionnaire, a student questionnaire, surveys of opportunity to learn, science problems, calculation problems, and practical tests for laboratory work. The objectives of the tests were classified into three categories: (a) knowledge, (b) understanding indicating that students could use the knowledge attained in the textbook, classroom, or laboratory situation, and (c) application which required students to extract and apply pertinent knowledge to new circumstances using the processes of analysis, synthesis, evaluation, and problem-solving (Mikake, 1989).

Populations tested

The nine countries selected for this thesis participated in the SISS general science tests at the fifth and ninth grade levels; biology, chemistry, and physics

advanced science tests were given at the senior high school level (Anderson, 1989).

The three populations included in the SISS were Population 1, the 10-year-olds generally in the fourth or fifth grades representing the elementary school level; Population 2, the 14-year-olds or ninth grade in the United States representing the lower secondary school level; and Population 3, students in their final year of secondary school who were studying science, who in the United States were seniors currently taking second year or advanced biology, chemistry, or physics representing the upper secondary level (Eichinger, 1990).

Although final results are not yet available, the SISS had preliminary results from 17 of the 24 participating countries as of 1988. A total of 71,576 students from 2,617 schools were tested in 17 countries at Population 1; Population 2 involved 73,001 students from 2,819 schools (IEA, 1988). Population 2 was chosen because this was the last year that it was still supposed that nearly all students were still in school in each of the countries (Rosier, 1987). Population 3 included 76,271 students from 4,372 schools (IEA, 1988).

The SISS was limited by the small sample of the advanced science populations compared to the entire United States population enrolled in science courses (Ferko, 1989).

Population 3, consisting of all upper secondary level students, had the greatest variation in age since it included the students in the terminal year of secondary school at whatever age (Riddle, 1986). Population 3 was subdivided into three subgroups (Anderson, 1989). The 3P population was those students who were taking a second year of physics, 3C was the Population 3 chemistry students, and 3B, the biology students (Mikake, 1989).

First international science study--FISS

The first IEA study in 1970 tested 258,000 students in 9,700 schools in 19 countries and in 14 different languages. Since the results from some countries and some of the studies examining the SISS in 1986 have not yet been reported, for this paper relevant research from the FISS in 1970, particularly relating to the opportunity to learn, is cited and identified when similar data are not available for the SISS (Riddle, 1986).

Although the focus of this thesis is on the test scores of the SISS since those represent the most recent data available, it should be noted that the wide variation in the size of the populations tested and still in school in the last year of secondary school led to the top nine percent being used for some comparisons in the FISS. This percentage represented the smallest number of students in upper secondary school in any of the countries. There were

also comparisons made for the top five percent and the top one percent. When the top nine percent were compared for their mean scores, the score for the United States was doubled (Husen, 1983) and the United States ranked second (Andren, 1989). No such smaller comparisons are yet available for the SISS, so all tables presented in chapter four represent the total populations tested in each country in the SISS.

Second international science study--SISS

In 1983 and 1984 background information about the schools, the intended curriculum, and related information were collected, and the testing began in 1986 (Anderson, 1989). There were some differences among some of the tests administered in some of the nations. The United States used only 25 out of 30 of the same test questions on the biology and chemistry tests and 26 out of 30 on the physics test. Questions omitted were not covered as part of the advanced curriculum in the United States and were replaced with optional national questions. These scores were compared with the other countries which took all 30 questions (IEA, 1988).

The international science achievement test scores used in this study are a result of the SISS. In the Second IEA study over 12,000 students from 597 classes from 125 American schools were tested; ninety percent of these were

public schools (Jacobson & Doran, 1985; Ferko, 1989).

Assessment of advanced science students included testing of 1736 students from 118 schools which offered second year courses in biology, chemistry, or physics (Fenko, 1989).

Science Programs for Nations in this Study

The second part of this chapter is a brief description of some of the science programs of each of the countries involved in this study. A more complete description may be found in Appendix A or in some of the sources listed in the references. The information included for each country varies because many are national reports and, therefore, do not include identical data but have common strands of information. More data are included for the United States since its programs are better known in this country.

Australia

Since science begins in the third grade, students have a minimum of eight years of science. Science is offered as a core subject in grades seven or eight through grade ten and is still part of the core curriculum in grades 11 and 12 (Kurian, 1988). Physics and chemistry are both taught extensively in grade 12 (Rosier, 1985).

Canada

Science is often taught as an integrated or environmental course in the secondary schools. In general, students are required to take only one semester of science

in order to graduate. Advanced physics is offered in grade 11, and chemistry is available in grade 12 in most provinces. Some provinces offer courses in physics, chemistry, and biology in grade 13 (Raat, Harding, Mottier, 1982).

England

Each school selects its own curriculum with science offered beginning in the primary grades, but generally it amounts to only two lessons per week. Most students take science for each of the first four years of secondary school (Male, 1988). The first two years consist of integrated science courses, and the final two years are a combination of integrated and non-integrated courses (Raat, Harding, & Mottier, 1982). In the last two years the students begin to specialize, usually in two or three major subjects in either math-science or social science, languages, and humanities. Usually at least half of their time is spent on these major subjects (Male, 1988). All students are supposed to study science during the compulsory years of schooling (Lapointe, Mead, & Phillips, 1989).

Finland

In the equivalent of grades seven, eight, and nine, students study chemistry and physics for an average of seven hours per week with total classroom instruction totaling 30 hours of instruction per week. Students are required to

study biology, chemistry, and physics and may take additional elective courses in the three years of non-compulsory upper secondary school (Kurian, 1988).

Hungary

At grade six students begin studying biology and physics with an average of 64 lessons per year in the sixth, seventh, and eighth grades. Students begin studying chemistry in the seventh grade and average 64 lessons per year in grades seven and eight. Science is also required in the upper secondary levels (Mitter, 1988). The amount of time that science is taught in Hungarian schools is high and can presently be regarded as the leading branch of Hungarian education (Bathory, 1989).

Japan

Science is emphasized and taught at all levels of compulsory schooling (U.S. Department of Education, 1986; Nakayama, 1987). In elementary and lower secondary schools more than 25 percent of the class time is spent teaching math and science (Jacobson et al., 1986); in grades seven and eight 105 class hours, each consisting of 50 minutes, are spent in science instruction, and in grade nine students study science for 140 class hours (Kobayashi, 1988).

Science is taught as a somewhat integrated course particularly from the third grade on. At the lower secondary level science is divided into fields: the first

field combines chemistry and physics; and second field combines biology and earth science (Nakayama, 1987). Math and science courses are often integrated so that the advanced science courses may require calculus, for example. Science topics, which are not usually taught in the United States until upper secondary school or even college level, are taught in lower secondary schools in Japan (Jacobson et al., 1986).

At the upper secondary level science is taught as both an integrated program and as a separate subject. Nakayama (1987) reported that in the tenth grade all students take the integrated Science I course while few students enroll in the optional integrated Science II course. Instead, most students elect to take at least two of the following subject courses, physics, chemistry, biology, and earth science with physics and chemistry the most often selected electives. The choice of electives is up to the student, but a science course, consisting of periods of 50 minutes four days a week, is taken each year the student is in upper secondary school. The total number of class hours or 50 minute periods is 140 per year at this level (Nakayama, 1987).

Norway

Norway's centralized system of education determines the common curriculum, dictating even the number of lessons to be taught for each subject (Raatt, Harding, & Mottier, 1982).

Science begins at the fourth grade (Kurian, 1988) with integrated science classes taught in the last three years of compulsory schooling. However, physics, chemistry, and biology are easily identified as separate parts within this integrated program. Science is also integrated in the first year of upper secondary schooling. In the following years students specialize and take separate courses; some exclusive universities only accept students who specialized in physics (Raaij, Harding, & Mottier, 1982). For those students who are accepted into post-basic schooling, science is required in each of the three years (Kurian, 1988).

In the seventh, eighth, and ninth grades students take two to three hours of science each week, and in grades 11 and 12 students specialize in one of four areas, one of which could be natural science which includes the study of physics, chemistry, and biology (Kurian, 1988).

Poland

Students study nature study or biology for two hours per week from grades three through eight, adding two hours of physics instruction each week in the sixth grade and three hours in the seventh and eighth grades. Two hours per week of chemistry are required in the seventh and eighth grades totaling seven hours per week of science instruction in grades seven and eight (Tomiak, 1988).

Some of the secondary general-education schools

specialize in the biological and chemical sciences or mathematics and the physical sciences. In the general profile or nonspecialty programs, students study biology and chemistry for two hours a week for three years during secondary school, and physics is studied for three hours a week in the first, third, and fourth years and for two hours a week in the second year (Tomiak, 1988).

Sweden

Students are introduced to science in grades one to six, and in upper-secondary school science and technology is one of the three main integrated areas of study for students following academic, general, or vocational courses of study. Integrated programs at this level are an effort to give equal emphasis to academic, general, and vocational education (Marklund, 1988). Technology and the natural sciences are part of the required curriculum throughout compulsory schooling (Raatt, Harding, & Mottier, 1982).

United States

In elementary schools less time is devoted to science than to reading, mathematics, and social studies (Hurd, 1982). At grades one through three approximately 17 minutes is spent studying science, and at grades four through six students study science for about 28 minutes per day (Jacobson, 1986). There is no common curriculum at this level, although science is generally taught as an integrated

course (Hurd, 1982) by an elementary teacher with a weak science background (Jacobson, 1986). In the seventh and eighth grades 90 percent of the students in the United States are enrolled in either a single semester or a year-long science class usually studying general science, earth science, biology, physical science, or occasionally an integrated course. In the ninth grade only 75 percent of the student population is taking science; however, recently nearly half of the states have increased the science requirement for graduation from one to two years (Jacobson, 1986), so that the average number of years of science taken by students in the United States is 2.2 years (NSF, 1985).

Science is usually taught as separate topics in both lower and upper secondary schools which means that one kind of science is taught one year and a different kind the following year. According to Jacobson (1986), a typical science program at the secondary level is earth science in ninth grade, biology in tenth, chemistry in eleventh, and physics in the twelfth grade with additional advanced science courses also offered in the twelfth grade. In many other nations students are taught each of the sciences every year (Jacobson, 1986).

Only seventy-four percent of the students from the United States in academic curriculums at their high schools had taken two years of science, and fifty-five percent had

taken three or more years of science. Approximately thirty-five percent of the students enrolled in a vocational curriculum, and of this group only 44 percent had completed two or more years of science. Biology was an elective course in 55 percent of the schools and required in 44 percent of the nation's schools, and sixty percent of the schools required an additional science for high school graduation (Hurd, 1982).

Conclusion

There are major similarities and major differences in the science programs of the ten countries relating to the time spent teaching science. Some countries had a very specific number of minutes scheduled for science at each level while others were much more general in their requirements. There was also much variation in the curriculum at each level; many countries had some type of integration in their science programs but the degree of integration varied considerably.

The complexity of the results from the international tests is evident from the lack of available data for the more recent SISS. For this reason some data from the earlier FISS are also used for this study.

CHAPTER THREE

ABOUT THE TEST AND FINDINGS OF OTHER RESEARCHERS

Introduction

This chapter focuses on test results and opinions of other researchers which are now available for the United States and nine other countries--Australia, Canada, England, Finland, Hungary, Japan, Norway, Poland, and Sweden in which students have higher test scores than the American students on the international science achievement tests. Most of the test results are covered in detail in chapter four. The findings of other researchers are cited in both chapter three and four as they relate to this study.

Addressing the chapter in this way supports the purpose of this study: to determine whether there is a relationship between test results and differences in science education programs, noted in terms of the class time allocated to science, in years of schooling requiring science and the curriculum organization used in the ten nations selected for this study.

At this point many exhaustive quantitative research studies of the SISS have not yet been concluded; therefore, there is too little consistent, reliable data presently available for a correlational study. However, this study was designed to further the analysis of the SISS. Adding to knowledge gained from the study about the tests provides the

teaching profession with data to examine local programs.

This chapter is divided into the following subheadings: population, instrumentation/data collection, data analysis, questions on the international tests, and conclusions of other researchers. Section five is further divided into second international science study--SISS, time spent teaching science--FISS, and curriculum and organization--FISS and SISS.

Population

The population of this study includes Populations 1, 2, and 3 which were tested in the Second International Science Study for each of the ten countries. Population 1 represented the elementary level in fifth grade, Population 2 the lower secondary level in ninth grade, and Population 3 the upper secondary level in twelfth grade. Population 3 was further divided by students taking the advanced biology test (3B), advanced chemistry students (3C), and advanced physics students (3P). The test performance and the time spent on science education were examined to see how they relate to the students in each of these populations.

Table 1

Population 1 and 2 Sample Sizes

Country	Pop. 1 (5th grade)		Pop. 2 (9th grade)	
	# of sch	# of students	# of sch	# of students
Australia	220	4259	233	4917
Canada	215	5104	209	5543
England	181	3748	147	3118
Finland	106	1600	90	2546
Hungary	100	2590	99	2515
Japan	221	7924	199	7610
Norway	91	1305	77	1420
Poland	199	4390	201	4520
Sweden	64	1449	69	1461
U.S.	123	2822	119	2519

Note. sch means schools.

(IEA, 1988).

Table 2

Populations 3B, 3C, and 3P Sample Sizes - Upper Secondary

Country	3B-Biology		3C-Chemistry		3P-Physics	
	Sch	Stnts	Sch	Stnts	Sch	Stnts
Australia	164	1631	164	1177	163	1073
Canada	187	3254	179	2923	181	2766
England	123	884	123	892	125	917
Finland	43	1652	44	971	42	810
Hungary	71	301	56	143	75	398
Japan	38	1212	43	1468	36	1187
Norway	52	276	46	283	55	443
Poland	71	764	71	765	79	1716
Sweden	119	1232	119	1172	119	1156
U.S.	43	659	40	537	35	485

Note. sch means schools, stnts means students.

(IEA, 1988).

Tables 1 and 2 show the number of schools and students involved in each country for each of the populations in the SISS which took place in 1986. The variation in the number of schools and students tested adds to the complexity of the testing issue and the need to examine data for possible relationships as in this study.

Instrumentation/Data Collection

Data were collected by document analysis. Most of the information was gathered from The Encyclopedia of Comparative Education and National Systems of Education (1988), World Education Encyclopedia (1988), The International Encyclopedia of Education (1985), Science Achievement in Seventeen Countries: A Preliminary Report (1988), Digest of Education Statistics 1990, as well as other related documents, magazines, and journals identified by ERIC. The research generated quantitative and qualitative data which were primarily analyzed using a cross matrix format or rank orders.

Data Analysis

Data are derived from published studies of the two international examinations. To clarify and simplify the complex results, the researcher uses tables, figures, and some narration. The figures in chapter four present the science results for Populations 1 and 2, the elementary and lower secondary levels and each country's performance for Population 3, the upper secondary students, in biology, chemistry, and physics.

Tables in chapter four are used to show the length of the school year as it can be determined, number of years of compulsory schooling, years of required science, rankings on the various tests, and mean scores on each of the tests. A

cross matrix table indicates integrated science programs, non-integrated programs, or a combination of both for each country.

Questions on the International Tests

Some of the questions were identical to test questions in the first IEA study which allowed for comparisons between the two studies. These were referred to as "bridge items." There were also questions which were the same on first and second year biology tests which also allowed comparisons between these groups (Anderson, 1989). The fifth graders in the United States scored 3.5 percent higher in the SISS than on the FISS on 18 of 26 bridge questions. The ninth graders improved their scores from 1970 to 1986 by 2.8 percent on 15 of 33 bridge questions. They scored higher on the biology bridge questions than on the physical science questions (Jacobson & Doran, 1985).

There were 15 anchor questions which indicated identical questions on both the ninth and the twelfth grade tests. The twelfth grade physics students from the United States scored 22 percent higher than the ninth graders on these anchor questions. The grade nine students scored 19 percent higher on the anchor items than the Population I students (Helgeson, 1988). There were 20 questions which were the same on the fifth and the ninth grade tests, and the ninth graders were more successful on each of these

items (Jacobson & Doran, 1985).

Conclusions of Other Researchers

Second international science study--SISS

Although not all were a part of this study, Population 3, or the twelfth grade level in Hong Kong, England, and Singapore scored the highest out of all the students who participated. These students study a limited number of subjects and basically specialize at the upper secondary level (IEA, 1988).

The achievement by students from the United States on all three of the advanced science tests was below the international mean (Ferko, 1989; Anderson, 1989).

According to the results of the second IEA study with 17 countries participating at the ninth grade level, students from the United States only scored higher than the students of Singapore and the Philippines (Walberg, 1989).

The Japanese physics students had an average of 17 correct out of 30 questions on the international physics test, but students from the United States had an average of only ten correct (Jacobson et al., 1986).

According to Jacobson and Doran (1985) the data indicated that students did better on questions dealing with process skills, such as questions dealing with classification, measurements, calculations, and data analysis than they did in 1970. According to the SISS the

ninth graders tested in 1986 scored higher in science than their 1970 counterparts. Students showed improvement in higher order thinking skills and process skills. In the SISS 81 percent of the students correctly read the volume of a liquid in a graduated cylinder, only 42 percent answered it correctly in 1970 (Jacobson & Doran, 1985).

Time spent teaching science--FISS

Since most of the more detailed analysis of the SISS, especially relating to the opportunity to learn, has not yet been reported, relevant research relating to the FISS important to this study has been included instead.

Most foreign countries require that their students take science at all grade levels. Students usually do not meet everyday, and the coursework may extend over several years. However, based on total class hours of science at most three-year foreign high schools, all students have had about three times as many class hours of science as their counterparts taking three years of science in the United States (Hurd, 1982; Kurian, 1988). According to Hurd (1982) science is obviously viewed as being more important to more students in these countries since the total population receives more science. Most foreign high schools have few elective subjects and when available are usually offered only in the final year and in addition to the required coursework (Hurd, 1982).

Dunkin (1988) cited various studies which examined the opportunity to learn and test performance for the FISS. According to the IEA there was a significant positive relationship between the opportunity to learn and achievement in science when comparisons were made between the countries in at least some of the test populations (Dunkin, 1988). Students in Japan, West Germany, East Germany, and the former Soviet Union are exposed to twice to three times the amount of science that students from the United States receive. Their school year is longer, 210 to 220 days instead of 180 days. There are also differences in the length of the school day and school week, attendance standards, amount of homework, and amount of time devoted to science in the general curricula (NSF, 1985).

Curriculum and organization--FISS and SISS

Klopfer (1973) and Jacobson (1987) noted that students in the United States study secondary science in a horizontal or layer cake format where each subject is studied separately for a year. Meanwhile, many European countries have more integrated programs where students study several science subjects at the same grade level and continue to do this over a period of several years (Eichinger, 1990).

In many European countries, the government determines the curriculum by setting national performance standards and then administering standardized exams. In Sweden the

National Board of Education formulates the standardized achievement tests and then administers the tests to all students in order to ensure that teachers use a uniform grading scale for students (Husen, 1983).

The goals of upper secondary schools also determined the curriculum; for example, European secondary schools used to prepare only a select few to go on to the university. For example, in the mid-1960's only nine percent of German students graduated from upper secondary school while 75 percent graduated in the United States. However, most of those German students planned on continuing their education at the university, but that was not the case for the American students. For this reason, in some of the studies only the top five to ten percent were considered and compared. In these cases, the comprehensive systems, like those in the United States, had top students who performed at close to the same levels of the more selective systems. In the United States the comprehensive school uses ability grouping or homogeneous classes to separate students. In the selective systems of most European countries, students are divided into different types of schools which separate the students at a young age, sometimes after only completing four or five grades. The recent trend has been to postpone this process of separation (Husen, 1983).

In Canada and Sweden there were two tracks, one of

which consisted of twelfth graders and the other students in grade 13. In Canada grade 13 was in English speaking Ontario. In Sweden grade 13 consisted of the technology track (Snyder & Hoffman, 1991).

Riddle (1986) noted that some countries reported educational philosophies indicating that they wanted to maintain high standards. In so doing, they accepted the fact that large parts of their population would not have the opportunity to complete the academic educational program. On the other hand, Riddle (1986) reported that countries like Japan seemed to succeed in maintaining high academic standards and kept high participation at the same time. For example, Japan currently graduates 96 percent of its students from high school; the United States graduates 76 percent (Walberg, 1989). Some countries had selective systems due to the limited number of university spaces available and consequently had tough competition for those spots. Riddle (1986) stated that American universities may also be selective but more by their drop out rate or number of students who do not complete a degree program rather than by their entrance requirements. Many nations had strict national exams that students needed to pass for high school graduation. Some countries had early ability tracking while in the United States it is usually delayed until high school. In the United States there seems to be greater

emphasis on elective courses as well. There are greater ties in some countries between the secondary schools and the universities than with the elementary schools. In the United States the ties are closer between the elementary and secondary schools so there may be fewer university influences (Riddle, 1986).

Conclusion

The data from reports of the two tests make it evident that the wide variations in the time spent teaching science, the science curriculum, and school organization add to the complexities of comparing test results.

CHAPTER FOUR

ANALYSIS OF TEST DATA: THREE CONSIDERATIONS

Introduction

Previous chapters in this thesis have delineated the reasons for concern about the scores from the United States, information about the development of the tests, and differences within the nations and even among the researchers. The purpose of this chapter is to present and discuss available data which are pertinent to this study. The analysis of the test results of the SISS are presented after all the data carried in this research have been given so that the results can be categorized according to time spent on science education, emphasis placed on science education, and the science curriculum.

As the discussion which follows will suggest, the complexity of the problem of using a single test to demonstrate knowledge of science worldwide makes a definitive statement difficult because of the many aspects of learning which are not addressed, including the exact age of the students as indicated in the tables in this chapter. Limiting this study to three aspects controlled generally by a school system can provide some ideas about the way time in the classroom, the emphasis placed on science in the school, and curriculum organization have perhaps influenced achievement on these international tests.

This chapter is divided into the following headings: population 1--elementary level; population 2--lower secondary level; populations 1 and 2, elementary and lower secondary levels; population 3--upper secondary level, biology; population 3--upper secondary level, chemistry; population 3--upper secondary level, physics; summary of data; time; emphasis; and curriculum. The summary of data is further divided into Figure 2--upper secondary level test results, Table 8--rank on each of the tests, and additional information and possible problems. Time is subdivided into length of the school year, class time spent teaching science, required years of science, and additional studies relating to time.

There are nine tables and two figures included in the chapter. Table 3 gives pertinent information about Population 1, the elementary school level; Table 4 presents data about Population 2, the lower secondary level; and Figure 1 presents data from both of these levels. Tables 5, 6, and 7 present the data for Population 3, the upper secondary level in the areas of biology, chemistry, and physics, and Figure 2 displays this data in the form of a bar graph. Table 8 presents the rank of each of the countries at each population. Table 9 gives the length of the school year and years of required science for each of the ten countries. Table 10 furnishes more detailed

information for some of the countries about the number of hours per week and per year spent teaching science. Table 11 provides the type of science program as well as the rank of the various populations for each country.

Table 3

Population 1 - Fifth Grade Science Achievement Scores - SISS

Country	Relative Rank	Mean correct	% of schools with means below 12.6	Mean Age
Japan	1	15.4	0	10:7
Finland	2	15.3	7	10:10
Sweden	3	14.7	3	10:10
Hungary	4	14.4	21	10:3
Canada	5	13.7	25	11:1
United States	6	13.2	38	11:3
Australia	7	12.9	37	10:6
Norway	8	12.7	58	10:11
Poland	9	11.9	66	10:11
England	10	11.7	61	10:3

(IEA, 1988)

Population 1--Elementary Level

In rank order Table 3 presents the mean scores in the SISS for each of the ten countries in this study for Population 1, fifth graders. In addition, the table also includes the percentage of schools which scored below the average score of the lowest achieving school in the top ranking country; in this case Japan, with a mean of 12.6 out of a possible 24. Table 1 on page 30 contains the data on the number of schools and students participating in this test.

Japan, Finland, and Sweden ranked first, second, and third, respectively, and Finland and Sweden had fewer than ten percent of their schools score below Japan's lowest ranking school. Finland with a mean score of 15.3 was only a partial percentage point behind Japan with 15.4. Students in this population scored better than their counterparts in any of the other science categories in Japan, Finland, Sweden, and the United States. However, while each of the other countries placed first, second, and third, the United States placed sixth. It is also interesting to note that the students in the United States were the oldest of the ten countries at this level. Norway, Poland, and England were the lowest ranking nations in this category and all three had approximately 60 percent of their schools score below Japan's lowest ranking school.

Table 4

Population 2 - Ninth Grade Science Achievement Scores - SISS

Country	Relative Rank	Mean Correct	% of schools with means below 14.8	Bottom 25% Mean	Mean Age
Hungary	1	21.7	0	15.7	14:3
Japan	2	20.2	1	13.7	14:7
Canada	3	18.6	6	12.4	15:0
Finland	4	18.5	2	13.7	14:10
Sweden	5	18.4	1	12.2	14:10
Poland	6	18.1	14	11.4	15:0
Norway	7	17.9	1	12.5	15:10
Australia	8	17.8	8	12.2	14:5
England	9	16.7	19	10.5	14:3
U.S.	10	16.5	30	10.3	15:4

(IEA, 1986)

Population 2--Lower Secondary Level

Table 4 indicates the mean scores for the ninth grade, or 14-year-old level, as part of the SISS and includes the rank and the percentage of schools which scored below 14.8 out of a possible 30 earned by the lowest performing school in top ranked Hungary. Hungary, Japan, and Canada were the

top ranking countries in this category followed closely by Finland and Poland. The United States ranked last and had 30 percent of its schools score below 14.8, the nine other countries had fewer than 20 percent score below this level. The lowest scores were Australia, England, and the United States, all English speaking countries. The students in the United States were the second oldest students at the time of this test, while first place Hungary tied with the youngest students. Table 1 on page 30 supplies data about the number of schools and students participating at the lower secondary level.

The mean scores for the bottom 25 percent in each country for Population 2 are also given in Table 4. The scores earned by the bottom 25 percent in England and the United States indicated that these students barely scored above chance level according to the IEA study (1988). The same group of students in Hungary, Japan, and Finland scored well.

The United States had the greatest drop in ranking from Population 1 to Population 2 going from sixth to tenth place. Finland and Sweden dropped their rankings by two places, and Japan and Australia each fell one place in the rankings. Hungary showed the most improvement in its ranking of Population 1 and Population 2 going from fourth to first place. Poland went from ninth to sixth in the two

populations and Canada went from fifth to third.

Students from the United States even showed a decline from the FISS in 1970 to the SISS in 1986 when compared to other students from the United States. The United States dropped from seventh out of 17 countries in the FISS to fourteenth out of 17 countries or third from the bottom in the SISS in Population 2. England, Italy, the Philippines, and the United States were the only countries which did not earn maximum scores of 30 in the SISS; for the United States the top score was 29 (IEA, 1988). For those who question the validity of making comparisons between countries, this comparison between the performance in the United States in 1970 and in 1986 should suggest a valid reason for concern for declining test scores. In addition, according to the IEA study only 42 percent of this age group in the United States could analyze scientific data and use scientific methods (Lapointe, Mead, & Phillips, 1989). All of these data support the fact that science scores in the United States are declining and that differences exist in the American educational system and its science programs and those of other countries. Again, these rankings demonstrate the complexity of the problem.

According to the IEA (1988) the lower secondary level of Japan, Norway, Finland, and Sweden seemed to have a similar curricula and similar performance between their

schools as indicated by the lack of variation among their schools (IEA, 1988). Kifer (1989) notes, for example, that in Japan the variation in scores seemed to be between the students since there was little variation between schools or classrooms. Apparently their educational policies produce relatively equal schools and classrooms (Kifer, 1989).

Figure 1

Populations 1 and 2, Elementary and Lower Secondary Levels

The data from Tables 3 and 4 (pp. 42 & 44) are reinforced by Figure 1 on the previous page which presents the mean scores of both Population 1 and 2, for each of the ten countries. Although they are shown together, the test administered to 10-year-olds in Population 1 consisted of 24 common questions and the test given to the 14-year-olds in Population 2 consisted of 30 common questions which adds to the complexity of making assumptions. Note the high performance at the upper secondary level by Hungary and Japan and the poorer performance by England and the United States.

Table 5

Population 3 - Upper Secondary Biology Achievement Scores

Country	Relative Rank	Mean	% of schools with means below 56.6	% of students in course	Mean Age
England	1	63.4	14	4	18:0
Hungary	2	59.7	37	3	18:0
Poland	3	56.9	48	9	18:8
Norway	4	54.8	56	10	18:11
Finland	5	51.9	91	45	18:7
Sweden	6	48.5	78	15	19:0
Australia	7	48.2	93	18	17:1
Japan	8	46.2	84	12	18:1
Canada	9	45.9	95	28	18:2
U.S.	10	37.9	98	6	17:5

(IEA, 1988).

Population 3--Upper Secondary Level, Biology

Table 5 shows the mean results of the biology test, and the percent of schools scoring below the lowest mean score of 56.6 percent at a school in Singapore, which, although was not a part of this study, had the highest ranking in biology overall. The top three countries in this category

were England, Hungary, and Poland, and the United States placed tenth with a mean of 37.9 behind Canada in ninth place with 45.9. Four countries, Finland, Australia, Canada, and the United States had over 90 percent of their schools scoring below the lowest scoring school in the highest ranked country (IEA, 1988). Students from the United States were the second youngest at the time of the test while students in the top three countries were half a year or more older. Table 2 on page 31 contains data about the number of students and schools participating in each country on the biology test.

England ranked first in Population 3 in biology, chemistry, and physics, moving up from ninth place at the ninth grade level (see Figure 2 p. 57). England's poor performance at Population 1 and 2 and outstanding performance at Population 3 could also be affected by the number of students who leave school before reaching their terminal year of secondary school. Hungary ranked second or third in each of the three science areas in Population 3. Poland had its highest rank of third place on the biology test. Norway ranked fourth on both the biology and the physics tests which were its two best rankings, see Table 8 on page 59. This was the only test where the Japanese students did not score in the top three, placing eighth in biology. English-speaking Canada dropped from third place in

Population 2 to ninth place on each of the biology, chemistry, and physics tests. The range on the biology test was from a high of 63 percent in England to 38 percent in the United States (IEA, 1988).

Included in the table are the percentage of total students in school taking advanced biology in each country. Canada had 28 percent of its students taking advanced biology, Finland had 45 percent and the remaining eight countries had enrollments ranging from 18 percent in Australia to three percent in Hungary (IEA, 1988). The top three countries all had below ten percent enrolled in advanced biology but the United States also had under ten percent enrolled and was last.

Table 6

Population 3 - Upper Secondary Chemistry Achievement Scores

Country	Relative Rank	Mean	% of schools with means below 30.0	% of students	Mean Age in course
England	1	69.5	0	5	18:0
Japan	2	51.9	14	16	18:2
Hungary	3	47.7	13	1	18:1
Australia	4	46.6	4	12	17:3
Poland	5	44.6	13	9	18:7
Norway	6	41.9	4	15	18:11
Sweden	7	40.0	11	15	18:11
U.S.	8	37.7	48	1	17:8
Canada	9	36.9	26	25	18:4
Finland	10	33.3	24	14	18:6

(IEA, 1988).

Population 3--Upper Secondary Level, Chemistry

Table 6 shows the mean scores for each country on the chemistry test for Population 3, including the percentage of schools in each country which scored below the lowest mean score of 30.0 percent at a school in Hong Kong which, although not a part of this study, had the highest ranking

in chemistry overall. The United States had almost 50 percent of its schools score below 30.0 percent followed by Canada and Finland with approximately 25 percent (IEA, 1988).

The top three countries in chemistry were England, Japan, and Hungary followed closely by Australia and Poland (IEA, 1988). Japan and Australia earned their highest rankings for this population on the chemistry test, Finland dropped to last place, while Canada remained in ninth place, and the United States moved up to eighth but still in the bottom half. Again, the students from the United States were the second youngest at the time of the testing, though they were less than half a year younger than the students in the top three countries.

The percentage of students enrolled in chemistry in each country is also provided in Table 6. Canada had the highest percentage of students enrolled in advanced chemistry with 25 percent; the United States had the lowest with only one percent.

Table 7

Population 3 - Upper Secondary Physics Achievement Scores

Country	Relative Rank	Mean	% of schools with means below 50.5	% of students in course	Mean Age
England	1	58.3	18	6	18:0
Hungary	2	56.5	45	4	18:1
Japan	3	56.1	36	11	18:2
Norway	4	52.8	44	24	18:11
Poland	5	51.5	53	9	18:7
Australia	6	48.5	67	11	17;3
U.S.	7	45.5	89	1	17:8
Sweden	8	44.8	82	15	18:11
Canada	9	39.6	93	19	18:4
Finland	10	37.9	93	14	18:6

(IEA, 1988).

Population 3--Upper Secondary Level, Physics

The mean scores are presented in Table 7 for the students in each country on the physics test for Population 3. In addition, the percentage of schools is provided in each country which scored below 50.5, the lowest school in Hong Kong, not a part of this study, but ranked first

overall. Canada, Finland, and the United States had the highest percentage of schools ranking below the lowest scoring school in the highest ranking nation. Canada and Finland both had 93 percent of their schools scoring in this category, and the United States had 89 percent of its schools in this group. England, Hungary, and Japan were the top ranking countries in physics and the United States ranked seventh (IEA, 1988). The age of the students at the time of the test did not seem to effect the rankings of each country.

England ranked first in all three of the Population 3 categories; Hungary consistently placed second or third; Poland placed in the top five in each of the three divisions; and the United States never placed in the top five in any of the populations.

The percent of students taking second year or advanced physics in each country is also shown in Table 7 on page 55. The largest percentage of students was enrolled in advanced physics in Norway with 24 percent. The United States, again, had the smallest number with only one percent, while Sweden, Canada, and Finland all had more students enrolled in advanced physics than did the three top scoring countries (IEA, 1988). Table 2 on page 31 furnishes the number of schools and students participating in the physics test for the upper secondary level.

Figure 2

Science Test Scores by Subject and Country

Percent Correct - Second International Science Test

Biology
 Chemistry
 Physics

Summary of DataFigure 2--upper secondary level test results

Figure 2 on the previous page displays the percent of correct answers on the biology, chemistry, and physics tests for each of the ten countries in this study for Population 3, the upper secondary level. The high performance by England in all three areas and the high performance in at least two subject areas by Hungary, Japan, Norway, and Poland contrasts with the poor performance in two subject areas for Finland, Canada, and the United States. Students from the United States scored approximately the same on the biology and chemistry tests. This figure summarizes the discussion of test performance at the upper secondary level for each of the ten countries.

Table 8

Rank of Each of the Ten Countries

Country	Pop. 1 5th gr.	Pop. 2 9th gr.	Population 3			No. of days/yr	Yrs. of Req. Sci
			Bio	Chem	Phys		
Australia	7	8	7	4	6	---	8
Canada	5	3	9	9	9	(195)	---
England	10	9	1	1	1	190	11
Finland	2	4	5	10	10	190	9
Hungary	4	1	2	3	2	---	5
Japan	1	2	8	2	3	225	9
Norway	8	7	4	6	4	(188)	5
Poland	9	6	3	5	5	---	5
Sweden	3	5	6	7	8	(200)	---
U.S.	6	10	10	8	7	180	---

Note. () indicate approximations or an average number of days.

--- information was not available or it varies too widely.

(IEA, 1988).

Table 8--rank on each of the tests

The relative rank of the ten countries with one another on each of the science tests is shown on Table 8. One represents the highest score of the ten countries and ten represents tenth or last place. On the same table the number of days in the school year and the number of years of

required science are given if known. Some countries such as England and Japan had 190 or more days of school per year and did well in three or more of the populations but others such as Canada and Finland had a similar number of days but did not rank nearly so well. England, Japan, and Finland required the most years of science and though England and Japan had high scores for Population 3, Finland was last in both chemistry and physics.

Additional information and possible problems

According to the IEA (1988) although the variation between schools at the lower levels in Japan was low, at Population 3 the variation between schools was high, a fact which could be attributed to some of the well known private schools (IEA, 1988).

It should also be noted that the number of students still enrolled in school for Population 3 varied from 17 percent in England to 79 percent in the United States (IEA, 1988) and 90 percent in Japan according to some studies (Kifer, 1989). Table 2 on page 31 supplies data about the number of schools and students participating in each of the subject areas at the upper secondary level. The 50 percent still in school in Hungary were all taking advanced math, in effect, saying that it is so important that every student should learn it (Kifer, 1989). Of the top three countries in Population 3 Japan had the highest percentage of students

enrolled in advanced courses. Low enrollment did not seem to be a factor effecting science achievement since the United States and England both had low enrollments as did some other nations which were at opposite ends of the rankings. However, Finland had its best ranking of fifth in biology when it had the highest percent of students enrolled, 45 percent. Canada, on the other hand, generally had high enrollments and poor performance. Therefore, the number of students still in school and those enrolled in advanced classes varied considerably between the ten countries.

As indicated by the tables the age of the students at the time of testing varied to different degrees but then so did the curricula, so if students had all been the same age they might not have been taking the same course.

Eichinger (1990) notes that some possible problems with the IEA studies include the lower achievement scores expected by schools which retain large percentages of their students in school while other school systems may have lower retention rates but those who do remain may be of better ability. However, since such a small percentage of the total number of 17-year-olds still in school enroll in advanced science courses in the United States this does not seem to be a valid argument for the United States. Only the students of better ability tend to enroll in these courses.

Therefore, the top students in the United States are, in fact, compared with the top students of other countries (Eichinger, 1990).

Table 9

The School Year and Years of Schooling in Each Country

Country	No. of Days	No. of Months	School Year	Yrs. of Schooling	Yrs. of Req. Science
Australia	---	10.5	Feb.-mid Dec.	10	8
Canada	195-200	(10)	Sept.-June	9-10	---
England	190	(10)	Oct.-July	11	11
Finland	190	(9.5)	mid Aug.-May	9	9
Hungary	---	10	Sept.-June	10	5
Japan	225-250	(10)	April-March	9	9
Norway	(175-190)	(9.5)	Aug.-June	9	5
Poland	---	10	Sept.-June	8	5
Sweden	(200)	(10)	late Aug.- mid June	9	---
U.S.	180	9.5	late or mid Aug-May or Sept.-mid June	10	---

Note. () indicate approximations or estimates and yrs of schooling indicates years of compulsory schooling.

(Kobayshi, 1988; Kurian, 1988; Lapointe, Mead, & Phillips, 1989; Male, 1988; Marklund, 1988; Mitter, 1988; O'Driscoll, 1988; Tomiak, 1988).

TimeLength of the school year

The length of the school year in each country, the number of years of compulsory schooling, beginning from the first grade, and the total number of years of required science for all students, if that information was available, are presented in Table 9. The length of the day, however, may not be the same, and it should also be noted that Japan has a five and a half day school week (Kobayashi, 1988) and students in Hungary attend school on every other Saturday (Mitter, 1988). Japanese students also have assignments which must be completed over their summer vacation. These are not included as part of their school year (Shimahara, 1985). According to the table Japan clearly has the longest school year and the United States the shortest. Information was not available for the exact number of days of school each year in Australia, Hungary, and Poland.

Sometimes comparing years of education can be deceiving. For example, since Japan has 240 days of instruction in the school year, 12 years in Japan's school system equals 16 years in the United States with its 180 day school years (Shimahara, 1985). This does not even consider differences in national curriculum or home encouragement (Walberg, 1989).

Class time spent teaching science

According to Kurian (1988) many other industrialized nations begin teaching required courses in biology, chemistry, and physics in the sixth grade. The class-time spent on these subjects is about three times what science oriented students receive in the United States. The average school in the United States has only 22 hours of academic instruction per week. At academic high schools in England and other industrialized countries, it is not uncommon for students to spend eight hours per day in school and attend school 220 days per year. In contrast, the average school day in a high school in the United States is six hours and the students attend school only 180 days per year (Kurian, 1988).

When comparing the opportunity to learn in the various countries, the researcher noted that at the fifth grade level most countries apportioned 20 percent of the entire class time to science instruction. In the United States 20 minutes was the average time scheduled for science in grades K-6. At grade seven there was much variation in the United States depending on the curriculum in use. At some schools science was not required, and so students could choose not to study science at all (Ferko, 1989).

Table 10

Time Spent Teaching Science

Country	Lower Secondary		Upper Secondary	
	Hours/week	Hours/year	Hours/week	Hours/year
Australia	2.3	107	---	---
Finland	7	---	---	---
Hungary	4-6	192 (lessons)	5-7	---
Japan	4	105-140 (50 min. lessons)		140 (50 min.)
Norway	2-3	---	---	---
Poland	7	---	7	---

Note. --- indicates the data were not available. The four countries not included in the table had none of the above information available, often because there was no national standard.

(Johnston & Rennie, 1990; Kobayashi, 1988; Kurian, 1988; Mitter, 1988; Nakayama, 1987; Tomiak, 1988).

The number of hours per week and per year of science instruction, when available, at the lower and upper secondary levels for six of the ten countries are shown in Table 10. The four countries not included in this table did not have any of this information available, frequently because there was no national standard. Hungary had the

most lessons of science instruction per year at the lower secondary level and ranked the highest at this level. Norway and Australia had the fewest hours of science each week at the lower secondary level and ranked seventh and eighth.

In 1970 Australia ranked third but dropped to the middle in the second study (IEA, 1988). Before 1987 students in the three years of lower secondary school in Australia studied science for approximately 155 hours each year. Since the introduction in 1987 of the 40 hour units as part of the Unit Curriculum, students took a minimum of 107 hours of science each year and averaged 140 hours in the pilot schools (Johnston & Rennie, 1990). Obviously, then, the amount of time devoted to science has declined during the same time that the test scores declined.

Required years of science

It does not seem too surprising that students from the United States are outperformed by many students of other countries considering that 36 states require only one year of science for high school graduation (Kurian, 1988). Students in the United States do not study science for the same length of time as do students in many other countries. American high school students average 2.2 years of science. According to Comber and Keeves (1973) the tenth grade is the last year that most American high school students take a

science course. In contrast, most students in other countries take science every year during secondary school (Ferko, 1989; Comber & Keeves, 1973).

Additional studies relating to time

Dunkin (1988) cited various studies which examined the opportunity to learn and test performance for the FISS. According to the IEA there was a significant positive relationship between the opportunity to learn or the amount of time that students are exposed to science and achievement in science when comparisons were made between the countries in at least some of the test populations (Dunkin, 1988). Students in Japan, West Germany, East Germany, and the former Soviet Union are exposed to twice to three times the amount of science that students from the United States receive. Their school year is longer, 210 to 220 days instead of 180 days. There are also differences in the length of the school day and school week, attendance standards, amount of homework, and amount of time devoted to science in the general curriculums (NSF, 1985).

Research has shown that one common factor of the most effective schools, as indicated by student achievement scores, is more time spent on academic instruction (Hersh, 1983). Since the Japanese students did so well at Populations 1 and 2, the elementary and lower secondary levels, it seems that this would help support the claim that

the more time spent on science the better students perform in science. According to Table 4 on page 44 Hungary placed first and Finland fourth in Population 2. Based on the amount of time students study science in these countries at this level, these results would also support this claim, (see Table 10 on page 65). Carroll (1975) showed that the more students study a subject, the more competent they become in that subject. Therefore, the studies done by the IEA consider the time allotted to various topics as well as what they call the opportunity to learn. Comber and Keeves used this data for a 1973 study and found a strong positive relationship between the opportunity to learn and achievement on international tests. According to Kifer (1989), this does not seem too surprising because students tend to learn topics that they are taught (Kifer, 1989). According to studies of the 1970 FISS, the single most significant influence on achievement in cross country comparison was the "opportunity to learn" or the amount of time that a student was exposed to a particular subject (Riddle, 1986). Similar data is not yet available for the SISS.

According to Dunkin (1988) and Comber and Keeves (1973) there was much variation in the opportunity to learn or exposure to topics in each country in the First IEA study. At the 10-year-old level the United States was one of three

countries which had the greatest opportunity to learn when compared with 19 other countries in the FISS (Dunkin, 1988). Students from the United States also ranked fourth in this 1970 study (IEA, 1988). At the same level Hungary had one of the least opportunities for learning and ranked sixth (Dunkin, 1988). Japan and Hungary provided one of the greatest opportunities for learning at the 14-year-old level (Comber & Keeves, 1973). Japan ranked first and Hungary second at this level (IEA, 1988). Again, according to the IEA using data from the FISS, there was a significant positive relationship between the opportunity to learn and achievement in science when comparisons were made between the countries in the 14-year-old group (Dunkin, 1988).

In the Population 3 group some positive relationships were shown for the United States, many of the Western European nations, England, and Australia (Dunkin, 1988). According to the IEA Six-Subject Survey the opportunity to learn was identified as the single most important factor which could explain differences among students, schools, and nations (Husen, 1983). (This study is being completed before researchers have published studies relating the opportunity to learn and the science achievement of countries involved in the Second IEA study.)

Emphasis

Emphasis as it relates to this study refers to the

importance placed on science in terms of science requirements such as years of required science or minutes per day of science instruction.

According to Table 8 on page 59 schools in Finland did well at grades four and eight on the science achievement tests but scored much lower at grade 12, particularly in physics and chemistry. Upper secondary schools in Finland emphasize a humanistic and language direction. There is little emphasis on investigative and practical work in science (IEA, 1988).

Another result of the SISS was that students who were taking advanced placement (AP) science classes had significantly higher mean scores than those students taking classes that were advanced but not advanced placement. The AP students from the United States who had completed a minimum of three years in both mathematics and science did not score significantly different from the international mean for each of the tests. Another component which was identified with high achievement in each of the advanced groups was the quantity of physical science studied in grades nine through twelve. The minimum number of years of math and science required for high school graduation was also a factor which was significantly associated with advanced science achievement (Ferko, 1989).

England, Hungary, and Japan all place greater emphasis

on science than does the United States. England requires the most years of science, eleven years, and ranked first in biology, chemistry, and physics for Population 3. According to Bathory (1989), the amount of time that Hungarian students study science is high, and it is considered the leading branch of Hungarian education. This emphasis may be the reason Hungary always ranked in the top four in each of the tests.

According to the U.S. Department of Education (1986), science is emphasized at nearly all levels of the Japanese curriculum; and Nakayama (1987) reports that, in general, the Japanese curriculum has a broader range of subjects, and those subjects are studied in more depth than in most schools in the United States. The SISS reported that Japanese high schools had the highest as well as the most advanced coverage of science (Jacobson et al., 1986) and ranked high in all areas except biology. Students in the United States are required to take only one or two years of science in high school; science is given little emphasis in the elementary schools and is not always required in lower secondary schools (Jacobson, 1986). Therefore, the more emphasis placed on science the better the overall performance by students.

Table 11

Type of Science Program

Country	Rank Pop. 2	Lower Secondary			Rank			Upper Secondary		
		Int	Non-Int	Partial	3B	3C	3P	Int	Non-Int	Partial
Australia	8	X			7	4	6			X
Canada	3				9	8	9			X
England	9			X	1	1	1			X
Finland	4	X			5	10	10		X	
Hungary	1	X			2	3	2			X
Japan	2	X			8	2	3			X
Norway	7	X			4	6	4			X
Poland	6	X			3	5	5			X
Sweden	5				6	7	8	X		
U.S.	10		X		10	8	7		X	

Note. There was no information found for Canada or Sweden at the lower secondary level. This information reflects the programs at the majority of schools in each country not necessarily all schools in each country.

Int - indicates an integrated science program

Non-Int - indicates non-integrated science program

Partial - indicates a partially integrated and partially non-integrated program.

3B - Population 3 - biology, 3C - Population 3 - chemistry, 3P - Population 3 - physics.

(Dekkers, DeLaeter, & Malone, 1986; Jacobson, 1986; Kurian, 1988; Marklund, 1988; Mitter, 1988; Nakayami, 1987; Raat, Harding, & Mottier, 1982; Tomiak, 1988).

Curriculum

In table 11 a cross matrix is used to indicate whether particular countries have an integrated science program, non-integrated science program, or a combination of both at the lower and upper secondary levels. Most countries taught lower secondary science as part of an integrated program and used both integrated and non-integrated science programs at the upper secondary levels. However, an integrated program in many of the countries simply meant having a certain number of chemistry, physics, and biology classes in the same year. The sciences were not necessarily taught around a theme where the different sciences could be blended and taught in connection with one another. The United States was always in the minority or even alone in its non-integrated approach to teaching science. An integrated or non-integrated science program did not appear to be relevant in science achievement. Countries that did well and countries that did poorly had the same types of programs.

Countries which had an explicit national science curricula may have been favored by the tests because selection of test questions more clearly reflected what all students in the country had studied. In countries such as the United States where there is no national curriculum, having test questions which reflected the content studied by all students would be very difficult (Eichinger, 1990).

However, each country participated in the selection of test questions. Perhaps this could be a reason some might approach the idea of a common national curriculum in the future.

Some more recent research both by Mullis and Jenkins (1988) and Andrew Greeley examining curriculum indicate academic demands and even disciplinary standards schools place on their students can influence student achievement levels. Their study made comparisons with only the top one percent of each country. The results were that all of the countries which had at least some of their students begin to concentrate on the sciences by age 14 and had specialized upper secondary programs had higher scores than all of the countries which did not have such programs (Coleman, 1985). Other research also indicates that high expectations for all students, appropriate conduct and order, frequent and carefully graded homework and tests to monitor student progress may be additional factors which influence student achievement (Hersh, 1983).

Growth scores which compared achievement on common questions between Population 1 and 2 and between 2 and 3 allowed other comparisons. It appeared that the results of specialization in science at Population 2, the lower secondary level, was evident even if that country did not score very well. Hungary and Poland showed remarkable

growth from Population 1 to Population 2 (see Table 8 on page 59). The growth scores from Population 2 to Population 3 was high in England which has very selective schools where students only study three subjects at the Population 3 level (see Table 8 on page 59) (IEA, 1988).

Since more research has been done on the FISS than the SISS, it is important to note that according to Wolf (1977) there were only three countries which had lower growth scores than the United States as determined by the anchor items which were identical for Populations I and II. Only one country had a lower growth score than the United States for Population II and IV. For the countries which tested Population I and IV the United States had the lowest growth score. In the FISS the United States ranked fourteenth out of eighteen countries for science achievement in the Population IV group, the 17-year-olds. According to a study by Wolf (1977) the low achievement scores of the advanced science students can be attributed to the opportunity to learn, to less science specialization of the students, and less selection of the student population (Ferko, 1989).

Summary

This is a long and complex chapter, but it is evident that there is much variation in the educational systems and the emphasis on science in these ten countries. Some countries, such as Japan and Hungary, stressed the

importance of a well rounded science background for all students while others, such as England, stressed science only with an elite few. Some nations, such as Japan, Canada, Poland, and the United States, seemed to encourage large proportions of students to stay in school until the completion of noncompulsory secondary schooling, while England and Australia did not.

The length of the school day, the school year, and how the science curriculum should be administered also varied widely. Hungary, Finland, and Poland taught science as part of an integrated program where students studied one area of science over a period of several years while others taught them as totally separate courses to be covered in different years, and at other times the science curriculum showed a combination of both of these styles as in Australia, Canada, England, Japan, Norway.

Clearly, although there are also similarities between general education and the science-education programs in all ten countries, there are also a number of differences which add to the complexity of this issue.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

When students from 17 countries participated in the SISS the results were disappointing for the United States. Students were tested at the fifth, ninth, and twelfth grades. Students in the United States scored their highest in comparisons with other nations at the fifth grade level. They ranked 14th at the ninth grade level, last in biology, eleventh in chemistry, and ninth in physics at the twelfth grade level. These rankings are cause for concern if the United States wants to continue to compete and even participate in a world market.

The purpose of this chapter is to draw conclusions, make recommendations, and present further questions for consideration. The ten countries examined in this study were Australia, Canada, England, Finland, Hungary, Japan, Norway, Poland, Sweden, and the United States.

For purposes of review, the purpose of this study was to determine whether there is a relationship between test results and differences in science education programs, noted in terms of the class time allocated to science in years of schooling requiring science and the curriculum organization used in the ten nations selected for this study.

Summary and Conclusions

In general, the amount of class time and the greater the emphasis placed on science education influence achievement on international science tests; the more exposure and emphasis, the greater the achievement. Integration of the major fields of science in the curriculum does not, of itself, improve success on international science tests.

Results of this study based on an analysis of the student scores, support the following conclusions:

- 1) The amount of time per day, per week, or per year spent teaching science influences science achievement: the more exposure, the greater the achievement;
- 2) The greater the emphasis placed on science education throughout the period of schooling, grades one through twelve, the greater the achievement on international science tests; and
- 3) Integration of the major fields of science in the curriculum does not, of itself, improve success on international science achievement tests.

Discussion: Time Spent Teaching Science

The amount of time spent teaching science does make a difference as indicated by England's first place ranking in biology, chemistry, and physics for Population 3, the upper secondary level. England led in years of compulsory

schooling (Riddle, 1986) and the most years of required science (Lapointe, Mead, & Phillips, 1989). Japan had the longest school year (Kobayashi, 1988), Hungarians went to school every other Saturday (Mitter, 1988). The United States had the shortest school year. From the data, as well as other studies, it is evident that the more that students are exposed to science the more science they will learn.

Research has shown that one common factor of the most effective schools, as indicated by student achievement scores, is the time spent on academic instruction (Hersh, 1983). In addition, a number of studies such as those by Comber and Keeves (1973), Walker (1976), Kelly (1972), Coleman et al. (1981), and Tamir (1986) support the relationship between student achievement and opportunity to learn, or exposure to science in the classroom (Ferko, 1989).

Discussion: Emphasis of Science in the Curriculum

According to Rosier (1987) science is included in the curriculum of a school for two basic reasons. First, it is necessary for all citizens to understand their environment and to cultivate skills in scientific processes for solving problems. Second, it is required to lay the foundation of basic skills for students who will eventually pursue science careers. The United States needs people in these careers for further growth and development (Rosier, 1987).

Discussion: Combined Effects of Time and Emphasis

According to "The 1990 Science Report Card," NAEP found that fewer than half of the schools in the United States gave science a priority in the fourth grade, and fewer than two-thirds gave science a priority in the twelfth grade. Students in the United States have fewer science classes than students in most of the rest of the world starting in elementary school and continuing through high school (Blosser, 1985).

Most nations in this study require that their students take science at all grade levels. Students usually do not meet everyday, and the coursework may extend over several years. However, based on total class hours of science at most three-year foreign high schools, all students have had about three times as many class hours of science as their counterparts taking three years of science in the United States (Hurd, 1982; Kurian, 1988). Science is obviously viewed as being more important to more students in these countries since the total population takes more science (Hurd, 1982).

Discussion: Curriculum Integration

An integrated or non-integrated science program did not appear to be relevant in science achievement. Countries that did well and countries that did poorly had the same types of programs. However, the type of science program at

each level in the United States was always different from the type of program that the majority of countries had. However, this seems to be changing as indicated by a number of programs around the country, including the new science framework in California which calls for integrated science programs each year.

Further Research

Future studies should examine the curriculum of the advanced science courses in different countries and see how they compare with similar courses in the United States.

Further studies should analyze the number of schools which offer advanced and AP science classes, and options should be studied for expanding that number. There should also be an examination to determine the differences between advanced science courses and advanced placement classes.

Outstanding elementary, middle school, and high school science programs which emphasize science education should be examined and replicated such as the hands on programs provided by the Needham Center for both students and teachers (Peach, 1992). Further research studying outstanding science programs in other countries should be considered.

Further research should examine programs that already exist between scientists and industry and science education in the schools. Information on initiating and continuing

such programs should then be distributed to science teachers, scientists, and industries.

Studies examining the effects of national examinations should be analyzed because England, Hungary, and Japan have very competitive national examinations that students must take either to complete their secondary school program or to go on to the university. The top ten winners in a national competition in Hungary are exempted from the examinations in the area for which they placed (Mitter, 1988). Many countries which had a national exam also had a national curriculum (Husen, 1983). Future studies should examine these national curricula and tests in other countries as well as the concept of minimum competency testing.

The results of this thesis did not demonstrate a relationship between test performance and integrated science. The complexity of international testing is evident from the degree and manner of integration which varied widely between the countries. Future studies should examine available research and implemented programs to study their strengths for the many populations here and throughout the world.

When the data become available, future research should examine the more complete surveys done for the SISS which consider the opportunity to learn science in each country.

Family influences are also cited by other researchers

as a primary factor affecting school achievement when comparisons were made between students or between schools in national studies (Riddle, 1986; Anderson, 1983; Coleman, 1985). Family influences including amount of education of the parents, parental involvement, size of the family, socioeconomic status should be further studied (Coleman, 1985). The relationship between these family influences in this country and in others to performance may be the focus of future studies.

Future studies should examine factors which could affect student achievement in different countries such as differences in cultural and social issues, for example, after school jobs, extracurricular activities, and emphasis on academics versus sports.

Additional factors which relate to the emphasis placed on science education which future studies should consider include the amount of money spent on education, the kinds of equipment and facilities for the science programs, use of computers and other high tech equipment, the number of lab activities, and the kinds and amount of tracking in the science classes. These factors should be examined to perceive how they relate to time, emphasis, and curriculum integration and science achievement in the United States and other countries.

Surely, such new programs as Scope, Sequence, and

Coordination and the framework decision in California will be a focus for continuing examination of science programs so that informed decisions can be made concerning increasing the amount of class time spent teaching science and increasing the emphasis placed on science education in the United States.

References

- Anderson, L. (Ed.). (1983). Science subjects - an evaluation of student achievement and attitudes in international perspective. Stockholm, Sweden: Skolverstyrelsen National Board of Education. (ERIC Document Reproduction Service No. ED 237 321)
- Anderson, R. (1989). The teaching and learning of biology in the United States. Second IEA Science Study (SISS) - United States (Report No. NSF-SPA-847032). New York, NY: Columbia University, International Association for the Evaluation of Educational Achievement. (ERIC Document Reproduction Service No. ED 327 390)
- Andren, B. (1989). Swedish schools in an international perspective. Stockholm, Sweden: National Swedish Board of Education. (ERIC Document Reproduction Service No. ED 309 978)
- Bathory, Z. (1989). How two educational systems learned from comparative studies: the Hungarian experience. A. C. Purves (Ed.), International comparisons and educational reform (pp.45-49). Alexandria, VA: Association for Supervision and Curriculum Development.
- Blair, R. E. (1988). Canada, In T. N. Postlewaite (Ed.), The encyclopedia of comparative education and national systems of education (pp. 179-185), Elmsford, NY: Pergamon Press.

- Blosser, P. (1985). Improving science education.
Information bulletin (Contract No. 400-78-004).
Washington, D.C.: National Institute of Education.
(ERIC Document Reproduction Service No. ED 266 931)
- Carroll, J. B. (1975). The teaching of French as a foreign
language in eight countries. New York: Almqvist and
Wiksell and Wiley - Halsted Press.
- Coleman, J. S. (1966). Equal schools or equal students?
The Public Interest.
- Coleman, J. S. (1985). International comparisons of
cognitive achievement. Phi Delta Kappan, 66, 403-406.
- Coleman, J. S.; Hoffer, T.; & Kilgore, S. (1981).
Contractor Report. Public and private schools - an
analysis of high school and beyond; a national
longitudinal study for the 1980's. Washington, DC:
National Center for Educational Statistics.
- College Entrance Examination Board (1991). SAT verbal and
math averages each fall two points, but many students in
class of 1991 continue to do well. New York: August 27,
1991.
- Comber, L. C., & Keeves, J. P. (1973). Science education in
nineteen countries. New York: John Wiley & Sons.
- Connelly, F. M. (1987). Ontario science education report
card. Canadian national comparisons. Toronto, Canada:
Ontario Department of Education. (ERIC Document

Reproduction Service No. ED 294 726)

Dekkers, J., DeLaeter, J. R., & Malone, J. A. (1986). Upper secondary school science and mathematics enrolment patterns in Australia. Science and Mathematics Education Centre. (ERIC Document Reproduction Service No. ED 313 247)

Dunkin, M. J. (1988). Comparative studies in teaching & teacher education, In T. N. Postlewaite (Ed.), The encyclopedia of comparative education and national systems of education (pp. 60-65). Elmsford, NY.

Eichinger, J. (1990). Science education in the United States: are things as bad as the recent IEA report suggests? School Science and Mathematics, 90, 33-39.

Ferko, A. M. (1989). An analysis of United States advanced science student achievement. Doctoral dissertation, Columbia University. (ERIC Document Reproduction Service No. ED 309 086)

Gardner, M. H., & Yager, R. E. (1983). How does the U.S. stack up? The Science Teacher, 50, 22-25.

Greeley, A. (1982). Catholic schools and minority students. New Brunswick, NJ: Transaction Books.

Helgeson, S. L. (1988). The second IEA science study: data related to precollege science in the U.S.A. Washington, D.C.: Office of Educational Research and Improvement. (ERIC Document Reproduction Service No. ED 309 048)

- Hersh, R. H. (1983). How to avoid becoming a nation of technopeasants. Phi Delta Kappan, 64, 635-638.
- Hurd, P. D. (1982). An overview of science education in the United States and selected foreign countries (Report No. NIE-P-82-0063). Washington, D.C.: National Institute of Education. (ERIC Document Reproduction Service No. ED 227 076)
- Husen, T. (1983). Are standards in U.S. schools really lagging behind those in other countries? Phi Delta Kappan, 64, 455-462.
- International Association for the Evaluation of Educational Achievement (1988). Science achievement in seventeen countries: a preliminary report. Elmsford, NY: Pergamon Press.
- Jacobson, W. (1986). The United States curriculum case study. Honolulu, HI: United States - Japan Seminar on Science. (ERIC Document Reproduction Service No. ED 278 564)
- Jacobson, W. J., & Doran, R. L. (1985). How are our ninth graders doing? The Science Teacher, 52, 24-27.
- Jacobson, W. J., & Doran, R. L. (1985). The second international science study: U.S. results. Phi Delta Kappan, 66, 414-417.
- Jacobson, W., Takemura, S., Doran, R. L., Kojima, S., Humrich, E., & Miyake, M. (1986). Analyses and

comparisons of science curricula in Japan and the United States. Washington, D.C.: Office of Educational Research and Improvement. (ERIC Document Reproduction Service No. ED 271 395)

Jacobson, W. J. (1987). The current status of science curricula: Insights from the second international science study. In A. B. Champagne & L. E. Hornig (Eds.), The science curriculum (pp. 155-163). Washington, DC: American Association for the Advancement of Science.

Johnston, J. E., & Rennie, L. J. (1990). Structural change in curriculum: the implications for gender equity in science and mathematics. Boston, MA: American Educational Research Association. (ERIC Document Reproduction Service No. ED 317 404)

Kanaya, T. (1985). Japan: system of education. In T. Husen & T. Postlethwaite (Eds.), The international encyclopedia of education (5, 2766-2771). Elmsford, NY: Pergamon Press.

Kelly, P. J. (1972). Evaluation studies of the Nuffield A - level biology trials: 1 overall achievement of students. Journal of Biological Education, 5, 315-327.

Kifer, E. (1989). What IEA studies say about curriculum and school organization. A. C. Purves (Ed.), The international comparisons and educational reform (pp. 51-69). Alexandria, VA: Association for Supervision and

Curriculum Development.

- Klopfer, L. E. (1973). Evaluation of science achievement and science test development in an international context: The IEA study in science. Science Education, 57, 387-403.
- Kobayashi, V. N. (1988). Japan, In G. T. Kurian (Ed.), World education encyclopedia, 2, (pp. 696-715). New York: Facts on File Publications.
- Kurian, G. (1988). Australia. In G. T. Kurian (Ed.), World education encyclopedia (1, pp. 69-92). New York: Facts on File Publications.
- Kurian, G. (1988). Finland. In G. T. Kurian (Ed.), World education encyclopedia (1, pp. 389-405). New York: Facts on File Publications.
- Kurian, G. (1988). Norway. G. T. Kurian (Ed.), World education encyclopedia (2, pp. 953-963). New York: Facts on File Publications.
- Kurian, G. (1988). United States. G. T. Kurian (Ed.), World education encyclopedia (3, pp. 1344-1385). New York: Facts on File Publications.
- Lapointe, A. E., Mead, N. A., & Phillips, G. W. (1989). United Kingdom. A world of differences. An international assessment of mathematics and science (Report No. 19-CAEP-01). Princeton, NJ: Center for the Assessment of Educational Progress. (ERIC Document

Reproduction Service No. ED 309 068)

Lapointe, A. E., Mead, N. A., & Phillips, G. W. (1989).

United States. A world of differences. An international assessment of mathematics and science (Report No. 19-CAEP-01). Princeton, NJ: Center for the Assessment of Educational Progress. (ERIC Document Reproduction Service No. ED 309 068)

Male, G. A. (1988). United Kingdom. In G. Kurian (Ed.), World education encyclopedia (3, pp. 1321-1343). New York: Facts on File Publications.

Marklund, S. (1988). Sweden. In T. N. Postlethwaite (Ed.), The encyclopedia of comparative education and national systems of education (pp. 630-637). Elmsford, NY: Permagon Press.

Mikake, M. (1989). Science achievement of elementary and secondary school students in Japan: the results of the IEA study. Tokyo, Japan: National Institute for Educational Research. (ERIC Document Reproduction Service No. ED 317 379)

Mitter, W. (1988). Hungary. In G. T. Kurian (Ed.), World education encyclopedia (1, pp. 540-558). New York: Facts on File Publications.

Mullis, I. V. S. & Jenkins, L. B. (1988). The science report card elements of risk and recovery (Report No. 17-S-01). Princeton, NJ: Educational Testing Service.

- Nakayama, G. (1987). Perspectives on educational settings and school science curricula in Japan compared with the United States. North Carolina. (ERIC Document Reproduction Service No. ED 293 689)
- National Science Foundation (1985). Science indicators: the 1985 report (Report No. NSB-85-1). Washington, D.C.: National Science Foundation. (ERIC Document Reproduction Service No. ED 266 043)
- O'Driscoll, D. (1988). Canada. In G. T. Kurian (Ed.), World education encyclopedia, 1, (pp. 179-195). New York: Facts on File Publications.
- Peach, L. A. (1992, April 1). Science becomes elementary fun. The Christian Science Monitor. p. 12.
- Raat, J. H., Harding, J., & Mottier, I. (1982). Canada. Girls and science and technology. Eindhoven, the Netherlands: University of Technology. (ERIC Document Reproduction Service No. ED 262 997)
- Raat, J. H., Harding, J., & Mottier, I. (1982). England and Wales. Girls and science and technology. Eindhoven, the Netherlands: University of Technology. (ERIC Document Reproduction Service No. ED 262 997)
- Raat, J. H., Harding, J., & Mottier, I. (1982). Norway. Girls and science and technology. Eindhoven, the Netherlands: University of Technology. (ERIC Document Reproduction Service No. ED 262 997)

- Raat, J. H., Harding, J., & Mottier, I. (1982). Sweden. Girls and science and technology. Eindhoven, the Netherlands: University of Technology. (ERIC Document Reproduction Service No. ED 262 997)
- Riddle, W. (1986). Comparison of the achievement of American elementary and secondary pupils with those abroad - the examinations sponsored by the International Association for the Evaluation of Educational Achievement (IEA). Washington, D.C.: Congressional Research Services. (ERIC Document Reproduction Service No. ED 299 314).
- Rosier, M. (1985). The analysis of science curricula in Australia. In R. P. Tisher (Ed.), Research in Science Education (15, 182-189). (ERIC Document Reproduction Service No. ED 267 974)
- Rosier, M. J. (1987). The second international science study. Comparative Education Review, 31, 106-128.
- Shimahara, N. K. (1985). Japanese education and its implications for U.S. education. Phi Delta Kappan, 66, 418-421.
- Snyder, T. D., & Hoffman, C. M. (1991). Digest of education statistics 1990 (Report No. NCES 91-660). Washington, D.C.: United States Department of Education.
- Tamir, P. (1986). Home and school effects on science achievement of high school students in Israel.

Occasional paper reporting on the participation of Israel in the Second IEA Science Study.

Tomiak, J. J. (1988). Poland. G. T. Kurian (Ed.), World education encyclopedia (2, pp. 1006-1019). New York: Facts on File Publications.

U.S. Department of Education (1986). A United States study of education in Japan. Journal of College Science Teaching, 15, 478-481.

Viteli, J. (1989). Finnish educational system and computer education in Finland. Orlando, FL: Annual Florida Instructional Computing Conference. (ERIC Document Reproduction Service No. ED 320 556)

Walberg, H. J. (1989). Science, mathematics, and national welfare: retrospective and prospective achievements. A. C. Purves (Ed.), International comparisons and educational reform (pp. 99-109). Alexandria, VA: Association for Supervision and Curriculum Development.

Walker, D. A. (1976). The IEA six subject survey: an empirical study of education in twenty-one countries. Stockholm, Sweden: Almqvist and Wiksell International.

Wolf, R. M. (1977). Achievement in America: national report of the United States for the international educational achievement project. New York: Teachers College Press.

Appendix A

Additional Information on the Educational Systems of Each Country

Australia

Students are in school for ten years from ages six to fifteen or sixteen, depending on the territory, with the last two years not compulsory, but over half of the students remain one more year, and better than one third complete the educational program. Most secondary schools provide comprehensive programs with most states determining their own curricula (Kurian, 1988). The academic school year begins in early February and concludes in the middle of December (Kurian, 1988). Australia tends to have a decentralized educational system. Each state may set certain guidelines, but often the curriculum is determined by the individual school or even the science teacher in the classroom (Rosier, 1985). Throughout Australia about 25 percent of the students conclude year 12 and proceed to further studies. Approximately 15 percent finish year 12 and do not go on for further studies, 20 percent complete grade 11, and 40 percent complete year 10 and end their school studies (Dekkers, DeLaeter, Malone, 1986).

Before 1987 science was part of the core curriculum in lower secondary schools in Australia. Courses were taught at different levels to meet the academic abilities of the

different students. There were also additional optional courses offered in science at this level. In the tenth grade 75 percent of the students would have studied biology, chemistry, and physics (Johnston & Rennie, 1990).

The Unit Curriculum, introduced in 1987, consisted of a restructuring of the year-long courses into 40-hour units which allowed more choices for the students. Students selected roughly 24 of these 40 hour units each year. The units could be selected according to one of six levels of difficulty. There are presently 35 science and technology units. An integrated format was used in the lower levels, however, the units are differentiated by science subjects in the higher levels. One to four units in science were set as minimum standards (Johnston & Rennie, 1990).

Meteorology and the solar system were the major topics covered in the grade five curriculum. There is almost no coverage of chemistry at this level and a medium coverage of physics. Human biology, natural environment, and cycles in nature are the topics in biology which are covered at this level (Rosier, 1985).

At grade nine there is still little chemistry being taught and physics shows a medium level of coverage (Rosier, 1985).

At year 12 biology is studied to a high degree of coverage, particularly in genetics and evolution. There is

a high coverage of chemistry in the traditional subject areas but less emphasis on application of chemistry to industry or the environment. Physics receives a high degree of coverage at this level, but again there is less emphasis on applied areas of physics such as electronics and machines (Rosier, 1985).

Students in Australia do not need to take a science course in order to graduate from upper secondary school. Although the choice of science subjects, certification, and methods of assessment vary from state to state in Australia, the curricula for each subject are similar (Dekkers, DeLaeter, Malone, 1986).

Canada

Canada has 12 educational systems, one for each of the ten states and two territories (Blair, 1988) with the school year extending from September through June and ranging from 195 to 200 school days. School is compulsory from ages six to sixteen in five of the provinces, while the other five provinces allow the students to leave school at age 15 (O'Driscoll, 1988). In 1982-83 eighty percent of the Canadian students continued their education and started grade 12, although only 80 percent of that group actually graduated (O'Driscoll, 1988).

Population 3 in Canada varied from grades 11 to 13 depending on the province. The last biology, chemistry, or

physics course could be taken anywhere from grades 10 to 13. Therefore, Population 3 was defined in Canada as students enrolled in their last course in a specific science discipline at the time of testing regardless of age or grade (Connelly, 1987).

Some provinces, such as Ontario, require two years of science at the upper secondary level, while others only require one semester (Raat, Harding, Mottier, 1982). Many of the upper level science courses in Canada are becoming more integrated. For example, chemistry courses include the study of geochemistry and biochemistry. Physics includes topics relating to biophysics, geophysics, and physical chemistry (Connelly, 1987).

England

The school year goes from October to early July with students required to attend school for 11 years from age five to age sixteen (Male, 1988). Students attend school for 190 days in England and the United Kingdom (Lapointe, Mead, & Phillips, 1989). Two-thirds of the English students, called school leavers, drop out of school after completing the eleventh year of compulsory schooling at age sixteen. The primary schools in England educate students until age eleven and then the secondary schools complete the instruction until students are eighteen years of age. More than 80 percent of these secondary schools are comprehensive

secondary schools which provide both academic and vocational instruction (Male, 1988).

Science is inclined to be more process oriented in England than many other countries. There has been concern at the secondary level that there has been too much emphasis on rote learning and an overcrowded curriculum. Meanwhile topics such as astronomy, earth science, and technology are not emphasized enough (Lapointe, Mead, & Phillips 1989).

In England students in their terminal year of secondary school were in grade 13 rather than 12 as in the United States and many other countries (Riddle, 1986).

There are two types of examinations that 16-year-olds may take. One is designed for students of average ability, the other test is taken for the General Certificate of Education. Most of these students will take advanced examinations two years later before going on to a university. Most English students will leave the school system without a certificate, and there is no diploma to be earned in English schools (Male, 1988).

Finland

The school year starts in mid-August and extends through May consisting of 190 days with the day lasting from five to seven hours and with compulsory schooling extending from ages seven to sixteen. The peruskoulu is the heart of the educational system in Finland. It literally means basic

school but is more often translated to comprehensive school. It consists of two cycles, a six-year lower series and a three-year upper series. Private schools become more popular in the upper levels. At the secondary level almost two-thirds of the schools are private. At the lower levels the curriculum is the same as prescribed by law. At the upper levels variations occur based on differences in abilities of the students. Advanced elective subjects are available at the upper levels (Kurian, 1988).

The three years of upper secondary schooling provide education beyond the compulsory schooling. Approximately 50 percent of the students in the early 1980's continued their schooling at the upper secondary schools (Viteli, 1989). A matriculation examination terminates this level of education. This exam is used for university admission as well as the right to wear a favored student cap. The cap, apparently, affords a certain amount of status since this news in the newspaper surpasses the sports news (Kurian, 1988). In 1981 thirty-eight percent passed this examination. At the upper secondary level 22 to 29 percent of the curriculum is scheduled for math and science (Viteli, 1989).

Students in Finland tend to be extremely grade conscious and remember specific grades for years (Kurian, 1988).

Hungary

There are ten years of compulsory schooling from ages six to sixteen with school extending from September through June including school every other Saturday. Primary education consists of four years in the lower division and four years in the upper division. In the upper division students are taught by subject teachers who have college or university diplomas in that subject. Students attend classes five days a week and every other Saturday (Mitter, 1988).

In the first two years of the general secondary schools, or gimnazium, when school is still compulsory science is required. Two classes per week of physics are required each week in the first two years. In the third and fourth years three classes of physics are required each week. Two classes per week of chemistry are scheduled for the first year of secondary school. In the following year chemistry is taught four classes per week but no further classes are required in the final two years. Biology is not required until the third year of secondary school when it is taught four hours per week. In the last year of secondary school biology is taught for two hours per week (Mitter, 1988).

There are four types of schools in Hungary at the secondary level. The four-year general secondary school or

gimnazium is the traditional type of school. Students can proceed either to the university or directly to the work force from this type of school. If they proceed to the university, the competition can be tough since there are not enough available places for the students who take the entrance examinations. Students with special abilities may be placed in special divisions within these schools. Over half of the students participate in some type of study group, and there are national competitions in biology, chemistry, and physics. The top ten competitors at these competitions are not required to take the college or university entrance examinations in the subjects in which they participated. The other three types of secondary schools are the four-year technical secondary school, the three-year school for training of skilled employees, and two and three-year vocational training schools (Mitter, 1988).

Japan

The Japanese are required to attend school for nine years from ages six to fifteen with classes all day Monday through Friday and half a day on Saturday totaling 225 days that students attend school each year (Kobayashi, 1988). Education in Japan consists of six years of elementary school, three years of lower secondary school, and three to four years of noncompulsory upper secondary school. Approximately 94 percent of the students continue on to

upper secondary school. However, 28 percent go on to attend private secondary schools rather than public schools (Kanaya, 1985). In 1980 nearly all Japanese students fulfilled their compulsory education, and 94.2 percent went on to upper secondary school (Kobayashi, 1988). According to Nakayama (1987) fewer Japanese students continue their education beyond upper secondary school, only 33 percent as compared to a higher percentage in the United States. The entrance requirements to universities is much more competitive in Japan than the United States (Nakayama, 1987).

Entrance examinations are used to proceed to lower and upper secondary schools as well as to the universities in Japan. Performance on the upper secondary entrance examination determines which upper secondary school a student may attend. The tests consist of essay and multiple choice questions. Many Japanese students have home tutors or attend juku which are nonformal private schools in an effort to do their best on these examinations. According to a 1981 survey nearly one third of the primary students in Tokyo received additional instruction through tutors or juku. At the upper secondary level students may also attend yobiko which are private preparatory schools that help students prepare for university entrance examinations (Kobayashi, 1988). University entrance examinations are

generally much more competitive in Japan than in the United States (Nakayama, 1987).

The primary framework for the curriculum of each grade level is dictated by the Ministry of Education. In addition to objectives and instructional content, the amount of time that should be spent teaching each subject is also prescribed (Kanaya, 1985).

One of the objectives of the Japanese educational system seems to be to reduce the differences between individuals. There is no type of grouping or tracking in Japanese elementary or lower secondary schools (Nakayama, 1987). In Japan study and hard work are considered more important than natural ability. This is one reason why tracking is not considered necessary in Japan (Jacobson et al., 1986). However, students who can afford juku and other forms of additional help may have a competitive advantage which results in some differentiation indirectly caused by the educational system (Nakayama, 1987). Also, the entrance examinations effectively determine which students get into which schools so that students of similar abilities are in the same schools (Shimahara, 1985).

Japan has a solid commitment to educating its students. Average achievement in Japan is high and it focuses on a higher level of achievement than do most nations that have greater ranges of performance. Japanese achievement is one

of the highest and also one of the most uniform (U.S. Department of Education, 1986).

Japanese students attend school for more days, and in high school they do almost twice as much homework as their American counterparts. Even their summer vacation is not free from school work. Students are given assignments to complete over the summer break. The summer is also used for intensive study for students preparing for high school or college entrance examinations. In addition to their regular schooling many students also attend juku or tutoring schools (Shimahara, 1985).

Japan has 2.5 times more students graduating with engineering degrees than the United States which has twice the population. Japan awards 20 percent of its bachelor degrees in science and engineering fields. Forty percent of Japan's master's degrees are also in these fields. The united total of bachelors and masters degrees in science and engineering in the United States is only five percent (Gardner & Yager, 1983).

Norway

Norway's centralized system of education begins in August and extends through June, 35 to 38 weeks in length, with school hours usually from 8:30 a.m. to 2 p.m. consisting of mostly 45 minute classes. Students in Norway are required to attend school for a total of nine years from

ages seven to sixteen (Kurian, 1988). Schools in Norway are divided into two phases: grades one through six, the barnetrinnet, or junior level, and the ungdomstrinnet, the youth level, grades seven through nine with an optional tenth grade. At the termination of basic school, the junior and youth classes, students take written, oral, or even practical examinations in each of the subjects. The results of these examinations help determine their final grades. In 1983 a new school leaving certificate was adopted which includes subjects taken, number of teaching periods, and the number of periods missed (Kurian, 1988).

After post-basic schooling, grades ten through twelve, students select a general or vocational track. In theory, anyone may attend these upper secondary schools, but in reality the space available is limited (Kurian, 1988).

Poland

Between the ages of seven and fifteen school in Poland is compulsory from September through June each year for a total of eight years. More than 90 percent of the Polish students who complete their compulsory education continue some type of further education, with the majority going to vocational schools and 25 percent attending secondary general-education schools. Approximately 18 percent of the 19-year-olds who have completed some type of post compulsory schooling continue for higher education (Tomiak, 1988).

Programs in the secondary general-education schools contain a program covering the basics for all needs and future plans. Differentiated programs help develop individual abilities, interests, and talents (Tomiak, 1988).

Students are accepted to postprimary or noncompulsory schools based on teacher recommendations and the achievement of a primary-school certificate. There are no entrance examinations. In the four year secondary general-education schools or lycees students take regular oral and written tests. A final examination is taken after completing the program; students who pass the examination may continue to a university. Students who do not pass receive a certificate of completion and may go on to a vocational school (Tomiak, 1988).

Sweden

The academic year extends from late August to mid-June for a total of 40 weeks; and the nine years of compulsory education begin at age seven.

In Sweden there is very little variation between schools so student behavior and characteristics had a greater influence on their achievement. Since the first IEA study the educational system in Sweden has become less centralized (Anderson, 1983). The degree of variation between students' test scores was quite small in Sweden, Finland, and Japan. One of Sweden's educational objectives

is to have nationwide standards of education so that all schools are as equal as possible (Andren, 1982).

There are three tracks at the upper secondary level consisting of the academic, general, and vocational tracks. Due to limited availability students may not always follow their first choice of study in these tracks (Marklund, 1988). Population 3 students in Sweden were in grade three of the Natural Sciences and Technology track (Andren, 1989).

United States

The percentage of students taking precollege science courses has declined. In 1948-49 fifty-four percent of the students were enrolled in precollege classes in grades nine through twelve. In 1981-82 only 44 percent of the students were enrolled in these classes (NSF, 1985).

Appendix B

Sample Test Questions

POPULATION 2

Seven items have been selected for presentation. The first item is an earth science item and then there are two items each from biology, chemistry and physics. Whereas in Population 1 some children may not have had science as a formal school subject, Population 2 students did have science subjects at school.

The sun is the only body in our solar system that gives off large amounts of light and heat. Why can we see the moon ?

- A It is reflecting light from the Sun.
- B It is without an atmosphere.
- C It is a star.
- D It is the biggest object in the solar system.
- E It is nearer the Earth than the Sun.

Country	N	A*	B	C	D	E	None
Australia	4917	69.85	1.65	8.43	2.08	17.64	0.34
Canada(Eng)	5543	72.93	1.81	7.77	1.73	14.94	0.83
England	3118	53.47	2.85	10.48	3.82	28.60	0.78
Finland	2546	82.74	2.56	4.80	2.73	6.98	0.19
Hong Kong	4973	76.54	1.01	5.25	2.49	14.55	0.17
Hungary	2515	94.95	0.63	1.09	0.98	1.97	0.37
Italy	3228	62.22	3.50	10.56	1.80	18.57	3.35
Japan	7610	70.97	9.64	2.30	2.25	14.71	0.13
Korea	4522	62.95	3.43	13.93	2.41	17.21	0.07
Netherlands	5025	74.33	3.28	6.88	3.88	11.10	0.55
Norway	1420	68.12	2.37	5.01	2.45	20.67	1.38
Philippines	10874	71.66	1.86	3.85	10.15	12.28	0.19
Poland	4520	71.61	2.08	12.18	4.10	9.17	0.85
Singapore	4430	88.56	1.33	1.79	1.59	6.50	0.23
Sweden	1461	85.68	1.53	4.22	1.61	6.87	0.10
Thailand	3780	59.99	3.70	8.33	1.55	26.32	0.11
U S A	2519	69.53	2.43	10.41	2.76	14.58	0.29

This item was also given to students in Population 1. It is a relatively easy item for Population 2 students but the increase in performance from Population 1 to Population 2 ranges from 4 percent in Korea and the U.S.A. to 33 percent in Hong Kong.

Moreover, the responses from the 17 countries would appear to show differences between those countries where the content associated with this aspect of the solar system such as Hungary (95%) and Singapore (89%) is clearly taught to all students and those countries where it is only taught to some students, for example England (53%), or where the information necessary to answer this question is gained from the media and reference books. It should be noted that option E remains a strong distractor in England (29%), Thailand (26%) and Norway (21%).

A girl wanted to learn which of three types of soil (clay, sand and loam) would be best for growing beans. She found three flower pots and filled each with a different type of soil. She then planted the same number of beans in each, as shown in the drawing. She placed them side by side on a window sill and gave each pot the same amount of water.

Why was the experiment not a good one for the purpose?

- A The plants in one pot got more sunlight than the plants in the other pots.
- B The amount of soil in each pot was not the same.
- C One pot should have been placed in the dark.
- D Different amounts of water should have been used.
- E The plants would get too hot on the window sill.

Country	N	A	B	C	D	E	None
Australia	4917	8.81	65.24	5.17	14.06	5.79	0.94
Canada(Eng)	5543	7.31	72.30	5.25	11.68	2.52	0.95
England	3118	11.13	53.70	6.95	18.84	8.16	1.22
Finland	2546	9.51	54.10	3.64	26.65	5.39	0.71
Hong Kong	4973	8.70	61.55	5.34	20.04	4.17	0.20
Hungary	2515	3.13	62.27	2.87	26.95	3.69	1.08
Italy	3228	8.37	43.59	4.99	35.46	4.99	2.60
Japan	7610	12.27	63.01	11.63	9.62	3.20	0.26
Korea	4522	12.48	53.58	6.66	12.25	14.96	0.06

Country	N	A	B*	C	D	E	None
Netherlands	5025	9.63	64.61	3.63	17.40	3.87	0.74
Norway	1420	5.23	33.78	4.17	48.86	9.48	0.70
Philippines	10874	16.49	56.63	6.98	7.94	11.45	0.50
Poland	4520	9.46	54.05	2.90	25.23	6.56	1.81
Singapore	4430	13.37	62.60	4.62	12.21	6.52	0.69
Sweden	1461	7.15	52.65	9.78	24.38	4.72	1.33
Thailand	3780	8.02	77.06	6.65	4.30	3.77	0.11
U.S.A.	2519	10.42	62.00	7.73	15.00	4.21	0.65

This item is an interesting one from the perspective of science as an investigatory process, since it involves consideration of a controlled experiment.

The correct answer is B and the item is relatively easy and with relatively homogeneous performances across countries. However, it seems likely that responses to this question from the different countries indicate the extent to which science, and in particular biology, is taught as a subject involving experimentation. The high performance of the Thai students (77%) suggests that this is a feature of their science courses, while the relatively low performance of the Italian (44%) and the Norwegian (34%) students would appear to indicate that such investigatory activities are not commonly included in the science courses of those countries at the lower secondary school level.

Which of the cells shown below would commonly be found in the human nervous system?

A

B

C

D

E

Country	N	A*	B	C	D	E	None
Australia	4917	24.48	11.04	15.12	21.53	25.12	2.71
Canada(Eng)	5543	43.69	10.58	8.52	16.52	18.21	2.48
England	3118	22.03	14.83	15.20	20.33	22.58	5.05
Finland	2546	12.17	9.03	17.13	27.97	32.54	1.15
Hong Kong	4973	8.38	22.99	20.59	21.02	26.39	0.64
Hungary	2515	77.51	3.84	4.15	6.20	7.42	0.88
Italy	3228	59.85	10.88	5.54	5.16	9.85	8.72

Country	N	A	B*	C	D	E	None
Japan	7610	47.52	13.28	15.74	8.81	14.33	0.32
Korea	4522	67.76	5.62	8.36	9.47	8.74	0.05
Netherlands	5025	36.43	10.40	7.53	19.88	22.64	3.12
Norway	1420	32.06	8.12	6.24	22.27	28.48	2.83
Philippines	10874	23.50	13.79	18.67	10.33	33.36	0.36
Poland	4520	69.17	3.94	4.77	2.12	18.23	1.76
Singapore	4430	18.81	19.87	15.92	23.95	20.81	0.63
Sweden	1461	21.12	17.86	9.82	23.70	24.59	2.91
Thailand	3780	10.90	22.14	17.41	16.87	32.47	0.21
U.S.A.	2519	27.04	16.12	15.69	18.98	21.12	1.05

The correct answer to this question is option A, and the item assesses knowledge of the shape and structure of cells. It is a relatively difficult biology item for 14-year old students except Hungary (78%), Poland (69%) and Korea (68%). In these three countries the structure of the cells of the human nervous system would appear to be included in the science curriculum at the lower secondary school level.

This topic had not been covered in the Hong Kong curriculum when the test was taken and, hence, the guessing as can be seen by the percent selecting each option.

Paint applied to an iron surface prevents the iron from rusting. Which one of the following provides the best reason?

- A It prevents nitrogen from coming in contact with the iron.
- B It reacts chemically with the iron.
- C It prevents carbon dioxide from coming in contact with the iron.
- D It makes the surface of the iron smoother.
- E It prevents oxygen and moisture from coming in contact with the iron.

Country	N	A	B	C	D	E*	None
Australia	4917	4.77	6.03	6.15	4.23	77.51	1.31
Canada(Eng)	5543	4.53	5.59	7.20	2.28	78.82	1.58
England	3118	4.17	6.75	7.63	4.43	75.39	1.63
Finland	2546	5.96	3.68	2.98	1.64	85.14	0.60
Hong Kong	4973	5.44	3.59	7.84	4.13	78.65	0.35
Hungary	2515	1.73	1.51	4.07	1.27	90.72	0.69
Italy	3228	5.94	4.41	6.79	1.99	77.55	3.32
Japan	7610	7.14	5.50	5.37	3.05	78.49	0.45
Korea	4522	3.17	3.06	5.09	3.29	85.29	0.09

Country	N	A	B'	C	D	E	None
Netherlands	5025	3.56	2.31	5.11	1.48	86.95	0.50
Norway	1420	2.78	3.43	2.65	1.32	89.06	0.78
Philippines	10874	9.01	17.43	9.57	12.89	50.68	0.42
Poland	4520	4.67	2.53	5.30	3.28	82.45	1.77
Singapore	4430	4.16	5.53	11.28	4.55	73.81	0.68
Sweden	1461	5.02	5.22	5.52	1.63	81.81	0.80
Thailand	3780	7.06	9.37	8.78	2.84	71.86	0.09
U.S.A.	2519	7.25	8.77	11.13	5.61	66.27	0.97

This item was also given to 10-year old students in Population 1. The gains between Population 1 and Population 2 are quite high ranging from about 15 percent in the Philippines and Finland (although it should be noted that the performance in Finland was high in Population 1) to a 42 percent gain in Singapore. The low performance of the students in the Philippines (51%) should be noted, and it would appear that the topic of the rusting of iron is included in the science curriculum of only some of the students at the lower secondary school level in this country.

When 2 g (grams) of zinc and 1 g of sulphur are heated together, practically no zinc or sulphur remains after the compound zinc sulphide is formed. What happens if 2 g zinc are heated with 2 g of sulphur?

- A Zinc sulphide containing approximately twice as much sulphur is formed.
- B Approximately 1 g of sulphur will be left over.
- C Approximately 1 g of zinc will be left over.
- D Approximately 1 g of each will be left over.
- E No reaction will occur.

Country	N	A	B'	C	D	E	None
Australia	4917	29.83	28.83	7.11	12.08	18.94	3.19
Canada(Eng)	5543	22.83	31.56	7.18	11.68	20.58	6.18
England	3118	27.45	25.30	8.02	13.00	20.73	5.50
Finland	2546	30.53	31.45	8.78	11.01	17.01	1.22
Hong Kong	4973	29.58	21.91	12.59	12.73	22.07	1.11
Hungary	2515	25.90	42.01	4.51	13.59	12.57	1.42
Italy	3228	20.05	25.06	3.96	12.40	25.66	12.89
Japan	7610	21.31	55.56	7.14	6.57	8.88	0.55
Korea	4522	29.65	48.58	4.70	8.76	10.29	0.02
Netherlands	5025	18.72	43.77	8.95	8.21	17.17	3.18

Country	N	A	B	C	D	E	None
Norway	1420	30.28	19.25	5.20	11.98	30.79	2.51
Philippines	10874	37.21	20.97	7.32	12.26	21.84	0.40
Poland	4520	14.52	38.60	5.80	17.44	18.29	5.35
Singapore	4430	26.80	33.72	6.48	8.19	25.81	1.01
Sweden	1461	25.06	23.25	6.75	6.84	34.18	3.92
Thailand	3780	32.57	32.79	4.11	9.10	21.30	0.13
U.S.A.	2519	22.65	28.78	10.16	16.24	21.29	0.88

This item is a relatively difficult one for fourteen year old students. The range of correct responses (B) is from 19 percent in Norway to 56 percent in Japan. Options A and E were the wrong answers most frequently chosen and both attracted significant numbers of students in most countries. It is clear that the basic ideas of chemical change have not been explained to all students at the lower secondary school level.

A set of chimes was made by cutting four pieces of pipe of different lengths from a long metal pipe and hanging them as shown in the picture below. Which of the pipes gave the lowest note when struck with a hammer?

- A Pipe X
- B Pipe Y
- C All gave the same note.
- D You cannot tell without trying.
- E It depends on where you hit it.

What is the tension in the thread between P and Q?

- A 42 N
- B 35 N
- C 27 N
- D 15 N
- E 7 N

Country	N	A	B	C	D	E	None
Australia	4917	10.18	42.44	28.27	7.75	7.49	3.88
Canada(Eng)	5543	10.84	41.58	29.87	7.30	6.18	4.23
England	3118	12.28	41.26	26.07	8.73	7.94	3.73
Finland	2546	11.09	44.38	26.41	8.50	7.93	1.69
Hong Kong	4973	11.94	42.69	28.21	8.76	7.50	0.91
Hungary	2515	13.28	25.68	52.01	3.37	4.16	1.51
Italy	3228	16.21	34.96	19.95	3.28	16.40	8.19
Japan	7610	20.64	22.36	51.24	3.34	2.06	0.35
Korea	4522	14.04	35.82	27.98	11.54	10.49	0.11
Netherlands	5025	21.28	10.21	45.04	12.61	7.28	3.57
Norway	1420	9.69	33.58	31.87	12.04	8.22	4.59
Philippines	10874	13.93	59.93	10.89	7.34	7.56	0.34
Poland	4520	18.49	34.09	33.25	4.97	5.03	4.17
Singapore	4430	10.59	51.48	21.95	7.89	7.19	0.89
Sweden	1461	7.18	39.21	27.72	14.24	7.30	4.34
Thailand	3780	17.57	53.79	17.54	5.99	5.09	0.02
U.S.A.	2519	9.74	46.85	19.59	12.15	10.34	1.34

The correct response to this item is alternative C. The item assesses the higher order cognitive skills of application and analysis. It is clear that this is a relatively difficult item for 14-year old students with the percentage correct ranging from 11 percent in the Philippines to 52 percent in Hungary. B is a strong distractor presumably because the students have not learned the principles involved and, because the question refers to P and Q, they just added 15 N and 20 N. It would appear that the analyses of gravitational forces acting in a sample system is only taught at this grade level in Hungary (52%), Japan (51%), the Netherlands (45%), Poland (33%) and Norway (32%). This item was also given to students at Population 3.

Population 3

The figures presented for the first three items are based on the results of the combined groups of biology, chemistry and physics students at Population 3 level.

When 2 g (grams) of zinc and 1 g of sulphur are heated together, practically no zinc or sulphur remains after the compound zinc sulphide is formed. What happens if 2 g zinc are heated with 2 g of sulphur?

- A Zinc sulphide containing approximately twice as much sulphur is formed.
- B Approximately 1 g of sulphur will be left over.
- C Approximately 1 g of zinc will be left over.
- D Approximately 1 g of each will be left over.
- E No reaction will occur.

Country	N	A	B	C	D	E	None
Australia	3681	17.96	69.23	3.79	3.35	4.33	1.34
Canada(Eng)	8943	14.56	70.74	4.43	3.91	4.82	1.54
England	2693	8.73	85.37	2.83	0.97	1.11	0.89
Finland	2552	21.24	60.82	5.41	4.70	6.19	1.65
Hong Kong (Form 6)	6025	10.06	81.86	5.39	1.91	1.05	0.53
Hong Kong (Form 7)	3679	9.43	84.70	3.86	0.71	0.92	0.38
Hungary	842	15.20	75.53	1.54	0.95	5.94	0.83
Italy	2130	13.90	56.10	3.00	2.68	13.94	10.38
Japan	3867	5.33	88.03	2.53	1.50	2.56	0.05
Norway	1002	20.36	69.26	2.79	2.69	3.39	1.50
Poland	3245	7.24	79.69	5.33	2.90	3.48	1.45
Singapore	2918	10.11	83.62	2.78	0.55	2.43	0.51
Sweden	2430	11.56	80.58	3.09	0.82	3.21	0.74

This item assesses understanding of the concept of chemical change and the correct answer is option B. The scores on this item range from 56 percent in Italy to 88 percent in Japan. This was one of the items reported earlier for Population 2. The lowest gain from Population 2 to Population 3 was 31 percent in Italy and the highest gain was 60 percent in England. It is surprising that there are so many science students in some countries who do not understand this important concept. Perhaps, however, it is desirable to have carried out laboratory experiments involving the heating of such substances together in order to understand what happens.

This item was answered by biology, chemistry and physics students at Population 3.

Which of the cells shown below would commonly be found in the human nervous system?

Country	N	A*	B	C	D	E	None
Australia	3881	57.85	6.11	3.22	19.09	12.55	2.19
Canada(Eng)	8943	71.81	4.32	2.23	10.15	9.38	2.11
England	2693	78.28	4.16	0.97	8.91	5.38	2.30
Finland	2552	80.25	0.94	0.98	9.01	8.46	0.35
Hong Kong (Form 6)	6025	88.38	2.17	2.34	5.21	1.68	0.22
Hong Kong (Form 7)	3679	86.25	2.47	2.94	7.07	1.06	0.22
Hungary	842	95.49	0.95	0.83	0.95	1.43	0.36
Italy	2130	77.04	4.04	2.77	2.91	5.26	7.98
Japan	3867	83.01	2.22	2.46	6.34	5.90	0.08
Norway	1002	60.18	4.39	0.50	16.87	16.37	1.70
Poland	3245	95.01	0.59	0.62	0.80	2.74	0.25
Singapore	2918	71.14	7.13	3.56	11.38	6.00	0.79
Sweden	2430	51.28	5.51	1.23	23.95	17.00	1.03

The correct response to this item is option A, and the question is the same as that given to students at the Population 2 level.

This item was an easy one for Population 3 with scores ranging from 51 percent in Sweden to 85 percent in Hungary. Hungarian students in Population 2 had, however, performed well on this item (78%), and therefore, Hungary had the smallest gain of 17 percent, as did Italy, from Population 2 to 3. The highest gain was 80 percent in Hong Kong (Form 6).

This item was answered by biology, chemistry and physics students at Population 3.

The objects P, Q and R of weight 14 N (newtons), 20 N and 7 N, are hung with a light thread as shown in the figure.

What is the tension in the thread between P and Q?

- A 42 N
- B 35 N
- C 27 N
- D 15 N
- E 7 N

Country	N	A	B	C	D	E	None
Australia	3881	12.39	22.21	56.58	3.45	2.40	2.96
Canada(Eng)	8943	11.42	22.40	56.48	3.76	2.55	3.42
England	2693	10.55	9.58	75.64	1.75	1.00	1.49
Finland	2552	11.72	21.87	55.41	4.74	2.90	3.37
Hong Kong (Form 6)	6025	5.21	3.04	87.54	3.05	0.90	0.27
Hong Kong (Form 7)	3679	5.30	2.04	89.54	2.39	0.60	0.14
Hungary	842	6.29	9.03	60.17	2.38	1.43	0.71
Italy	2130	17.04	11.60	58.69	1.03	6.24	5.40
Japan	3867	11.87	9.35	73.11	3.16	1.50	0.49
Norway	1002	10.38	14.47	61.88	4.19	2.40	6.69
Poland	3245	9.68	13.96	71.37	2.71	1.14	1.14
Singapore	2918	14.12	11.62	68.71	3.36	1.44	0.75
Sweden	2430	7.33	6.67	79.05	3.25	1.86	2.14

To answer this question correctly by marking option C, requires the ability to apply knowledge and understanding of the simple principles of statics which are taught in physics courses. The lowest and highest scores were in Finland (55 %) and Hong Kong (90%). The gains from Population 2 to 3 levels ranged from 22 percent in Japan to 61 percent in Hong Kong.

This item was answered by biology students only at Population 3.

What initially determines whether a human baby is going to be a male or a female?

- A The DNA in the sperm.
- B The DNA in the egg.
- C The RNA in the sperm.
- D The RNA in the egg.
- E The DNA and RNA in both sperm and egg.

Country	N	A	B	C	D	E	None
Australia	1631	39.06	6.37	6.50	1.49	44.90	1.69
Canada(Eng)	3254	44.58	5.42	6.42	1.07	41.92	0.59
England	884	47.86	4.86	3.53	0.28	43.18	0.49
Finland	1652	58.06	4.31	10.21	1.56	25.20	0.66
Hong Kong (Form 6)	5960	43.46	5.84	13.10	2.68	33.73	1.19
Hong Kong (Form 7)	3614	50.93	4.65	11.15	2.28	29.58	1.39
Hungary	301	87.08	1.71	0.78	2.15	7.42	0.86
Italy	147	33.35	3.71	2.43	1.16	51.08	8.27
Japan	1212	37.95	12.21	8.58	3.05	37.95	0.25
Norway	278	46.85	3.44	9.06	0.82	39.15	0.69
Poland	764	73.96	5.36	5.40	0.61	14.32	0.36
Singapore	902	62.64	4.10	2.77	0.89	29.05	0.55
Sweden	1232	34.63	5.57	13.57	2.57	41.70	1.96
U.S.A.	659	48.44	6.00	9.17	2.72	33.25	0.42

The correct response to this item is option A. To answer the item correctly requires knowledge of key biological ideas. These ideas were well known in Hungary (87%) and Poland (74%) and not well known to biology students in Italy (33%) and Sweden (35%). Only in Hungary and Poland did distractor E fail to attract very large numbers of students. These results should be of interest to curriculum developers and textbook authors at this level.

This item was answered by biology students only at Population 3.

In order to obtain two crops in one growing season a farmer planted some seeds which he had harvested the previous week but the seeds failed to germinate. What can be concluded from this observation?

- A The farmer did not provide the right conditions for germination.
- B The seeds needed a longer period of maturation.
- C The farmer had not removed inhibiting substances.
- D The seeds required a period of low temperature.
- E The data are inadequate for a conclusion to be reached.

Country	N	A	B	C	D	E	None
Australia	1631	16.28	26.05	3.09	2.77	50.33	1.48
Canada(Eng)	3254	10.16	30.10	3.43	4.23	50.18	1.87
England	884	9.56	22.78	2.58	10.87	54.07	0.19
Finland	1652	9.18	32.18	4.18	31.78	21.89	1.01
Hong Kong (Form 6)	5960	20.83	19.24	14.26	5.08	38.58	1.89
Hong Kong (Form 7)	3614	18.55	18.18	11.30	7.80	41.80	2.38
Hungary	301	13.04	49.62	11.04	1.89	22.56	1.75
Italy	147	13.09	38.20	1.95	16.33	27.15	3.28
Japan	1212	10.73	33.09	3.96	20.13	31.83	0.17
Norway	276	5.12	57.55	2.59	3.50	28.42	2.83
Poland	784	6.72	43.28	3.40	13.55	32.10	0.66
Singapore	902	8.98	18.96	4.32	1.44	65.96	0.33
Sweden	1232	5.31	49.72	4.68	6.49	32.21	1.58
U.S.A.	658	14.02	24.13	4.28	3.39	53.39	0.79

The correct response to this item is option E, and to answer the question a student is required to analyze the alternatives and to recognize that insufficient evidence is provided. It is of interest to note the low level of performance in Finland (22%) and Hungary (23%) and the strong attraction of option D (32%) in Finland and option B in both Hungary (50%) and Finland (32%). Option B is the most common distractor in most countries, and this common misunderstanding warrants further consideration by curriculum developers. The high score in Singapore (66%) is of interest.

This item was answered by chemistry students only at Population 3.

The graph shows the solubility of two substances X and Y. A sample of 150 g of X and 75 g of Y is placed in a beaker containing 100 cm³ of water. Assume that the placing of the two substances together has no effect on how either dissolves. The mixture is filtered at 60°C. What would the residue on the filter paper consist of?

- A 95 g of X and 15 g of Y
- B 55 g of X and 75 g of Y
- C 95 g of X
- D 75 g of Y
- E 55 g of X

Country	N	A	B	C	D	E	None
Hong Kong (Form 6)	6018	17.77	23.05	5.92	39.29	11.89	2.07
Hong Kong (Form 7)	3670	10.48	6.42	1.83	71.45	6.92	2.90
Hungary	143	20.95	21.02	12.78	23.84	14.05	7.36
Italy	217	22.04	9.24	7.96	38.71	8.39	13.85
Japan	1468	17.78	14.37	6.81	37.67	22.21	1.16
Norway	283	24.78	6.81	12.86	44.22	8.44	2.90
Poland	765	20.23	11.17	10.84	45.35	8.05	4.56
Singapore	945	20.21	8.25	3.17	59.15	8.25	0.95
Sweden	1172	27.04	14.91	10.80	20.61	19.85	6.79

The correct response to this item is option D. The question requires a knowledge of the principles of organic chemistry and the ability to apply that knowledge. The increase in level of achievement between Form 6 (39%) and Form 7 (71%) in Hong Kong and the high levels of achievement in both England (67%) and Singapore (59%) would seem to indicate that organic chemistry is an important component of chemistry courses in these countries and of lesser importance in other countries. The results for Finland (21%), Hungary (24%), Canada (English) (19%) and Sweden (21%) would seem to indicate that organic chemistry is not taught in these chemistry programs.

This item was answered by physics students at Population 3.

A stone is dropped from rest down a deep well. It takes 2 s to reach the bottom. How deep is the well?

Assume that the air resistance on the falling stone is negligible and that the acceleration due to gravity $g = 9.8 \text{ m.s}^{-2}$

- A 4.9 m
- B 9.8 m
- C 19.6 m
- D 39.2 m
- E 78.4 m

Country	N	A	B	C	D	E	None
Australia	1073	2.07	3.61	88.11	5.40	0.11	0.71
Canada(Eng)	2766	5.91	5.70	74.33	13.05	0.26	0.76
England	917	0.83	2.53	90.50	5.45	0.49	0.21
Finland	810	7.30	9.06	63.42	18.59	0.55	1.09

Country	N	A	B*	C	D	E	None
Australia	1073	16.84	39.91	9.45	14.50	10.71	8.58
Canada(Eng)	2766	17.58	28.09	14.82	13.71	15.22	10.77
England	917	16.88	47.83	7.31	15.13	8.87	4.18
Finland	810	20.35	29.80	9.58	13.93	19.14	7.40
Hong Kong (Form 6)	6025	4.13	72.48	3.85	13.06	5.36	1.12
Hong Kong (Form 7)	3679	1.81	85.34	1.65	7.61	2.82	0.78
Hungary	398	1.72	62.86	11.36	16.89	3.91	3.48
Italy	1766	30.87	13.94	10.43	5.72	12.25	26.79
Japan	1187	12.81	49.28	6.66	19.46	8.52	2.27
Norway	443	13.33	54.22	5.32	9.42	12.89	4.82
Poland	1716	11.25	57.43	5.89	10.74	10.79	4.10
Singapore	1071	8.50	46.78	4.58	25.68	9.24	5.23
Sweden	1156	29.16	26.11	8.68	11.80	15.85	8.40
U.S.A.	485	14.12	35.50	7.83	13.56	14.11	14.87

The correct response to this question is option B. The item requires an understanding of the principles of circular motion in physics and proved surprisingly difficult for students in all countries except Hong Kong (Form 6: 72%; Form 7: 85%) and Hungary (63%). Only in Italy (14%), however, would it appear that students tested had not been exposed to the ideas involved.

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Our Ref: AI/B/ACD/P
Date: 25 March, 1992

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Re. IEA: Science Achievement in Seventeen Countries: A Preliminary Report, 1988

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