AN ABSTRACT OF THE THESIS OF

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Title: Attitudes Toward and Achievement in Science of Secondary Students in Kasetsart Demonstration School, Bangkok, Thailand

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Abstract approved: _____
Thomas P. Evans

The purposes of this study were to develop a valid and reliable attitudes toward science instrument in the Thai language and determine the differences in attitudes toward science and achievement in physical and biological science of Thai boys and girls in lower secondary education.

The population consisted of 709 students, 374 boys and 335 girls, in grades 7, 8, and 9 at the Kasetsart Demonstration School, Bangkok, Thailand.

The Attitudes Toward Science Test, a four-point Likert type scale was developed and validated in Thailand. The reliability coefficient was 0.95. Two-way analysis of variance, with sex and grade level as the independent variables, was used to analyze the Attitudes Toward Science Test scores. One-way analysis of variance was utilized to

analyze achievement test scores in physical and biological science. The 0.05 level was used to determine the significance of the results.

The findings revealed the following: (1) There were significant differences in attitudes toward science between boys and girls with boys having more positive attitudes toward science; (2) No significant differences in attitudes toward science were found among grade levels; (3) A significant interaction effect on attitudes toward science was found between sex and grade levels; (4) No significant differences in physical science achievement between boys and girls were found in grades 7 and 8, but there was a significant difference in grade 9, with boys scoring significantly higher; and (5) A significant difference in biological science achievement between boys and girls was found in grade 7 with girls scoring significantly higher, but no significant difference was found in grade 9.

The following conclusions were drawn with regard to the students in lower secondary education at the Kasetsart Demonstration School: (1) Students in all grades (grades 7, 8, and 9) demonstrated positive attitudes toward science; (2) Overall, boys had more positive attitudes toward science than girls; (3) Grade level needed to be considered to determine whether boys or girls had more positive attitudes toward science; (4) Girls' attitudes declined, and boys' attitudes improved when grade level

increased; and (5) The differential in achievement between boys and girls increased in physical science and decreased in biological science as grade level advanced.

ATTITUDES TOWARD AND ACHIEVEMENT IN SCIENCE OF SECONDARY STUDENTS IN KASETSART DEMONSTRATION SCHOOL, BANGKOK, THAILAND

by

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DEDICATION

To

my parents, Dr. Chumnong and Mrs. Nualnart Photisaro

my husband, Schwann

and my children, Maturawan, Tan, and Tai.

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CHAPTER I

INTRODUCTION

The major goal of science instruction is scientific literacy, including a positive attitude toward science, knowledge of content, and development of an understanding of and ability to use the scientific processes. In order for a person to become scientifically literate, he must have a positive attitude toward the study of science (Ayers and Price, 1975; Hasen and Billeh, 1975). Most science programs attempt to foster positive student attitudes toward science (Lawrenz, 1976), and science educators at varying educational levels are interested not only in their students' achievement but also in producing positive attitudes about science (Blosser, 1984).

It appears that even though educators desire to attend to affective development, they frequently fall short of their goals. Educators are accustomed to dealing with and attempting to measure cognitive objectives in their classes, but they tend to neglect the development of attitudes, interests, appreciations, and values (Ormerod and Duckworth, 1975; Wareing, 1982). Getting a handle on

how to measure the affective objectives of science education presents some major problems for the science teacher. It seems likely that the sensible way to begin to place more emphasis on affective awareness and understanding is to provide meaningful tools for assessment (Blosser, 1984; Wareing, 1982).

There is evidence which shows a strong relationship between attitudes toward science and science achievement (Brown, 1955; Crow and Piper, 1983; Harty, Beall, and Scharmann, 1985; Hedley, 1966; Hough and Piper, 1982). Attitudes toward science is one of the factors which influences a person in his or her decision concerning a career in science (Baker, 1981, 1983b). Achievement in science as well as attitudes toward science, is of special concern to science educators (Haladyna, Olsen, and Shaughnessy, 1982; Talton and Simpson, 1985).

The educational system in Thailand is of four levels: pre-school, elementary, secondary, and higher education. Secondary education is divided into lower and upper levels, each part containing three grades. The lower secondary level contains grades 7-9 and the upper level consists of grades 10-12 (Ministry of Education, 1977).

At the lower level, the student chooses courses from a wide range of subjects (both academic and vocational) according to his or her aptitude and interest. At the upper level, the student pays more attention to subjects

that will eventually be used in his or her line of employment.

The curriculum at the upper secondary education level consists of many study plans, which vary from school to school. Each study plan differs according to the student's aptitude and interests. The data for helping a student know his or her aptitude and interests for choosing a suitable program are obtained from many sources. One of the sources of data is the student's record of academic achievement. The student with a high score in science and mathematics during the lower secondary education level is encouraged to choose the study plan which emphasizes a science area; the student with a low or average score in science and mathematics or a high score in English during his or her study in lower secondary education is counselled to choose the study plan which emphasizes business or language arts.

Rationale for the Study

Wall (1976) stated that cognitive achievement should not be the singular goal of pupil progress, instruction, and the curriculum; areas such as the affective and psychomotor domains should also be included. In Thailand, the science and mathematics curricula are developed from the Institute for the Promotion of Science and Technology (IPST). The IPST, a semi-autonomous unit of the Ministry

of Education, was developed in 1970. The objectives of this Institute are to promote the development of modern science and mathematics curricula and teaching practices congruent with modern approaches to teaching and learning science and mathematics in the schools of Thailand. The cognitive, affective and psychomotor domains have all been considered in the development of a science curriculum in Thailand (Lockard, 1974). Although measurement in the affective area is presently being considered, few valid and reliable instruments are available for assessing student interests, beliefs and attitudes. Thus, there is a need to construct suitable instruments to measure attitudes toward science.

The IPST science program at the upper secondary education level is divided into physics, chemistry, and biology. The student who chooses the science program has to take physics and chemistry, but biology is optional. Students with above average science and mathematics scores at the lower secondary education level will be guided to study in the science program. Many students in the science program at the upper level tend to do well in biology, but not in physics and chemistry. Since an above average science score at lower level may be the result of the score in biological rather than physical science, it might be well to consider the achievement in these two areas separately in order to successfully guide students in

choosing their programs. Therefore, in this study physical science and biological science scores have been tabulated separately.

A study by Baker (1982, 1983a) indicated that science majors had higher mathematics scores than nonscience majors, mostly as a result of the scores of physical science majors. No significant difference existed in the mathematics scores of biological science and nonscience majors. Science majors were shown to have had scientific personalities and positive attitudes toward science. Nonscience majors had nonscientific personalities and negative attitudes toward science.

Schibeci (1983) reported that many variables have been investigated for their possible influence on student attitudes. He summarized several reviews and reported that sex appears to influence attitudes. Boys were found to display more favorable attitudes toward science than girls and appeared to be more favorably disposed to physical science than girls. Biological sciences tended to be viewed in a reasonably favorable light by girls. According to Kahle and Lakes (1983), an analysis of the 1976-1977 National Assessment of Educational Progress (NAEP) survey of science attitudes showed that, by age nine, females had consistently fewer experiences in science than boys of the same age. At ages 13 and 17, girls again reported fewer classroom and extracurricular science activities than boys.

In addition, girls displayed generally negative attitudes toward science classes and careers. In Thailand, it is interesting to note that there are proportionately more girls than boys in the language area, more boys than girls in the science area with no biology option, but equal numbers of boys and girls in the science area where biology is as an option.

The differences for the sex and grade levels of the students in lower secondary education have led this study to examine whether there are differences in physical and biological science achievement and attitudes toward science. Further, in order to measure the affective outcomes having the most relevance and suitability for Thai students at the lower secondary education level, the Attitudes Toward Science Test was developed by selecting, modifying, and translating items from existing instruments into the Thai language.

A theoretical framework for the study of attitudes toward science used in this study is derived from Haladyna and Shaughnessy (1982). This framework provides the dimensions and the causal factors which may account for students' attitudes toward science. Three independent constructs are posited: teacher, student, and learning environment. Each of these constructs can be explicated more specifically in terms of classes of variables.

All variables can be classified into one of two categories: exogenous and endogenous. Exogenous variables are those outside the immediate influence of the educational process, for example, age, sex, family background, cultural factors, and the like. Endogenous variables are those within the system that are under the control of the educational process and its agents, specifically, teachers, parents, and school administrators. Figure 1. shows the model of attitude toward science.

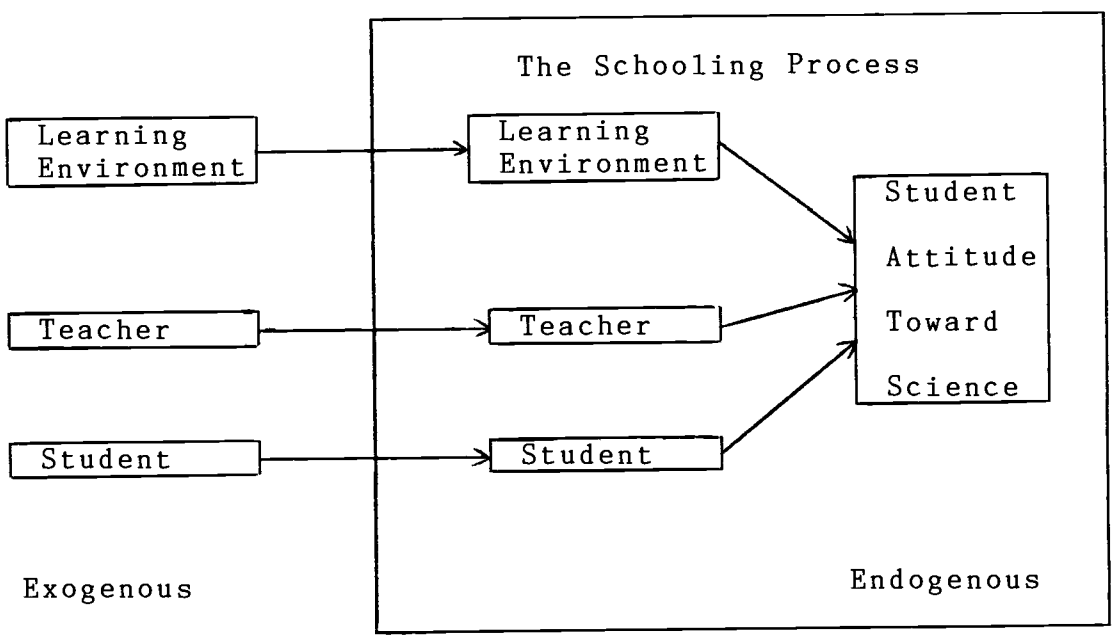

Figure 1. Model of Attitude Toward Science Used as Theoretical Framework.

This framework reveals that the teacher is the primary change agent affecting the learning environment, and that these two constructs, the teacher and the learning

environment, work in concert to affect student attitudes. From this theoretical framework, the science attitude instrument was developed by selecting and modifying the items which related to these two constructs.

Statement of the Problem

The purposes of this study were to develop a valid and reliable attitudes toward science instrument by selecting, modifying and translating items from existing instruments into the Thai language, and to determine the differences in the attitudes toward and achievement in physical and biological sciences of Thai boys and girls at the lower secondary education level at the Kasetsart Demonstration School, Bangkok, Thailand.

Research Hypotheses

1. A valid and reliable science attitude instrument for measuring attitudes toward science can be constructed for use at the lower secondary education level.
2. There is a significant difference in the attitudes toward science in terms of sex and grade level of the students at the lower secondary education level.
3. There is a significant difference in physical science achievement between boys and girls in each grade at the lower secondary education level.

4. There is a significant difference in biological science achievement between boys and girls in each grade at the lower secondary education level.

Assumptions

The assumptions were as follows:

1. Attitudes are measurable.
2. A Likert-type scale can reliably and validly measure attitudes.
3. Science achievement can be reliably and validly measured by the science achievement tests obtained from the Kasetsart Demonstration School.
4. A group of scientists and science educators can determine the applicability and relevance of attitude items.

Limitations

The limitations were as follows:

1. The study was limited to the extent that students respond honestly to the attitudes toward science instrument.
2. The study was limited to Thai students at the lower secondary education at the Kasetsart Demonstration School.

3. The study was limited to the extent that the items in the attitudes toward science instrument did not represent all aspects of attitudes toward science.

Definition of Terms

The following definitions are relevant to this study. Other terms or phrases used in the report are deemed to be self-explanatory.

1. Attitude. An attitude is a mental and neural state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related (Allport, 1935).
2. Attitude Toward Science. This refers to how an individual feels about science, an emotional feeling for or against science (Dutton and Stephens, 1963).
3. Achievement. This refers to an accomplishment or proficiency of performance in a given skill or body of knowledge (Good, 1973).
4. Physical Science. This refers to organized knowledge about physical composition and structure of phenomena; it includes chemistry, physics, astronomy, geology, meteorology, and areas of specialization derived from these (Good, 1973).
5. Biological Science. This refers to organized knowledge about living things; it includes botany,

zoology, and related sciences; description of living things in terms of origins (evolution), structure (morphology), function or operation (physiology), interrelations with environmental components (ecology), and areas of specialization derived from these (Good, 1973).

6. Achievement in Science. This refers to knowledge attained or skills developed in physical and biological science in the school science program. In this study, it is designated by test scores on teacher-made final examinations for second semester science.

7. Lower Secondary Education Students. This refers to the lower secondary education students who attend grades 7, 8, and 9 at the Kasetsart Demonstration School.

Design of the Study

The research project consisted of two major parts. The first part was the development of an Attitudes Toward Science Test in the Thai language. The second part of the study was to gather data from students in grades 7, 8, and 9 at the Kasetsart Demonstration School and to analyze the data for answers to the research hypotheses. For the analysis, student scores on the Attitudes Toward Science

Test and the second semester final examination in science were used.

The Attitudes Toward Science Test, with a Likert-type scale, was developed in Thailand, with content validity being established using the DELPHI technique. A two-way analysis of variance with sex and grade level as the two independent variables was used to analyze the Attitudes Toward Science Test scores. A one-way analysis of variance was utilized to analyze student scores on achievement tests in the physical and biological sciences.

Organization of the Remainder of the Study

The remainder of the study is organized in the following manner. Chapter 2 presents a review of research and other related material. Details of the process of developing the Attitudes Toward Science Test, procedures used to gather data and a description of the design are presented in chapter 3. Chapter 4 reports the findings of the analysis of the data. Chapter 5 presents the summary and conclusions for the study.

CHAPTER II

REVIEW OF RELATED LITERATURE

The purpose of this chapter is to review the research and literature pertaining to (1) differences between attitudes toward science and scientific attitudes, (2) instruments used to measure attitudes toward science at the secondary education level, (3) relationship of attitudes toward and achievements in science, (4) differences in attitudes toward science by sex, grade level, and/or age, and (5) differences in science achievement by sex, grade level, and/or age.

Attitudes Toward Science and Scientific Attitudes

According to Borg and Gall (1983) and Travers (1982), an attitude is usually thought of as having three components: an affective component, which consists of the individual's positive or negative affects (feelings) about the attitude object; a cognitive component, which is the individual's beliefs or knowledge about the attitude object; and a behavioral component, which is the individual's predisposition to act toward the attitude object in a particular way.

Schibeci (1983) noted that there are two broad subsets of science-related attitudes, scientific attitudes and attitudes toward science. The use of the terms scientific

attitudes and attitudes toward science have been overlapped and confused. Gauld and Hukins (1980), in their review of scientific attitudes, mentioned that there is a lack of agreement about the meanings of various terms, including the terms scientific attitudes and attitudes toward science.

Stead et al. (1979) said that it was found to be appropriate to distinguish between "attitudes to science" such as enjoyment and satisfaction and "scientific habits" such as open-mindedness, intellectual honesty and objectivity. Since the meaning of the two concepts of attitudes differs among researchers, it seems necessary to find the consensus of those who have used these terms. Another reason to distinguish between these terms is that it may be possible for a student to like science but yet not have "scientist-like" thinking patterns.

Gardner (1975) stated that there is a different emphasis in each category: "scientific attitudes" have a predominantly cognitive orientation, while "attitudes to science" have a predominantly affective orientation.

Attitudes Toward Science

Koballa and Crawley (1985) mentioned that the term attitudes toward science should be used to refer to a general and enduring positive or negative feeling about science. They stated:

> It should not be confused with scientific attitudes, which may be aptly labeled scientific attributes (e.g., suspended judgment and critical thinking). "I like science," "I hate science," and "Science is horrible!" are considered to be expressions of attitudes toward science because they denote a general positive or negative feeling toward the formal study of science or science as an area of research.

Hasen (1985) did a study to determine the influence of some selected instructional student and home variables on "attitudes toward science" of secondary school students in Jordan. He stated that his use of the term "attitudes toward science" was as follows:

> ...the term "attitudes toward science" is used to indicate all that an individual feels and thinks about science and scientists as a result of interacting directly or indirectly with various aspects of the scientific enterprise and which exert a directive influence on his behavior toward science. Thus, "attitudes toward science" reflect the individual's opinions and dispositional reactions to the scientific enterprise: its significance and utility to individuals and societies; the comprehensibility, validity, and reliability of its claims (in both knowledge and methodology); the "should be" functions and roles of science and scientists; and the ethical standards of the scientific community.

Dutton and Stephens (1963) developed an attitude scale for measuring attitudes toward science for prospective elementary school teachers. In their study, the term "attitude" referred to how an individual felt about elementary school science--an emotionalized feeling for or against science. These authors stressed that a distinction

needs to be made between this type of attitude and the term scientific attitudes. The scientifically-minded person, who possesses an open mind, looks at a problem from many sides and seeks reliable sources for his evidence.

Shrigley (1974) assessed the correlation of science knowledge and science attitude of preservice elementary teachers. He defined the term "science attitude" as the feelings toward science and the teaching of science. Aiken and Aiken (1969) stated that the majority of studies on "attitudes toward science" have been concerned with affect or feeling (like vs. dislike) toward science in general or a particular science.

The following items are examples of those used in measuring attitudes toward science:

1. The day after day search for scientific knowledge would become boring for me (Moore and Sutman, 1970).

2. Science teaches us to prepare for the future (Wareing, 1982).

3. I dislike coming to science class (Fisher, 1973).

4. People live healthier lives because of science (Wareing, 1982).

5. One gets sick at just the thought of science (Wareing, 1982).

6. It is undemocratic to favor exceptional scientific talent (Allen, 1959).

Scientific Attitudes

Munby (1983) wrote that the term "scientific attitudes" is taken to represent those habits of the mind generally associated with critical thinking and typically characterizing mental processes of a scientist at work. The scientist is thought to have attitude characteristics such as keeping conclusions tentative, weighing evidence carefully, and remaining uninfluenced by the biases of his colleagues and himself.

Gauld and Hukins (1980) stated that the scientific attitudes represent the motivation which converts knowledge about scientific facts and skill in the use of scientific methods into action and refers to a willingness to use scientific procedures and methods. Scientific attitudes may best be described as "an attitude to ideas and information and to particular ways of evaluating them." It is a formulation which distinguishes "an attitude to science or scientists" from "an ability to carry out scientific procedures."

Gauld (1982) stated that scientific attitude is most often characterized by a list of component attitudes ("scientific attitudes") such as objectivity, skepticism, open-mindedness, and a willingness to suspend judgment if there is insufficient evidence. He also provided a description of what constitutes the "scientific attitude":

> The scientific attitude as it appears in the science education literature embodies the adoption of a particular approach to solving problems, to assessing ideas and information or to making decisions. Using this approach evidence is collected and evaluated objectively so that the idiosyncratic prejudices of the one making the judgment do not intrude. No source of relevant information is rejected before it is fully evaluated and all available evidence is carefully weighed before the decision is made. If the evidence is considered to be insufficient then judgment is suspended until there is enough information to enable a decision to be made. No idea, conclusion, decision or solution is accepted just because a particular person makes a claim but it is treated skeptically and critically until its soundness can be judged according to the weight of evidence which is relevant to it. A person who is willing to follow such a procedure (and who regularly does so) is said by science educators to be motivated by the scientific attitude.

Davis (1935) developed a list of characteristics of an individual who has a scientific attitude. A person with a scientific attitude would (1) show a willingness to change his opinion on the basis of new evidence, (2) search for the whole truth without prejudice, (3) have a concept of cause and effect relationships, (4) make a habit of basing judgment on fact, and (5) have the ability to distinguish between fact and theory.

Haney (1964) stated that to be scientific means that one has such attitudes as curiosity, rationality, suspended judgment, honesty, open-mindedness, critical-mindedness, objectivity, and humility.

Diederich (1967) listed the components of scientific attitude or attitudes as follows:

1. Skepticism--Not taking things for granted and asking the prior question.
2. Faith in the possibility of solving problems.
3. Desire for experimental verification.
4. Precision.
5. A liking for new things.
6. Willingness to change opinions.
7. Humility.
8. Loyalty to truth.
9. An objective attitude.
10. Aversion to superstition.
11. Liking for scientific explanations.
12. Desire for completeness of knowledge.
13. Suspended judgment.
14. Distinguishing between hypotheses and solutions.
15. Awareness of assumptions.
16. Judgment of what is of fundamental and general significance.
17. Respect for theoretical structures.
18. Respect for quantification.
19. Acceptance of probabilities.
20. Acceptance of warranted generalizations.

Kozlow and Nay (1976) developed multiple choice test items for measuring scientific attitudes based on eight characteristics. These characteristics were suspended judgment (restraint), critical-mindedness, objectivity,

respect for evidence (reliance on fact), honesty, willingness to change opinions, open-mindedness, and a questioning attitude. A second pair of researchers, Billeh and Zakhariades (1975), developed an instrument for measuring scientific attitudes using the following six components: open-mindedness, aversion to superstitions, objectivity-intellectual honesty, curiosity, rationality, and suspended judgment. Hasen (1985) used the term "scientific attitudes" in the same manner as Kozlow and Nay.

The work by Davis (1935), Haney (1964), Diederich (1967), Kozlow and Nay (1976), and Billeh and Zakhariades (1975) provide attempts to determine the nature of the scientific attitudes by identifying components. However, the components are not identical. They overlap in their meaning and cause some confusion with respect to understanding the concept. Gauld and Hukins (1980), from their extensive review, mentioned that the components of the scientific attitudes seem to fall into three broad groups:

> Group 1 General attitude towards ideas and information (such as curiosity, open-mindedness, scepticism, humility, antiauthoritarianism and creativity).
> Group 2 Attitudes related to the evaluation of ideas and information. This can generally be labelled as critical-mindedness and contains such things as:
> (a) objectivity (showing lack of personal bias and with a high regard for (scientific) criteria

such as accurate empirical data, controlled experimentation, logic and reason).
(b) intellectual honesty.
(c) a tendency to exercise caution when drawing conclusions or making decisions (including a willingness to weigh all available evidence and to change one's mind or suspend judgment depending on the result of weighing the evidence).

Group 3 Commitment to particular (scientific) beliefs (such as loyalty to truth, belief in the understandability of nature, the existence of natural cause and effect relationships and the lack of foundation for superstition).

In conclusion, the literature review revealed that there are differences between the terms "attitudes toward science" and "scientific attitudes." The first term, attitudes toward science, deals with the affective component by denoting a general positive or negative feeling about science. In contrast, scientific attitudes are those attributes in the cognitive area which distinguish scientific thinking and problem solving strategies from non-scientific. This conclusion was corroborated by Ramsey and Howe (1969). They stated:

> It is difficult to pinpoint exactly what is meant by the development of attitudes. If the development of a scientific attitude is meant, then characteristics to be evaluated include habits of accuracy, intellectual honesty, open-mindedness, seeking cause-and-effect relationships, and the ability to suspend judgment. If the development of positive attitudes toward science or scientists is meant, then the feelings, opinions, emotions, and appreciations of our students must be evaluated.

Instruments Used to Measure Attitudes Toward Science at the Secondary School Level

The purpose of this section is to present the instruments used for measuring attitudes toward science at the secondary school level. Several instruments have been developed for measuring attitudes toward science. The instruments presented here are considered to be valid and reliable and have been used recently by several researchers. These instruments are the Attitudes Toward Science and Science Careers (ASSC) (Allen, 1959), Scientific Attitude Inventory (SAI) (Moore and Sutman, 1970), Science Opinionnaire (Fisher, 1973), Test of Science-Related Attitudes (TOSRA) (Fraser, 1981), Wareing Attitudes Toward Science Protocol (WASP) (Wareing, 1982), and Preferences and Understandings of Science (Bonstetter, 1984).

A majority of the instruments used to measure attitudes toward science have utilized Likert-type scales. According to Lowery (1966), Thurston was the first to adapt methods of psychophysical scaling in the scaling of judgments. Thurston marked the categories "favorable-unfavorable" or "agree-disagree," which were utilized with a series of statements about the subject being assessed. Following Thurston, Likert constructed an attitude scale by which the degree or intensity of agreement was marked "strongly agree," "agree," "undecided," "disagree," and

"strongly disagree." These units were used as measurement scales for research work.

Attitudes Toward Science and Science Careers (ASSC)

Allen (1959) developed the Attitudes Toward Science and Science Careers (ASSC) for high school seniors. The instrument was organized into three sections: Personal Data, Vocabulary Test, and Attitude Scale. The attitude instrument consists of a 95-item Likert-type scale. The statements in the attitude scale are sorted into five categories: (1) science's impact on society, (2) society's impact on science, (3) the scientist, (4) scientific work, and (5) nature of science. Periodicals which expressed many points of view on scientific endeavor were reviewed by the author, and the special note of derogatory statements from various sources were made in preparing the attitude scale. A list of questions was formulated for interviews with scientists and professors of sciences, and high-ability high school students, who were planning either scientific or nonscientific careers. These interviews were used as a basis for the formulation of the 95-item scale. Therefore a panel type process was used to retain those items which the interviewed considered valid. The reliability of the instrument was not reported.

The ASSC was first used to determine the attitudes of the New Jersey public high school seniors. The purpose of

the study was to identify those attitudes which might act as deterrents to a scientific occupational choice.

Scientific Attitude Inventory (SAI)

The Scientific Attitude Inventory (SAI) developed by Moore and Sutman (1970) is a 60-item Likert-type instrument with a 4-point response scale (there is no neutral response). The content validity of the SAI, which was designed for high school students, was established by using a panel of judges and a group of students. Construct validity was established through field testing. It has reported reliabilities of 0.93 for the test-retest procedure and 0.58 for Cronbach's alpha (Munby, 1983) for samples of high school or older subjects. No reliability has been reported for middle school students.

Though referred to as the Scientific Attitude Inventory, the instrument begins with the title of "What is your attitude toward science?." Munby (1983), mentioned that the name of the test is somewhat misleading, that the instrument goes beyond the usual concept of scientific attitudes, and that an inspection of the items demonstrates much attention to attitudes toward science. Further, Billeh and Zakhariades (1975) stated:

> "A major criticism of the SAI is that it does not measure the scientific attitude as such, but rather looks at a mixture of attitudes concerning science, sociology of science, and knowledge of the nature of science."

In addition, Baker (1985) used the SAI and claimed that the instrument was designed to measure attitudes toward science.

Science Opinionnaire

Fisher (1973) developed the Science Opinionnaire, an attitude survey for junior high science students. The test consists of twenty Likert-type items with a five-point scale and one open-ended question. Six science curriculum specialists helped design the instrument; thus, content validity was assumed to be established. The instrument, using test-retest and the split-halves methods, had reliability coefficients of 0.793 and 0.833 respectively.

Test of Science-Related Attitudes (TOSRA)

The Test of Science-Related Attitudes (TOSRA) developed by Fraser (1981) is an instrument consisting of seven attitude scales, each having ten Likert-type statements. The names of the scales are (1) social implications of science, (2) normality of scientists, (3) attitude of science inquiry, (4) adoption of scientific attitudes, (5) enjoyment of science lessons, (6) leisure interest in science, and (7) career interest in science. Reliability coefficients on the seven scales in the four grade levels (grades 7-10) ranged from 0.66 to 0.93.

Scales 3 and 5 of TOSRA are those used for testing the like or the dislike students might have for science in the classroom. Scale 4 deals with scientific attitudes. The other scales represent the subcomponents of science attitude that their titles suggest.

According to Shrigley (1983), TOSRA has been tested in a number of public and private schools in Australia. When used in two American Catholic schools, the data were similar to the Australian data, suggesting that the scales have cross-cultural validity. Shrigley (1983) suggested that, since TOSRA consists of seven scales in dealing with specific attitudes, it should be considered when testing two or more component attitudes.

Wareing Attitudes Toward Science Protocol (WASP)

Wareing (1982) developed the Wareing Attitudes Toward Science Protocol (WASP) for measuring students' attitudes toward science in grades 4 through 12. The test was constructed by using an item pool. The final inventory of the attitude instrument consists of a 50-item, Likert-type scale with twenty-five positive statements and twenty-five negative statements. Content validity was determined by a panel of nineteen scientists and science educators. Reliability coefficients were calculated using several split-half methods. The results showed the reliability to be in the range of 0.91-0.94.

Preferences and Understandings of Science Instrument

Bonstetter (1984) developed the Preferences and Understandings of Science instrument. The test consists of 40 multiple choice items. The first 32 questions measure science preferences, and the last eight questions cover the understanding of eight terms in science. The instrument is available in both English and Spanish versions.

The preceding descriptions of attitudes toward science scales show that the feasibility of constructing valid and reliable Likert-type instruments has been well established. The most commonly used and accepted method for establishing the validity of these instruments has been through a panel of knowledgeable judges and through field testing.

Attitudes Toward Science and Science Achievements

The relationship between attitudes toward science and science achievement has not been established since there seems to be no real agreement among study results. Munby (1983), in his report on a conceptual analysis to determine the validity of the Scientific Attitude Inventory (SAI), found that there is a variation in the relationship between the SAI scores and science achievement.

A strong relationship between attitudes toward science and science achievement was found in several studies (Brown, 1955; Crow and Piper, 1983; Hamilton, 1982; Harty, Beall, and Scharmann, 1985; Hedley, 1966; Hough and Piper,

1982). Brown (1955) found that elementary students with significantly high science achievement scores had significantly high science attitude test scores. Harty et. al. (1985) found a significant positive correlation between achievement in science and attitudes toward science of fifth grade caucasian students. Hough and Piper (1982) studying elementary students found a relationship between achievement and attitudes toward science when using residualized gain scores. Hedley (1966) found a positive relationship between science achievement scores and attitudes toward science in secondary science students. Hamilton (1982) found a significant relationship between "Ordinary" level science achievement and attitudes toward science in Jamaican students. Crow and Piper (1983) investigated the relationship of perceptual orientation and attitudes toward science as they related to science achievement with students in an urban community college. They found that students, who were field independent and possessed a positive attitude toward science, scored significantly higher on the science achievement test than students who were field dependent and possessed a negative attitude toward science.

A meta-analysis of research results in the relationship between science achievement and science attitude of kindergarten through undergraduate college students was conducted by Wilson (1983). He wrote that

there does not appear to be a consistent cross-age causal direction between attitude and achievement. At the elementary and junior high levels there is a higher correlation for achievement-causing attitude than for attitude-causing achievement. This is reversed for senior high and college levels, but at no levels were the results statistically significant. He stated that educators should be more concerned with the attitude of children after their science experience than the correlation between achievement and attitude. He suggested that if the reviewed data are to be believed, successful achievement will cause a positive attitude. Another meta-analysis, done by Haladyna and Shaughnessy (1982), revealed a consistent, but weak, association between achievement in science and attitudes toward science.

Baker (1983c) found that attitude and mathematics ability seemed to affect science grades more than did personality factors. He found that in junior high school, girls were not only less likely to have a positive attitude toward science, but were more likely to have the higher science grades. Baker further stated that if girls do not take more science courses in high school, the reason is not aptitude but attitude. Mondrinos (1984) made similar conclusions regarding undergraduates, stating that females were more influenced by attitudes, while males appeared to be more achievement oriented.

Further, some studies showed that a relationship between positive attitudes toward science and high science achievement does not exist. Fraser (1982), in his review of previous research, concluded that the relationship between science attitudes and achievement is weak. He recommended that science teachers focus directly on achievement, rather than attempting to promote positive attitudes as a means of improving achievement. Baker (1985) assessed the attitude toward science of 98 eighth grade middle school students from a single school in a large metropolitan area using the Scientific Attitude Inventory (SAI). He reported that females and males with science grades of A and B had negative attitudes toward science, while those with grades of C and D had a more positive attitude toward science.

Overall, the results of studies relating to attitude toward science and science achievement reveal that attitude is not a strong factor causing achievement in science. Females and males with high achievement in science have a less positive attitude toward science than do those with low achievement. At best the studies have not shown a positive relationship between attitudes and achievement in science.

Differences in Attitudes Toward Science by Sex, Grade Level, and/or Age

Sex, grade level, and/or age of the student are frequently among the factors considered when researchers study attitudes toward science or achievement in science. Gardner (1975) referred to sex as the "single most important variable related to pupils' attitudes to science." Squiers (1983) and Schibeci (1983) agreed that sex was a factor in student attitudes toward science. Haladyna, Olsen, and Shaughnessy (1983), found gender was the only one exogenous student variable correlating to science attitude. Lowery, Bowyer, and Padilla (1980), in their studies of the Science Curriculum Improvement Study program (SCIS), hypothesized about the differences in attitudes between boys and girls. They pointed out that gender was considered as an important factor for analysis since the sciences have been identified as preparatory subject areas which currently screen women from many career opportunities.

There are several other studies concerned with sex differences in attitudes toward science (Anderson, 1983; Baker, 1983c; Blosser, 1984; British Columbia Science Assessment, 1982; Czerniak and Chiarelott, 1984; D'Annucci, 1978; Fleming and Malone, 1983; Garcia and McFeeley, 1978; Haladyna and Thomas, 1977; Koelsche and Newberry, 1971; Lowery, 1967; Maehr and Steinkamp, 1983; National

Assessment of Educational Progress (NAEP), 1979; Schibeci, 1983; Stead et al., 1979; Steinkamp, 1982). Each of these found some significant differences in attitudes between genders.

The survey of attitudes toward science by NAEP (1979) found that males were more likely than females to have favorable attitudes toward science classes and science-related careers, more science-related experiences, and use the scientific method of inquiry. Similar results were reported by Koelsche and Newberry (1971), Haladyna and Thomas (1977), D'Annucci (1978), and the British Columbia Department of Education (1982). Lowery (1967) found fifth-grade girls had more positive attitudes than fifth-grade boys, on Lowery's projective test of attitudes toward science.

Steinkamp (1982) conducted a synthesis of 83 documents dealing with sex differences in attitudes toward science. She found the differences, though small, consistently favored males. Anderson (1983) and Baker (1983c) agreed that there were few sex differences, and that girls had a less positive attitude toward science. Fleming and Malone (1983) conducted a meta-analysis for determining the relationships of student characteristics to student performance and attitudes from kindergarten through twelfth grade. In regard to the gender factor, they found the

weakest relationship dealt with attitudes; males generally scoring slightly higher than females.

It was interesting to note that sex differences in attitudes toward science were found to depend upon the subject areas. The nature of boys' and girls' interests in science tended to differ by subject area, with boys relatively more interested in physical science and girls more interested in biology and social science (Blosser, 1984). Schibeci (1983) concurred, emphasizing that a distinction needs to be drawn between the physical and biological sciences. Boys appeared to be more favorably disposed to physical sciences than girls, while biological sciences tended to be viewed in a reasonably favorable light by girls. Further, in their review of research concerning attitudes toward science, Ormerod and Duckworth (1975) concluded that physical science has a far weaker attraction for girls than for boys.

Garcia and McFeeley (1978) studied the attitudes toward biology among biology and non-biology majors using the Biology Attitude Scale. This study demonstrated that the students' attitudes toward biology were only minimally related to sex and age. Stead et al. (1979), in a final summary section focusing on attitudes, reported that, on the average, girls prefer biological topics while boys preferred physical and chemical topics. They also stated that younger students seemed to have more positive

attitudes. Similarly, Steinkamp (1982), and Maehr and Steinkamp (1983) stated that sex differences in attitudes toward science were larger in some subject areas than in others. Girls' attitudes toward biology, botany, and chemistry surpassed those of boys, while boys' attitudes were more positive than girls' in physical and general sciences.

In addition, the grade level and/or age of the group appears to affect the relationship between sex differences and attitudes toward science. Steinkamp (1982) indicated that male/female differences varied as a function of age; sex differences in attitudes toward science tended to be largest at the junior high school age. Gardner (1975) wrote that there was a "substantial body of evidence" involving upper primary and secondary school pupils which indicates that boys have greater interest in science than do girls. Further, these differences appear to carry over into adulthood.

According to Czerniak and Chiarelott (1984), studies have shown that primary age children, both male and female, liked science. Attitudes about science and math in the lower grades, as well as achievement, were about the same for both sexes. By adolescence, girls had begun to dislike both subjects. In high school, girls felt incompetent in science and mathematics and thought that boys did better.

Hummell (1981) indicated that positive attitude declined as children passed through elementary, middle school, and junior high school grades. Haladyna and Thomas (1977) used sex and grade level as factors relating to attitudes of elementary school children toward school and subject matters. The results of the study indicated a general decline in attitudes toward school and several subject matter areas from grades one to six. However, boys preferred science to a greater degree than did girls.

The 1982 the British Columbia Science Assessment reported that the attitudes of British Columbia pupils towards science in school declined from Grade 4 to Grade 12. Boys' attitudes towards science appeared more positive than did girls (British Columbia Department of Education, 1982).

D'Annucci (1978) investigated the attitudes of inner-city intermediate/junior high school students toward their science teachers and science classes. He found no significant difference between younger (11- and 12-year old) and older (13- and 14-year old) students with regard to their attitudes toward science teachers and classes. Further, his study indicated that there were no significant attitude differences among four age groups (11, 12, 13, and 14).

Research on attitudes has consistently shown that females have less favorable attitudes toward science than

do males. The relationship of age or grade level has more often been found to be inversely related to attitude; that is, the attitudes become less positive as the grade level, and/or age, increases.

Differences in Science Achievement by Sex, Grade Level, and/or Age

Hamilton (1982) noted that sex difference is a feature which is closely related to achievement in the arts and sciences. She mentioned that in the Jamaican study, not only did boys pass a greater number of science subjects, but they also performed markedly better in the physical sciences. On the other hand, girls outperformed boys in the arts.

Studying male-female achievement in eight learning areas, Herman (1975), found that the advantage of males over females in physical science increased with age. She noted that boys and girls alike tended to be exposed to both physical and biological science topics in elementary grades. In high school science courses, physics, chemistry, and biology are more often electives, and boys, more frequently than girls, select courses in these areas. The differential exposure of boys to the physical science curriculum might explain the advantage of boys and young men over girls and young women on the typical exercise that assesses physical science.

The British Columbia Assessment reported that sex-related differences in science were apparent at all three grade levels of the study (grades 4, 8, and 12). There was some evidence of a grade-level effect. At all three grade levels the boys outscored the girls, and the grade 12 differences were greater than those of the earlier grades. The sex-related differences in biology were very small. The differences were more substantial in the physical sciences area. There was an increase in these differences as one moves from chemistry to earth/space science and, finally, to physics. In the physical sciences the male advantage progressively increased with age, but in biology there was no such increase. Rather, the differences in biology scores declined from 2.8 to 1.0 from grade 4 to grade 8 and then changed little from grade 8 to grade 12 (Erickson and Erickson, 1984).

In Sweden, it was found in the First International Association for the Evaluation of Educational Achievement (IEA) Science Study (Anderson, 1983) that sex differences in science achievement at the 10-year-old level were small and increased at the 14-year-old level. Sex differences, in favor of the boys for science as a whole, were clearly visible by the beginning of upper primary school. They increased and became most marked by the end of lower secondary school. The differences were least for

biology and greatest in physics, chemistry, and practical skills.

In conclusion, the reviewed literature showed that sex differences in achievement in physical sciences seemed to be much more pronounced than in the biological sciences. Though achievement favored males in both areas, the sex difference was larger in physical sciences and increased as age or grade level increased. In biological sciences the difference, though present, was much smaller and decreased in magnitude as age or grade level increased.

CHAPTER III

RESEARCH PROCEDURES

The purpose of this chapter is to describe the research process and the procedures used in the study. The chapter encompasses the following: (1) a description of the subjects studied, (2) the dependent variables, (3) the instruments, (4) the procedures used to gather the data, and (5) the design of the statistical analysis of the research data.

The Population

The population for this study consisted of 709 students, 374 boys and 335 girls, at the lower secondary education level (grades 7, 8, and 9) in the Kasetsart Demonstration School, Bangkok, Thailand. There were 223 students, consisting of 122 boys and 101 girls, in grade 7; 232 students, consisting of 123 boys and 109 girls, in grade 8; and 254 students, consisting of 129 boys and 125 girls, in grade 9. The range of ages of the population was between 13 and 15 years. The distribution of the student population is shown in Table 1.

Table 1

Student Population

	sex		
grade level	boys	girls	total
7	122	101	223
8	123	109	232
9	129	125	254
total	374	335	709

According to Cohen's sample size tables, the minimum sample size, where Υ = .25, power level (1-β) equal to .80, and significance level (α) set at .05, is 45 subjects per cell (Cohen, 1969). Thus, the 709 students utilized for this study exceeded the minimum sample size requirements.

The Dependent Variables

The dependent variables in this study were student scores of attitudes toward science, achievement in physical science, and achievement in biological science. The variables were measured by administering two tests, the Attitudes Toward Science Test and a science achievement test.

The Instruments

Two tests were administered to each student participating in the study. One test was a device to measure the student's attitude toward science, and the other was a science achievement test for the grade level of the participant. The test for attitudes toward science was developed at Kasetsart University; each student received the same form of the instrument. The tests for achievement in science were supplied by the Kasetsart Demonstration School and were designed to summatively evaluate the student's progress at the end of their current term of study. Students in the study were given the achievement test according to their current grade level.

Developing the Attitudes Toward Science Test

The Attitudes Toward Science Test was developed by selecting, modifying, and translating into the Thai language, items from existing instruments.

The procedure for test construction used in this study followed the process given by Oppenheim (1966), Wareing (1982), and Gardner (1975) as follows:

1. Item Pool. Four instruments were used to form the item pool, The WASP: Wareing Attitudes Toward Science Protocol (Wareing, 1984), Science Opinionnaire (Fisher, 1973), Preference and Understanding of Science (Bonstetter, 1984), and Attitudes Toward Science and Science Careers

(ASSC) (Allen, 1959). The items were translated into the Thai language. Modification to make the items understandable to lower secondary students in Thailand were completed by three Thai language experts. These experts had previous experiences in teaching the Thai language at the elementary school, secondary school, and university levels. A listing of the Thai language experts is shown in Appendix B.

2. Scale and Scoring. During the developmental stage, all items were given a five-point Likert selection scale of "strongly agree," "agree," "undecided," "disagree," and "strongly disagree." The items with the most "strongly agree" and "strongly disagree" responses were maintained as positive attitudes toward science or negative attitudes toward science items. The items with the most "undecided" responses in the field study were excluded from the final inventory. Borg and Gall (1983) stated that the use of pretesting or "no opinion" categories are ways to determine whether or not subjects have sufficient background information to make a meaningful response. Evans (1985) mentioned that if the "undecided" response is used on an item by a large number of subjects, it can be assumed that the subjects do not have adequate background information. Thus, the items judged to have a large enough number of "undecided" responses were eliminated.

3. Content Validity. According to Aiken (1980), evidence of content validity can be obtained from careful inspection of the inventory by attitude "experts" and their judgments of its validity. Thus, the DELPHI panel technique as outlined by Courtney (1982) was used to establish content validity. The DELPHI panel consisted of eight science educators in Thailand. These were three female and five male members with various areas of expertise in science education from three different well known institutions. The areas of expertise included general science, biological science, and physical science. A listing of the DELPHI panel members is shown in Appendix A.

The steps followed by the DELPHI panel were as follows:

(1) An inventory of 177 items was presented for the panel members' judgment about the possible contents of a data-gathering device. The items were judged, and it was decided whether or not to reject, accept, or modify them for use in the device. The items receiving at least six out of eight favorable judgments, either full acceptance or acceptance with modification, were maintained for consideration in the second round. When more than one item made essentially the same query they were reduced to a single item.

(2) In the second round, each panel member received the reduced list of 65 items and was asked to first evaluate the proposed items as to their clarity in indicating positive or negative attitudes toward science. They were also asked to consider the probable readability of items by the target population of lower secondary students. Each panel member checked "P" or "N" for the appropriateness of items with positive or negative attitude toward science and "S" or "U" for satisfactory or unsatisfactory readability.

(3) The third step in the DELPHI panel procedure was to summarize the findings of the survey in step 2 and present the findings to the panel members. In effect, this step asked the individual panel members to either revise their opinions or else to specify their reasons for remaining outside of the consensus of the other panel members. At this step the inventory of items was reduced to 54 items from the responses of the panel.

(4) In step four the 54 items resulting from the above three steps were presented to the panel members for final judgment and revision. There were no important changes suggested at this time. The panel was nearly unanimous in its agreement as to the

appropriateness of the items to be included on the test.

4. Readability. A trial test to assess the readability of the items was conducted with four selected sixth-grade students, two boys and two girls, at the Chulalongkorn Demonstration School. The students were asked to identify which items they were not able to understand clearly. These items were discussed, with the students emphasizing the meaning and the reason for these items. The discussion responses were recorded. The time required for the students to complete the instrument and the clarity of the instructions for the test were judged and recorded. The wording of some of the items was modified to make items more appropriate for the sixth-grade student group. The readability of the instructions was deemed acceptable. The three Thai language experts reconsidered the language and the readability of the items before they were used with the field test students. They judged the items to be of appropriate reading level for lower secondary education students.

5. Field Test. The 54 items, judged to be valid by the DELPHI panel and having a suitable readability level as assessed by the sample of sixth-grade students and reading experts, formed the inventory which was field tested. Students from the Chulalongkorn Demonstration School were chosen for the field test. These students were chosen

because they were from an identical type of school, with compatible educational programs and similar students' backgrounds as the research population. Permission for using this group of students was obtained from the Dean of the Department of Education at Chulalongkorn University. The field test was administered to 100 students from one class each of seventh, eighth, and ninth grades from the Chulalongkorn Demonstration School, Bangkok, Thailand.

6. Final Version of the Test. Of the 54 items used in the field test, 16 received a large number of "undecided" responses by the students. This indicated that these items did not provide sufficient background information in attitude toward science. These items were removed from the inventory. Thus, the final form of the Attitudes Toward Science Test, which was used to gather the data for this research, consisted of 38 items. The Likert scale for scoring the responses was changed to a four-point scale of "strongly agree," "agree," "disagree," and "strongly disagree." According to Courtney (1985), the four-point equal-appearing interval scale permits a response pattern which allows a dichotomous agreement or disagreement judgment for each item. At the same time, sufficient variance can be generated for the valid interpretation of analysis of variance results.

The scoring of the student responses was 4, 3, 2, and 1 for positive statements and 1, 2, 3, and 4, respectively,

for negative statements. Thus, a high score represented a positive attitude toward science.

7. Reliability. The reliability was determined by using the method presented by Hoyt and Stunkard (1952). This method provided a straight-forward solution to the problem of estimating the reliability coefficient under the condition that the item scores are not restricted to a 1 or 0. Here, let x represent the score obtained by the i^{th} item for the j^{th} respondent; where: i = 1, 2, 3,.....k, and j = 1, 2, 3,..... n. The matrix with n respondents for all k attitude toward science items is presented as follows:

	Respondents					
items	1	2	3....j....n			total
1	x_{11}	x_{12}	x_{13}	x_{1j}	x_{1n}	$x_{1.}$
2	x_{21}	x_{22}	x_{23}	x_{2j}	x_{2n}	$x_{2.}$
3	x_{31}	x_{32}	x_{33}	x_{3j}	x_{3n}	$x_{3.}$
.	.	.	.	.	.	.
.	.	.	.	.	.	.
i	x_{i1}	x_{i2}	x_{i3}	x_{ij}	x_{in}	$x_{i.}$
.	.	.	.	.	.	.
.	.	.	.	.	.	.
k	x_{k1}	x_{k2}	x_{k3}	x_{ki}	x_{kn}	$x_{k.}$
total	$x_{.1}$	$x_{.2}$	$x_{.3}$	$x_{.j}$	$x_{.n}$	$x_{..}$

The various summations of the x_{ij} give:

$x_{i.} = \Sigma x_{ij}$, the score for the i^{th} item for all individuals;

$x_{.j} = \Sigma x_{ij}$, the score obtained by the j^{th} individual for all items.

$x_{..} = \Sigma\Sigma x_{ij} = \Sigma x_{i.} = \Sigma x_{.j}$, the sum of the scores of all individuals over all items.

The sum of squares for individuals is obtained by:

$$A = \frac{\Sigma_i x^2_{i.}}{n} - \frac{x^2_{..}}{kn}$$

The sum of squares for items is computed by:

$$B = \frac{\Sigma_j x^2_{.j}}{k} - \frac{x^2_{..}}{kn}$$

The total sum of squares is obtained by:

$$T = \Sigma_i \Sigma_j x^2_{ij} - \frac{x^2_{..}}{kn}$$

The residual sum of square is obtained by subtraction.

$$C = T - A - B$$

The estimate of reliability is obtained by:

$$\frac{\text{Mean Square Respondents - Mean Square Residual}}{\text{Mean Square Respondents}}$$

The Layout for reliability of the Attitudes Toward Science Test is shown in Table 2.

Table 2

Table for Reliability

Source of Variation	df	SS	MS	r_{tt}
Among items	k-1	A	A'	
Among individual	n-1	B	B'	
Residual	(k-1)(n-1)	C	C'	
Total	kn-1	T	T'	

The estimate of reliability coefficient is computed using the following formula:

$$r_{tt} = \frac{A' - C'}{A'}$$

The Science Achievement Tests

The tests for science achievement were supplied by the Kasetsart Demonstration School and were designed to summatively evaluate the students progress at the end of their second semester of study. Students in the study were given the achievement test according to their current grade level.

The test for seventh grade students consisted of 80 multiple choice items; fifty (50) items were in physical science and 30 items were in biological science. The test for eighth grade students consisted of 70 multiple choice

items in physical science only. The test for ninth grade students included 100 multiple choice items of which 70 items were in physical science, and 30 items were in biological science. In the scoring of each test, each item was worth one (1) point, making the total score of 80, 70, and 100 points respectively in grades 7, 8, and 9.

The science teachers at the Kasetsart Demonstration School at each grade level met as a group to develop the achievement tests. They concluded that the items were representative of the content areas and reflected the behavioral objectives of the science subject. Thus, the tests were assumed to have content validity. The reliability of the tests was also one of the stated assumptions for this research.

Collection of Data

Permission for collecting the data was obtained from the Principal of the Kasetsart Demonstration School. The Head of Science Project and the Head of the Lower Secondary School of the Kasetsart Demonstration School arranged the schedule for administering the Attitudes Toward Science Test. The student scores on the science achievement tests were provided by the administration of the Kasetsart Demonstration School.

Administration of the Attitudes Toward Science Test

The Attitudes Toward Science Test was administered to the student population in grades 7, 8, and 9 at the Kasetsart Demonstration School in the week before final week of the second semester 1984. The test was given over three consecutive days to the three grade levels. The home-room hour, which began at 8:20 AM. and ended at 8:40 AM., together with 20 minutes of the first period, was arranged for the students to complete the test. The instructions for giving the test to the students was explained to the classroom teachers, who helped administer the test. After the students finished answering the tests, the test papers were collected by the classroom teachers. The tests were then scored in order to obtain data for the study.

Administration of the Science Achievement Tests

The science achievement tests were administered to the students during the final week of the second semester of 1984 by their regular classroom teachers. The tests for grades 7 and 9 contained both physical and biological science questions. The physical and biological science scores were separated for the students in grades 7 and 9. Only physical science scores were obtained for grade 8, since all items were in physical science.

Statistical Design

The study was designed to determine the differences in the attitudes toward science and achievement in physical and biological science of Thai boys and girls at the lower secondary education level. The difference in attitudes toward science between boys and girls at the lower secondary education level was determined using two-way analysis of variance. The difference in achievement in physical and biological science between boys and girls at each grade level was determined using one-way analysis of variance.

Statistical Analysis for Attitude Toward Science

The statistical hypotheses to determine the differences in attitude toward science between boys and girls at the lower secondary education level at the Kasetsart Demonstration School were tested using two-way analysis of variance. The null hypotheses were as follows:

1. There is no significant sex level effect.

$$\sigma^2_S = 0.$$

2. There is no significant grade level effect.

$$\sigma^2_G = 0.$$

3. There is no significant interaction effect.

$$\sigma^2_{SxG} = 0.$$

The mathematical model for testing of hypotheses for the two-way fixed model is as follows: (Courtney, 1983)

$$Y_{ijk} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + \varepsilon_{ijk}$$

where,

μ is a constant representing the general mean,

α_i is the differential (fixed) effect associated with sex,

β_j is the differential (fixed) effect associated with grade,

$\alpha\beta_{ij}$ is the differential (fixed) effect associated with the interaction of levels of sex and grade, and

ε_{ijk} is a random variable characterized as being normally and independently distributed with a mean equal to zero and a variance equal to σ^2.

The two-way analysis of variance layout for this study is shown in Table 3.

Table 3

Two-Way Anova Layout

Source of Variation	df	SS	MS	Computed F
Sex	c-1	A	A/c-1	MS_S/MS_E
Grade	r-1	B	B/r-1	MS_G/MS_E
Interaction	(c-1)(r-1)	C	C/(c-1)(r-1)	MS /MS_E
Error	n-rc	D	D/n-rc	
Total	n-1	E	E/n-1	

An F-ratio was computed for ascertaining significant differences at the .05 level of significance. Tukey's Test was used to determine individual mean differences for grade levels when the F test showed significance. Thus, the alternate hypotheses for the grade variable consisted of the following:

$$\mu_1 > \mu_2$$
$$\mu_1 > \mu_3$$
$$\mu_2 > \mu_3$$

Statistical Analysis for Physical and Biological Science Achievements

The statistical hypotheses to determine the differences in physical and biological science achievement between boys and girls at each grade level in grades 7, 8, and 9 in the Kasetsart Demonstration School were tested using one-way analysis of variance.

The null hypotheses for determining the differences in physical and biological science achievement between boys and girls were as follows:

1. There is no significant difference in physical science achievement between boys and girls in grade 7.

$$\mu_1 = \mu_2$$

2. There is no significant difference in physical science achievement between boys and girls in grade 8.

$$\mu_1 = \mu_2$$

3. There is no significant difference in physical science achievement between boys and girls in grade 9.

$$\mu_1 = \mu_2$$

4. There is no significant difference in biological science achievement between boys and girls in grade 7.

$$\mu_1 = \mu_2$$

5. There is no significant difference in biological science achievement between boys and girls in grade 9.

$$\mu_1 = \mu_2$$

The mathematical model which was appropriate for testing of hypotheses for the one-way fixed model is shown below: (Courtney, 1983)

$$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$$

where,

μ is a fixed but unknown constant,

α_i is a differential (fixed) effect associated with groups, and

ε_{ij} is a random variable characterized as being normally and independently distributed with a mean of zero and a variance of σ^2.

Table 4 shows the one-way analysis of variance layout for determining the difference in (1) physical and biological science achievement between boys and girls in grade 7, (2) physical science achievement between boys and girls in grade 8, and (3) physical and biological science achievement between boys and girls in grade 9.

Table 4

One-Way Anova Layout

Source of variation	df	SS	MS	F
Between groups	k-1	A	A/k-1	MS_B/MS_E
Within groups	n-k	B	B/n-k	
Total	n-1	C		

Thus, the F-ratio was computed and the .05 level of significance was used to determine the differences in achievements in physical and biological science between boys and girls for the one-way Anova layout in Table 4.

CHAPTER IV

RESULTS OF THE STUDY

The purposes of this study were to develop a valid and reliable attitudes toward science instrument by selecting, modifying and translating items from existing instruments into the Thai language and to determine the differences in the attitudes toward and achievement in physical and biological science of Thai boys and girls at the lower secondary education level.

The results of the study are reported in two parts, attitudes toward science and science achievement. The attitudes toward science part contains (1) the reliability of the Attitudes Toward Science Test and (2) the differences in attitudes toward science between boys and girls at the lower secondary education level. The science achievement part consists of (1) the differences in physical science achievement between boys and girls in grades 7, 8, and 9 and (2) the differences in biological science achievement between boys and girls in grade 7 and grade 9.

Attitudes Toward Science

The Attitudes Toward Science Test was given to 693 students at the Kasetsart Demonstration School. Of the 693 respondents' tests, 685 papers were scored for purposes of

determining the reliability coefficient and the differences in attitudes toward science. The remaining eight papers were incomplete and were not used.

Reliability of the Attitudes Toward Science Test

The reliability of the Attitudes Toward Science Test was determined by using the method described by Hoyt and Stunkard (1952). This method provides a straight-forward solution to the problem of estimating the reliability coefficient under the condition that the item scores are not restricted to 1 or 0. The results of computing the reliability coefficient of the Attitudes Toward Science Test are shown in Table 5.

Table 5

Reliability Coefficient of the Attitudes Toward Science Test

Source of Variation	df	Sum of Square	Mean Square	r_{tt}
Among items	37	1831.92317	49.51144	
Among individual	684	4732.91879	6.91947	0.95
Residual	25308	8772.07683	0.34661	
Total	26029	15336.91879		

Table 5 reports that the reliability coefficient of the Attitudes Toward Science Test used in this study was

0.95, indicating a high degree of reliability. Thus, the result of measuring 38 attitude toward science items from 685 respondents indicated that a very dependable relationship existed for the responders, verifying a highly consistent pattern of reliability.

Differences in Attitudes Toward Science

The means and standard deviations of attitude toward science scores between all boys and girls at the lower secondary education level (grades 7, 8, and 9) are presented in Table 6.

Table 6

Means and Standard Deviations of Attitude Toward Science Scores by Sex at the Lower Secondary Education Level

Sex	Mean	Standard Deviation
Boys	3.0046	0.4278
Girls	2.9294	0.4228

Table 6 reports that the mean score of attitude toward science for the boys at the lower secondary education level was 3.0046, and the mean score of the girls was 2.9294.

The means and standard deviations among grade level at the lower secondary education level are presented in Table 7.

Table 7

Means and Standard Deviations of
Attitude Toward Science Scores by Grade Level

Grade	Mean	Standard Deviation
7	2.9267	0.4765
8	2.9889	0.3948
9	2.9885	0.4070

Table 7 reports that the mean scores in attitude toward science of students in grades 7, 8, and 9 were 2.9267, 2.9889, and 2.9885 respectively.

The obtained means and standard deviations of attitude toward science scores of the students for boys and girls in grades 7, 8, and 9 are presented in Table 8.

Table 8

Means and Standard Deviations of
Attitude Toward Science Scores by Sex and Grade Level

Grade	Sex	Mean	Standard Deviation
7	Boys	2.9009	0.4891
7	Girls	2.9580	0.4612
8	Boys	3.0106	0.3583
8	Girls	2.9648	0.4323
9	Boys	3.0990	0.4063
9	Girls	2.8742	0.3765

It can be observed in Table 8 that the mean scores ranged from 2.87 to 3.10, indicating a positive attitude toward science for boys and girls in all grade levels.

The statistical hypotheses to determine the differences in attitude toward science between boys and girls at the lower secondary education level at the Kasetsart Demonstration School were tested using two-way analysis of variance. In situations where the P value was larger than 0.05, the null hypothesis was accepted. Where the P value was found to be smaller than 0.05, the null hypothesis was rejected.

The null hypotheses for determining the differences in attitude toward science between boys and girls at the lower secondary education level were as follows:

1. There is no significant sex effect;
2. There is no significant grade level effect; and
3. There is no significant interaction effect.

The results of the hypotheses testing are presented in Table 9.

Table 9

Two-Way Analysis of Variance for Differences in Attitudes Toward Science

Source of Variation	df	Sum of Squares	Mean Squares	F	P value
Sex	1	0.863	0.863	4.854	0.028*
Grade	2	0.490	0.245	1.379	0.253
Interaction	2	2.342	1.171	6.588	0.001**
Error	679	120.688	0.178		
Total	684	124.608	0.182		

* significant at .05 level.
** significant at .01 level.

Table 9 shows that the results of two-way analysis of variance were as follows:

1. The analysis of variance for sex yielded an F ratio of 4.854 and a P value of 0.028. Since the P value is smaller than the specified level of significance ($\alpha = .05$), the null hypothesis was rejected. Thus, significant differences were found at the 0.05 level in attitudes toward science between boys and girls for the two groups. Table 6 shows that the mean score for boys was 3.0046, and the mean score for girls was 2.9294.

2. The analysis of variance by grade level yielded an F ratio of 1.379 with the P value of 0.253. Since the P value is larger than the specified level of significance

(α = .05), the null hypothesis was retained. Hence, no significant differences in attitudes toward science were found to exist for grade level. The means for grades 7, 8, and 9 were 2.9267, 2.9889, and 2.9885 respectively (Table 7).

3. The interaction between sex and grade level yielded an F ratio of 6.588 with the P value of 0.001. Since the P value is less than the specified level of significance (α = .05), the null hypothesis was rejected. Thus, there was a significant interaction between sex and grade level. The presence of an interaction effect translates that the effect of the sex factor on students' attitudes toward science was dependent upon the grade level factor. The separate main effects of sex and grade level had little educational or psychological significance on their own. The graph of the interaction between sex and grade level factors is shown in Figure 2.

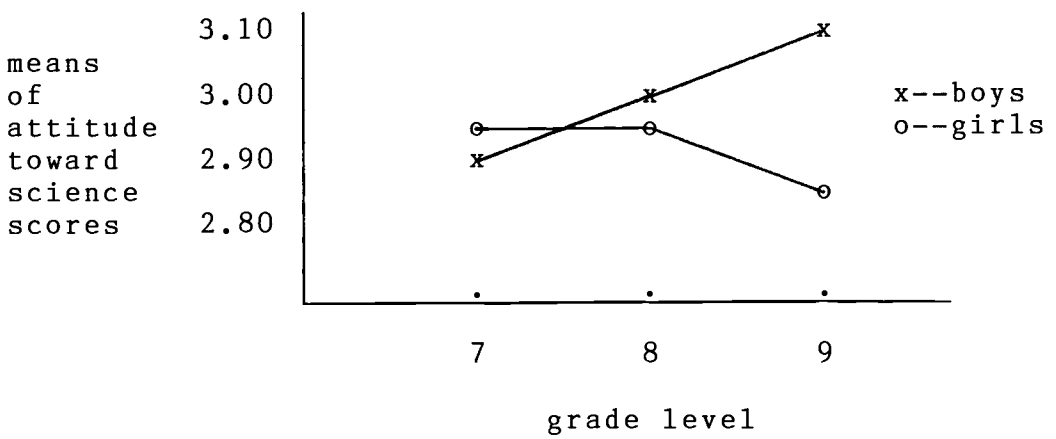

Figure 2. Plotting of the Interaction Between Sex and Grade Level Factors.

The interaction shown in Figure 2 revealed that between grades 7 and 8 it was of the disordinal type, and between grades 8 and 9 it was of the ordinal type. The disordinal interaction between grades 7 and 8 showed that the attitudes toward science of the boys is lower than the girls in grade 7 and higher than the girls in grade 8 (Table 8). The ordinal interaction between grades 8 and 9 showed that the attitudes toward science of the boys is higher than the girls in both grades (Table 8).

Achievement in Science

The student scores on the science achievement tests were obtained from the administration of the Kasetsart Demonstration School. There were 223, 232, and 254 students' test scores for grades 7, 8, and 9 respectively.

The statistical hypotheses to determine the differences in physical and biological science achievements between boys and girls at each grade level in grades 7, 8, and 9 were tested using one-way analysis of variance. In situations where the P value was larger than 0.05, the null hypothesis was retained. When the P value was found to be smaller than 0.05, the null hypothesis was rejected.

The null hypothesis for determining the differences between boys and girls in physical and biological science achievements at each grade level in grades 7, 8, and 9 was as follows:

$$\mu_1 = \mu_2$$

where,

μ_1 represented the population mean for boys, and

μ_2 represented the population mean for girls.

Physical Science Achievement in Grade 7

The means, standard deviations, standard errors, and ranges of the physical science scores of the boys and girls in grade 7 are presented in Table 10.

Table 10

Means, Standard Deviations, Standard Errors, and Ranges of Physical Science Scores of Boys and Girls, Grade 7

Group	N	Mean	Standard Deviation	Standard Error	Score Ranges Min	Max
Boys	122	40.8197	9.7802	0.8855	15	63
Girls	101	41.9109	9.0809	0.9036	25	66

Table 10 shows that the mean score of the boys for physical science achievement in grade 7 was 40.8197, while the mean score of the girls was 41.9109. Boys' scores ranged from 15 to 63. Girls' scores ranged from 25 to 66.

The results of the analysis of variance for physical science achievement in grade 7 are presented in Table 11.

Table 11

Differences in Physical Science Achievement Between Boys and Girls, Grade 7

Source of Variation	df	Sum of Squares	Mean Squares	F	P value
Between Groups	1	65.7961	65.7961	0.734	0.3926
Within Groups	221	19820.2308	89.6843		
Total	222	19886.0269			

The analysis of variance yielded an F ratio of 0.734 with the P value of 0.3976. Since the P value was larger than the specified level of significance ($\alpha = .05$), the null hypothesis was retained. There was no significant difference at the 5 percent level for physical science achievement between boys and girls in grade 7.

Physical Science Achievement in Grade 8

The means, standard deviations, standard errors, and ranges of the physical science scores of the boys and girls in grade 8 are presented in Table 12.

Table 12

Means, Standard Deviations, Standard Errors, and Ranges of Physical Science Scores of Boys and Girls, Grade 8

Group	N	Mean	Standard Deviation	Standard Error	Score Ranges Min	Max
Boys	123	57.6504	11.4190	1.028	20	80
Girls	109	57.0917	11.3778	1.092	29	77

It can be seen in Table 12 that the mean score of the boys for physical science achievement in grade 8 was 57.6504, while the mean score of the girls was 57.0917. Boys' scores ranged from 20 to 80; girls' scores ranged from 29 to 77.

The results of the analysis of variance for physical science achievement in grade 8 are presented in Table 13.

Table 13

Differences in Physical Science Achievement Between Boys and Girls, Grade 8

Source of Variation	df	Sum of Squares	Mean Squares	F	P value
Between Groups	1	18.0362	141.4497	0.140	0.710
Within Groups	230	29889.0500	124.6220		
Total	231	29907.0862			

Table 13 reports an F ratio of 0.140 with the P value of 0.710. Since the P value was larger than the specified level of significance ($\alpha = .05$), the null hypothesis was retained. No significant difference was found at the 5 percent level in the physical science achievement between boys and girls in grade 8.

Physical Science Achievement in Grade 9

The means, standard deviations, standard errors, and ranges of the physical science scores of the boys and girls in grade 9 are shown in Table 14.

Table 14

Means, Standard Deviations, Standard Errors, and Ranges of Physical Science Scores of Boys and Girls, Grade 9

Group	N	Mean	Standard Deviation	Standard Error	Score Ranges Min	Max
Boys	129	42.0310	12.0591	1.0617	11	81
Girls	125	38.4240	11.8908	1.0635	14	70

Table 14 shows that the mean score of the boys for physical science achievement in grade 9 was 42.0310, while the mean score of the girls was 38.4240. Boys' scores ranged from 11 to 81; girls' scores ranged from 14 to 70.

The results of the analysis of variance for physical science achievement for boys and girls in grade 9 are presented in Table 15.

Table 15

Differences in Physical Science Achievement Between Boys and Girls, Grade 9

Source of Variation	df	Sum of Squares	Mean Squares	F	P value
Between Groups	1	825.9622	825.9622	5.758	0.0171*
Within Groups	252	36146.4040	143.4381		
Total	253	36972.3662			

* Significant at .05 level.

The analysis of variance yielded an F ratio of 5.758 with the P value of 0.0171. Since the P value was smaller than the specified level of significance ($\alpha = .05$), the null hypothesis was rejected. There was a significant difference at the 5 percent level in the physical science achievement between boys and girls in grade 9. Boys had a greater mean (42.0310) than the girls (38.4240), indicating that they scored significantly higher in physical science achievement as a group than did the girls.

Biological Science Achievement in Grade 7

The means, standard deviations, standard errors, and ranges of the biological science scores of the boys and girls in grade 7 are presented in Table 16.

Table 16

Means, Standard Deviations, Standard Errors, and Ranges of Biological Science Scores of Boys and Girls, Grade 7

Group	N	Mean	Standard Deviation	Standard Error	Score Ranges Min	Max
Boys	122	23.8852	4.5020	0.4076	5	30
Girls	101	25.1782	3.1667	0.3151	14	30

Table 16 shows that the mean score of the boys for biological science achievement in grade 7 was 23.8852, while the mean score of the girls was 25.1782. Boys' scores ranged from 5 to 30. Girls' scores ranged from 14 to 30.

The results of the analysis of variance for biological science achievement in grade 7 are shown in Table 17.

Table 17

Differences in Biological Science Achievement Between Boys and Girls, Grade 7

Source of Variation	df	Sum of Squares	Mean Squares	F	P value
Between Groups	1	92.3750	92.3750	5.908	0.0159*
Within Groups	221	3455.1855	15.6343		
Total	222	3547.5605			

* Significant at .05 level.

Table 17 shows an F ratio of 5.908 with the P value of 0.0159. Since the P value was smaller than the specified level of significance ($\alpha = .05$), the null hypothesis was rejected. There was a significant difference at the 5 percent level for biological science achievement between boys and girls in grade 7. Girls had a greater mean (25.1782) than the boys (23.8852), indicating that they scored significantly higher in biological science achievement as a group than did boys.

Biological Science Achievement in Grade 9

The means, standard deviations, standard errors, and ranges of the biological science scores of the boys and girls in grade 9 are reported in Table 18.

Table 18

Means, Standard Deviations, Standard Errors, and Ranges of Biological Science Scores of Boys and Girls, Grade 9

Group	N	Mean	Standard Deviation	Standard Error	Score Ranges Min	Max
Boys	129	18.7132	4.9705	0.4376	0	27
Girls	125	17.8960	5.0559	0.4522	5	28

Table 18 shows that the mean score of the boys for biological science achievement in grade 9 was 18.7132, while the mean score of the girls was 17.8960. Boys' scores ranged from 0 to 27; girls' scores ranged from 5 to 28.

The results of the analysis of variance for biological science achievement for boys and girls in grade 9 are shown in Table 19.

Table 19

Differences in Biological Science Achievement Between Boys and Girls, Grade 9

Source of Variation	df	Sum of Squares	Mean Squares	F	P value
Between Groups	1	42.3935	42.3935	1.687	0.1952
Within Groups	252	6332.0356	25.1271		
Total	253	6374.4291			

The analysis of variance yielded an F ratio of 1.687 with the P value of 0.1952. Since the P value was larger than the specified level of significance ($\alpha = .05$), the null hypothesis was retained. There was no significant difference at the 5 percent level in the biological science achievement between boys and girls in grade 9. Table 18 shows that the mean scores for boys and girls in grade 9 were 18.7132 and 17.8960 respectively.

In conclusion, the results revealed the following:

1. The reliability coefficient of the Attitudes Toward Science Test was 0.95.

2. There were significant differences in attitudes toward science between boys and girls with boys having more positive attitudes toward science.

3. No significant differences in attitudes toward science were found among grade levels.

4. A significant interaction effect on attitudes toward science was found between sex and grade levels.

5. No significant differences in physical science achievement between boys and girls were found in grades 7 and 8, but there was a significant difference in grade 9, with boys scoring significantly higher.

6. A significant difference in biological science achievement between boys and girls was found in grade 7 with girls scoring significantly higher, but no significant difference was found in grade 9.

CHAPTER V

SUMMARY AND CONCLUSIONS

In Thailand, few valid and reliable instruments are available for assessing student attitudes toward science. The task of constructing a suitable instrument to measure attitudes toward science for Thai students at the lower secondary education level was a major part of this project. With increasing evidence that there are differences in physical and biological science achievement between boys and girls, science achievement test results were considered. Differences in these science areas between boys and girls were also reported. In addition, attitudes toward science may be a predictor of participation in upper secondary science courses. Therefore, the trends in attitudes toward science by sex and grade level were considered.

This chapter presents the following: (1) a summary of the study, which includes the statement of the problem, procedures, and results, (2) conclusions, (3) discussion of the results, and (4) suggestions for further study.

Restatement of the Problem

The purposes of this study were to develop a valid and reliable attitudes toward science instrument by selecting, modifying and translating items from existing instruments

into the Thai language and determine the differences in the attitudes toward and achievement in physical and biological science of Thai boys and girls at the lower secondary education level.

Specifically, the following null hypotheses were investigated:

1. There is no sex level effect in attitudes toward science.

2. There is no grade level effect in attitudes toward science.

3. There is no interaction effect between sex and grade level in attitudes toward science.

4. There is no significant difference in physical science achievement between boys and girls in grades 7, 8, and 9 respectively.

5. There is no significant difference in biological science achievement between boys and girls in grades 7, 8, and 9 respectively.

Research Procedures

The Population

The population for this study consisted of 709 students, 374 boys and 335 girls, at the lower secondary education level (grades 7, 8, and 9) in the Kasetsart Demonstration School, Bangkok, Thailand. The range of ages of the subjects was from 13 to 15 years.

The Dependent Variables

The dependent variables in this study were student scores of (1) attitude toward science, (2) achievement in physical science, and (3) achievement in biological science. The variables were measured by administering two tests. One test was a device to measure students' attitude toward science, and the other was a science achievement test for the grade level of the participant. The test for attitudes toward science was developed at Kasetsart University. Each student was given the same form of the instrument. The tests for achievement in science were supplied by the Kasetsart Demonstration School and were designed to summatively evaluate students' progress at the end of their current term of study. Each student in the study was given the achievement test for his or her current grade level.

Developing the Attitudes Toward Science Test

Four instruments were used to form the item pool for the Attitudes Toward Science Test; including the Wareing Attitudes Toward Science Protocol (Wareing, 1982), Science Opinionnaire (Fisher, 1973), Attitudes Toward Science And Scientists (Cummings, 1969), and Attitudes Toward Science And Scientific Careers (Allen, 1959). The items were translated into the Thai language and were modified to make

the items understandable to lower secondary students in Thailand.

The Attitudes Toward Science instrument was in the form of a Likert-type scale. Content validity was established by a panel of eight science educators in Thailand using the DELPHI technique. Four (4), sixth grade students were selected to assess the readability of the scale. A field test was conducted using students from the Chulalongkorn Demonstration School. The reliability coefficient was determined through the use of the Hoyt and Stunkard method.

Analysis of Data

Two-way analysis of variance was employed to determine the differences in attitudes toward science between boys and girls at the lower secondary level. The statistical hypotheses to determine the differences in physical and biological science achievement between boys and girls at each grade level (grades 7, 8, and 9) were tested using one-way analysis of variance. The 0.05 level of significance was utilized in testing the study's hypotheses.

Results of the Study

The results of the study were as follows:

1. The reliability coefficient of the Attitudes Toward Science Test was 0.95.

2. There were significant differences at the 0.05 level in attitudes toward science between boys and girls for the two groups. Boys had more positive attitudes toward science than girls.

3. No significant differences in attitudes toward science were found to exist for grade level (grades 7, 8, and 9).

4. A significant interaction effect on attitudes toward science was found between sex and grade level.

5. No significant differences in physical science achievement between boys and girls were found in grades 7 and 8, but there was a significant difference in grade 9 with boys scoring significantly higher than girls.

6. A significant difference in biological science achievement between boys and girls was found in grade 7 with girls scoring significantly higher than boys, but no significant difference was found in grade 9.

Conclusions

The results of the analyses point to several conclusions which can be made concerning attitudes toward science and achievement in physical and biological sciences

of the lower secondary education students (grades 7, 8, and 9) at the Kasetsart Demonstration School.

1. The Attitudes Toward Science Test developed in this study was verified as a reliable and valid instrument for measuring attitude toward science at lower secondary education level in the Kasetsart Demonstration School.

2. Students in all grades at the lower secondary education level in the Kasetsart Demonstration School demonstrated positive attitudes toward science.

3. Overall, boys had more positive attitudes toward science than girls.

4. There was no significant difference in attitudes toward science among grade levels (grades 7, 8, and 9).

5. Since significant interaction was found between levels of sex and grade, it can be concluded that to determine whether boys or girls at the secondary education level in the Kasetsart Demonstration School had better attitudes toward science grade level must be considered.

6. Girls' attitudes declined between grades 8 and 9, while boys attitudes became more positive from grade 7 to grade 9. Thus, it can be concluded that girls' attitudes toward science declined when grade level increased while the boys' attitudes improved as grade level increased.

7. The physical science achievement data showed that boys performed as well as or better than girls in grades 7 and 8, but the difference was significant only for the

students in grade 9. In grade 9, boys performed better than girls. Thus, it can be concluded that the differential in achievement between boys and girls in physical science increased with grade level.

8. The biological science achievement data showed that girls performed significantly better than boys in grade 7; however, in grade 9 the difference was not significant. Based on these data, it can be concluded that the differential in achievement between boys and girls in biological science decreased when grade level increased.

9. The lowest scores on each of the physical and biological sciences achievement test at all grade levels were performed by boys.

Discussion of the Findings

This study was intended to (1) develop a valid and reliable attitudes toward science instrument and (2) to determine the differences in attitudes toward and achievement in science between boys and girls.

Gardner (1975) discussed five steps in constructing a valid and reliable attitude instrument: (1) definition of the attitudes, (2) construction of the scale, (3) trial test, (4) appropriate use, and (5) appropriate choice of research design and statistical analysis. The Attitudes Toward Science Test, a four-point Likert type scale developed in this study, was constructed using the steps

Gardner stated. The content validity was validated through the DELPHI panel, and the reliability coefficient of the test was calculated to be 0.95. The field test was used to test the applicability and to see if there were any weaknesses in the test items. Thus, the Attitudes Toward Science Test developed in this study was verified as a valid and reliable instrument for use in measuring attitudes towards science of students at the lower secondary education level at the Kasetsart Demonstration School.

The findings indicated that boys had better attitudes toward science than girls. Girls' attitudes declined when grade level increased and boys performed better than girls in physical science, and as well as girls in biological science. These results are consistent with the findings of NAEP (1979), and Haladyna and Thomas (1977). Sex differences in attitudes toward science found in this study supported the findings of Steinkamp (1982), Anderson (1983), and Baker (1983). Further, sex differences in physical and biological sciences in this study were found to support the findings by the British Columbia Department of Education,(1982), and Erickson and Erickson (1984).

The science content in grade 8 is entirely devoted to physical science during the second semester. In grade 7 and grade 9 both physical and biological sciences are in the curriculum. The data concerning attitudes toward

science and science achievement in this study were collected during the second semester. A possible explanation for the findings that boys' attitudes, though poorer than girls' in grade 7, surpassed girls' attitudes in grades 8 and 9 is that the grade 8 physical science experience was better received by boys than girls. The factor of physical science only in grade 8, together with the social belief that physical science is a masculine area of study, may account for boys' achievement in physical science surpassing girls' in grade 8 and becoming significantly higher in grade 9. The changes in attitudes toward science and in physical science achievement followed the same pattern during the grades 7 to 9. Therefore, it is possible that there is a positive correlation between attitudes toward science and physical science achievement.

There may be several other reasons for these differences in reaction to the physical and biological sciences. Koelsche and Newberry (1965) noted that girls prefer subjects involving "living matter," whereas boys are more interested in "nonliving matter." Lowery (1967) has noted that middle-grade boys identify science with "destruction," whereas girls at the same level relate science to the medical profession. Vockell and Lobonc (1981) studied sex role stereotyping by high school females in science and found that both boys and girls viewed the biological sciences as less masculine than the physical

sciences, and girls in coed high schools rated physical sciences as more masculine than did girls in noncoed schools. Finally since males are, by tradition, dominant in the physical science fields, it is quite likely that a female who becomes interested in these sciences would be perceived as deviating from the social norm. Such a perception would be less likely in the biological sciences, since more females have careers in this area.

Erickson and Erickson (1984) reported, the explanations on nature and pattern of sex-related differences in science achievement, that there are two kinds of explanations or interpretations that have been given to account for sex-related differences.

> The first, the biological interpretation, suggests that inherent factors can account for female deficiencies in science performance and thus argues that females' intellectual capacity for science is not equal to that of males. The second, the sociological interpretation, accounts for sex-related differences in terms of social and cultural factors and thus would suggest that female intellectual capacity is, or at least could be (given appropriate social conditions), equivalent to that of males.

National Assessments's survey of attitudes provided the evidences that females perform better than males on attitudinal exercises at ages 9, 13 and 17; however, by young adulthood this pattern abruptly switches and males perform better than females (Herman, 1975). This supports

the interaction between sex and grade level found in this study.

It is interesting to note that the lowest scores on each of the physical and biological science achievement tests at all grade levels were performed by boys. This points to the differences in science achievement within the same sex in boys is larger than in girls. No explanation is available for this phenomenon.

Suggestions for Further Study

The conclusion that girls' attitudes toward science declined when grade level increased and that boys perform better in physical science than girls, implies the following recommendations for implementation in the curriculum:

1. It is especially important to promote girls' physical science achievement and attitudes toward science during lower secondary school, as students are making decisions at that time as to whether or not to choose upper secondary school science programs. If girls' attitudes toward science and achievement in physical science are low in the ninth grade, the opportunity of increasing the number of girls in upper secondary school science programs, or of increasing the number of girls seeking science related careers, will be diminished.

2. The science curriculum should be investigated with a focus on content and methods to enhance attitudes toward science and to make physical science less stressful and more understandable and desirable for girls.

The following issues are suggested for further study.

1. The present study demonstrated that boys had better attitudes toward science than girls in lower secondary education level at the Kasetsart Demonstration School. More research is needed to determine if the same is true of students at other Thai elementary and upper secondary education levels.

2. Sex differences in physical and biological science achievement were found in this study. A study should be designed to measure attitudinal differences toward physical science and biological science for males and females.

3. Since physical science achievement was shown to be greater for boys than girls in grade 9, there is an apparent need to examine whether or not this difference continues to be exhibited at the upper secondary education level.

4. This study should be repeated at regular intervals to monitor trends in the attitudes and achievement of students. Studies should be conducted with other demonstration schools and/or public schools in Thailand to determine differences in attitudes toward and achievement in science by sex and grade levels.

5. Research should be carried out to identify other factors that clearly exist which affect attitudes toward and/or achievement in science such as age, ability group, intelligence, and spatial ability.

6. A research study should be done to determine sex-related differences in attitudes toward and achievement in science at the elementary or upper secondary education levels.

7. Because of the difficulty in finding a suitable instrument to measure attitudes toward science in students from kindergarten through college, research should be performed to develop and refine instruments for such a purpose.

8. Research should also be repeated with the Attitudes Toward Science Test developed for this study to reexamine the reliability of the instrument.

9. A study should be done to examine the relationship which seems to exist between attitudes toward and achievement in physical science of female students.

10. A study should be done to investigate factors which might explain the larger variation in scores by male students.

11. It was found in this study that the lowest score on each of the physical and biological sciences achievement test at all grade levels were performed by boys making the range of sciences' scores in boys greater than in girls.

Additional research study should be conducted to examine this phenomenon in terms of the difference in science achievement within the same sex.

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APPENDIX A

THAI LANGUAGE ADVISORS

THAI LANGUAGE ADVISORS

Assoc Prof. Achara Chewapun	Faculty of Education Chulalongkorn University
Miss Charee Jitnuson	Faculty of Education Kasetsart University
Miss Somchit Watanakulang	Faculty of Education Kasetsart University

APPENDIX B

DELPHI PANEL MEMBERS

DELPHI PANEL MEMBERS

Chulalongkorn University

1. Dr. Wijit Senghaphan

Institute for the Promotion of Science and Technology (IPST)

1. Dr. Pisarn Soidurum
2. Dr. Pusadee Tamthai
3. Dr. Thongchai Chewpreecha

Kasetsart University

1. Dr. Boonriang Kajornsilp
2. Dr. Prateep Siamchai
3. Dr. Yongyut Chiamchaisri
4. Dr. Yupa Viravaidhaya

APPENDIX C

THAI VERSION OF

THE ATTITUDES TOWARD SCIENCE TEST

☆ เพศ_____ อายุ_____ ชั้น_____

☆ ขอให้นักเรียนตอบข้อความในแต่ละข้อ ซึ่งถามถึงความรู้สึกของนักเรียนที่มีต่อวิทยาศาสตร์

☆ ขอให้นักเรียนเขียนกากบาท X ลงในช่อง ◯ ให้ข้อความซึ่งแสดงความรู้สึกจริงของนักเรียน

☆ คำว่า " วิทยาศาสตร์ " ในที่นี้รวมทั้งวิทยาศาสตร์บริสุทธิ์ คือ เคมี ชีววิทยา ฟิสิกส์ ฯลฯ และวิทยาศาสตร์ประยุกต์ คือ การแพทย์ การเกษตร อุตสาหกรรม วิศวกรรม ป่าไม้ ประมง ฯลฯ

๑. เมื่ออยู่นอกชั่วโมงเรียนวิทยาศาสตร์ ข้าพเจ้ามักจะคิดคำนึงถึงเรื่องต่างๆที่ได้เรียนในวิชาวิทยาศาสตร์

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๒. ข้าพเจ้ากระตือรือร้นที่จะเรียนรู้เกี่ยวกับวิทยาศาสตร์ให้มากขึ้น

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๓. สิ่งที่ข้าพเจ้าเรียนรู้จากวิชาวิทยาศาสตร์เป็นประโยชน์แม้เมื่อจบจากโรงเรียนไปแล้ว

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๔. ข้าพเจ้าไม่เคยคิดอยากเรียนรู้วิทยาศาสตร์เพิ่มเติมจากที่เรียนในชั้นเรียน

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๕. วิทยาศาสตร์เป็นเรื่องที่น่าเบื่อ

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๖. ข้าพเจ้าชอบกิจกรรมวิทยาศาสตร์มาก

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๗. วิชาวิทยาศาสตร์ช่วยให้ข้าพเจ้าคิดได้กระจ่างขึ้นกว่าวิชาอื่น ๆ

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๘. วิทยาศาสตร์ช่วยให้เราเข้าใจสิ่งที่อยู่รอบตัวเรา

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๙. วิทยาศาสตร์กระตุ้นให้มีความอยากรู้อยากเห็น

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๑๐. ถ้าเลือกเรียนได้ตามใจชอบข้าพเจ้าจะไม่เลือกเรียนในแผนการเรียนวิทยาศาสตร์ในระดับมัธยมปลาย

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๑๑. การเรียนวิทยาศาสตร์ในโรงเรียนควรลดเวลาเรียนให้น้อยลง

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๑๒. ข้าพเจ้าชอบทำโครงงานวิทยาศาสตร์

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๑๓. วิทยาศาสตร์เป็นเรื่องที่น่าสนใจ

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๑๔. ข้าพเจ้าชอบอ่านเรื่องราวเกี่ยวกับวิทยาศาสตร์

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๑๕. สิ่งที่ได้เรียนในชั่วโมงวิทยาศาสตร์เป็นเรื่องไร้ประโยชน์

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๑๖. การเรียนวิทยาศาสตร์ช่วยให้ข้าพเจ้าให้เหตุผลชัดแจ้งยิ่งขึ้นในเรื่องต่าง ๆ

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๑๗. การเรียนวิทยาศาสตร์ช่วยให้คนเราตัดสินใจในเรื่องต่าง ๆ ได้อย่างมีเหตุมีผล

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๑๘. ชั่วโมงวิทยาศาสตร์มีบรรยากาศที่ทำให้ข้าพเจ้ารู้สึกอยากรู้อยากเห็น

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๑๙. วิทยาศาสตร์เป็นสิ่งจำเป็นในสังคมปัจจุบัน

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๒๐. ในชั่วโมงปฏิบัติการข้าพเจ้าชอบทำการทดลองเพื่อศึกษาปัญหาและผลที่เกิดขึ้น

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๒๑. การทดลองในชั่วโมงวิทยาศาสตร์ทำให้เข้าใจได้ดียิ่งขึ้น

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๒๒. ชั่วโมงวิทยาศาสตร์เป็นชั่วโมงเรียนที่น่าสนใจ

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๒๓. ถ้าเป็นไปได้ น่าจะมีการเรียนการสอนวิชาวิทยาศาสตร์ในโรงเรียนให้น้อยลง

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๒๔. ให้ข้าพเจ้าทำอะไรอย่างอื่นดีกว่าให้ทำอะไรที่เกี่ยวกับวิทยาศาสตร์

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๒๕. ชั่วโมงวิทยาศาสตร์เป็นชั่วโมงเรียนที่น่าเบื่อ

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๒๖. ชั่วโมงวิทยาศาสตร์เป็นชั่วโมงเรียนที่น่าอึดอัด

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๒๗. วิทยาศาสตร์ให้ประโยชน์ต่อคนทั่วไปน้อย

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๒๘. ความเข้าใจในวิทยาศาสตร์เป็นสิ่งที่เป็นประโยชน์สำหรับข้าพเจ้า

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๒๙. ข้าพเจ้าสนใจหาความรู้รอบตัวทางวิทยาศาสตร์

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๓๐. งานวิทยาศาสตร์เป็นงานที่น่าเบื่อ

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๓๑. การเรียนวิทยาศาสตร์ให้ประโยชน์ด้านสังคมแก่คนเรา

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๓๒. รัฐบาลควรให้ความสำคัญต่อนักวิทยาศาสตร์ที่มีความสามารถสูง

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๓๓. ชั่วโมงวิทยาศาสตร์เป็นชั่วโมงเรียนที่น่าตื่นเต้น

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๓๔. วิทยาศาสตร์และสิ่งประดิษฐ์ทางวิทยาศาสตร์มีโทษมากกว่าคุณ

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๓๕. ชั่วโมงวิทยาศาสตร์เป็นชั่วโมงที่เรียนสนุก

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๓๖. โรงเรียนให้ความสำคัญมากเกินไปกับการเรียนวิทยาศาสตร์

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๓๗. สิ่งที่ข้าพเจ้าได้เรียนจากวิชาวิทยาศาสตร์นั้นเป็นประโยชน์ในชีวิตประจำวัน

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

๓๘. วิชาวิทยาศาสตร์เป็นวิชาที่ข้าพเจ้าอยากเรียน

เห็นด้วยอย่างยิ่ง	เห็นด้วย	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
○	○	○	○

APPENDIX D

ENGLISH TRANSLATION OF
THE ATTITUDES TOWARD SCIENCE TEST

THE ATTITUDES TOWARD SCIENCE TEST

Note

Sometimes it is not possible to translate into English from Thai on a direct word for word basis. The following translation of the items was written to preserve the meaning of the statements.

Each of the 38 items of the Attitudes Toward Science Test was responded to on a four-point Likert type scale. The statements making up the test are as follows:

1. I often think about what I learn in science classes when I am not in school.
2. I am always eager to learn more about science.
3. Things I learn in science classes will be useful to me outside school.
4. I never want to take any more science classes than I have to.
5. Science is a dull subject to me.
6. I enjoy doing science activities.
7. Science, more than other classes helps me think clearly.
8. Science makes me have a better understanding about things around me.
9. Science makes me curious and eager to explore.

10. If I have a choice, I will not choose science classes in high school.
11. There should not be so much time spent on science in school.
12. I like doing science projects.
13. Science is a very interesting subject.
14. I like reading science materials.
15. What I learn in science classes is useless.
16. Learning science helps improve my reasoning ability.
17. Learning science helps improve my problem solving ability.
18. Science class creates an environment that make me feel curious.
19. Science is essential to our society.
20. Science experiments in class are fun and I enjoy finding out the results.
21. Experiments I do in class make me understand the subject matter more clearly.
22. Science classes are interesting.
23. If possible, there should not be so much science in school.
24. I would rather do non-science related things than science related things.
25. Science classes are boring.
26. Science class makes me feel uncomfortable.

27. Science is useless for most people.
28. Understanding science is useful to me.
29. I am interested in learning all the things around me.
30. Doing scientific work is boring.
31. Learning science will enable me to be socially excepted.
32. Government should pay more attention to the importance of gifted scientists in our country.
33. Science classes are exciting.
34. Science and scientific inventions cause more harm than benefit.
35. Science classes are fun.
36. Science is receiving too much attention in schools.
37. What I learn in science classes is useful to me in everyday life.
38. Science is my favorite subject.