0-315-05923-0

PERMISSION TO MICROFILM — AUTORISATION DE MICROFILMER

• Please print or type — Écrire en lettres moulées ou dactylographier

Full Name of Author — Nom complet de l'auteur

ANDRUSKI Gilbert Bryan

Date of Birth — Date de naissance

20/05/55

Country of Birth — Lieu de naissance

Canada

Permanent Address — Résidence fixe

Box 171
Boyle Alberta
T0A 0M0

Title of Thesis — Titre de la thèse

An Examination of the Relationships Between Self-Concept in Science, Scientific Attitude, and Achievement in High School Biology

University — Université

University of Alberta

Degree for which thesis was presented — Grade pour lequel cette thèse fut présentée

Master of Education

Year this degree conferred — Année d'obtention de ce grade

1981

Name of Supervisor — Nom du directeur de thèse

Kenneth G. Jacknicke

Date: June 15, 1981

Signature: Gilbert B. Andruski

THE UNIVERSITY OF ALBERTA

AN EXAMINATION OF THE RELATIONSHIPS BETWEEN SELF-CONCEPT IN SCIENCE, SCIENTIFIC ATTITUDE AND ACHIEVEMENT IN HIGH SCHOOL BIOLOGY

by

 GILBERT BRYAN ANDRUSKI

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF EDUCATION

DEPARTMENT OF SECONDARY EDUCATION

EDMONTON, ALBERTA

FALL 1981

THE UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR ..Gilbert Bryan Andruski..........

TITLE OF THESIS ..An Examination of the Relationships

Between Self-Concept in Science,

Scientifi Attitude, and Achievement

in High School Biology

DEGREE FOR WHICH THESIS WAS PRESENTED ..Master of Education

YEAR THIS DEGREE WAS GRANTED ..1981..........

Permission is hereby granted to THE UNIVERSITY OF ALBERTA LIBRARY to reproduce single copies of this thesis and to lend or sell such copies for private, scholarly or scientific research purposes only.

The author reserves other publication rights, and neither the thesis nor extensive extracts from it may be printed or otherwise reproduced without the author's written permission.

(SIGNED) Gilbert B. Andruski

PERMANENT ADDRESS:

Box 171

Boyle Alberta

T0A 0M0

DATED June 5, 1981

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled An Examination of the Relationships Between Self-Concept in Science, Scientific Attitude and Achievement in High School Biology submitted by Gilbert Bryan Andruski in partial fulfillment of the requirements for the degree of Master of Education.

K. G. Jacknicke
Supervisor

....

....

....

Date June 5/81

ACKNOWLEDGEMENTS

The author expresses sincere gratitude to Dr. Kenneth G. Jacknicke, committee chairman, slave-driver, and friend, for supervision of the project and for the advice and criticisms given during the writing of the manuscript.

Sincere thanks is also expressed to Professor Walter D. Samiroden for his time and patience as an advisory member of the committee.

A special thank-you is given to Dr. Derek Wilson for his service as a member of the committee.

The author would like to thank Dr. Heidi Kass and Dr. Marshall Nay for their helpful suggestions during the study.

Sincere thanks is expressed to the teachers and students of the Edmonton Public School system who participated in the study.

A very special thank-you is extended to my wife to be, Cheryl, for her time, patience and understanding during the study and the completion of the manuscript.

ABSTRACT

The study examines whether or not a significant and positive relationship exists between:

(1) self-concept in science and science achievement

(2) scientific attitude and science achievement

(3) self-concept in science and scientific attitude

The study also examines some of the variables that affected the significantly positive relationships found between the predictor variables and the criterion variables.

The sample consisted of two hundred and twenty-four high school Biology students from grades ten, eleven and twelve, selected from the Edmonton Public School system. Data for the present study were taken from four different test instruments in order to get a measure of the students' self-concept in science, scientific attitude, process achievement, and Biology content achievement. In addition to the test score data, mental ability scores, gender, and grade level were recorded for each student.

In order to test the major hypotheses in the study, a stepwise multiple regression analysis was carried out. From this procédure, a multiple regression equation was developed that was used in the decision to reject or hold tenable the hypotheses. Where it was found that a significant and positive relationship existed between the predictor and criterion under study, partial correlation coefficients were calculated to eliminate the effects of the variables of mental ability, gender, and grade level in order to answer the associated research questions.

Results indicated that self-concept in science was not a good predictor of process achievement or Biology content achievement. Self-concept in science did not correlate well with process achievement or Biology content achievement, and thus did not appear in the regression equation for the prediction of these variables.

Results also indicated that scientific attitude was a good predictor of process achievement, but not of Biology content achievement, as the prediction of Biology content achievement depended heavily on the process achievement variable.

Finally, the results indicated that self-concept could be used to enhance the efficacy of prediction of scientific attitude, but the relationship between these two variables depends heavily on mental ability.

It appears that development of self-concept in science is not a useful intent by itself for classroom teachers wanting to enhance science achievement in their classrooms. Conversely, development of scientific attitude appears to be a useful intent for classroom teachers wishing to enhance process achievement.

TABLE OF CONTENTS

Chapter		Page

Chapter Page

Chapter Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

THE PROBLEM

Introduction

Paradigmatic Conceptions of Research In Education

Different ideas can be brought to a research problem in any social setting including education, depending upon the frame of reference the researcher applies to his task of viewing and interpreting the world. In fact, the literature of research in education provides a large number of methodological and theoretical frames of reference for viewing the world. Many researchers bring to their task the conception of research as being the means to some predetermined end. This conception of research attempts to narrow the gap between what is real and what is ideal utilizing assumptions, techniques and interpretations unique to the ends means or empirical-analytic paradigm. The main thrust of the empirical-analytic paradigm is one of assessing the degree of relatedness between means and ends which, in turn, allows the researcher to enhance certainty in predicting outcomes with greater precision and efficiency.

The empirical-analytic world view not only dominates the literature and research, but also has had evolve from it many sophisticated models for guiding research.

It is recognized, however, that other research paradigms exist that provide alternative frameworks for guiding research (Habermas, 1971). A second world view of research sees its proponents conceiving this endeavor as judging the entire context of a problem. This context would include the writer's perception of people, as well as the situational factors that give a research problem its unique relevance and meaning. The main goal of a researcher utilizing the situational paradigm to view the real world would be to uncover the relevance and meaning that a particular activity has for those involved in that activity.

A third world view used in approaching research can be referred to as the critical-theoretic. From a critical perspective, researchers interpret their task as judging the fundamental, underlying assumptions and implications of a situation. A primary goal of a researcher utilizing this paradigm would be to uncover those fundamental elements necessary for social change that would ultimately lead to the betterment of man (Aoki, 1978).

Each world view allows people to understand different aspects of a research situation. That is to say, the three paradigms mentioned, and undoubtedly there are others, are not necessarily mutually exclusive, but can be complementary. By using different ways of viewing the real world and by answering different kinds of questions, a multi-paradigm approach will provide a much broader picture of the real world.

The present study utilizes the empirical-analytic orientation to research in order to begin to examine if a significant positive relationship exists between self-concept in science and achievement in science, and scientific attitude and achievement in science.

Self-Concept and a Science Classroom

For generations, teachers have sensed the significance of the positive relationship between a student's perception of himself and his performance in school. They intuitively believed that the students who felt good about themselves and their abilities were the ones who were most likely to succeed. Academic success or failure appears to be as deeply rooted in concepts of self as it is in measured mental ability or socio-economic status.

Brookover (1967), for example, concluded from his extensive research on the relationship between self-concept and achievement that the assumption that human ability is the most important factor in achievement is questionable, and that student attitudes limit the degree of achievement in school.

In our dynamic society, the intents of education are constantly being modified as a result of many diverse influences. Factors such as the social context of learning with new views toward curriculum evaluation and student performance, changing roles of the teacher, and technological advances with classroom application have directed many research efforts toward examining the need for affective and humanistic intents in the classroom. One result of the interest in examining humanistic intents has been the increasing emphasis on student self-concept.

Conceptualization of self-concept has been supported by the phenomenology of Combs and Snygg (1959), the client centered framework for human freedom in learning of Rogers (1951), and the writings of Maslow (1954).

These and similarly oriented theorists have had a large impact on education theory by formulating the notion that perception of self is an important factor in determining the scholastic achievement of a student.

From this writer's perspective, it is quite possible for a student to think of himself as handsome, well liked, a good football player, and yet do poorly in science. No single summarizing statement of this student's self-concept is appropriate. To think of this student as having a high or low general self-concept would be to ignore relative characteristics of the student, and at the same time, dehumanize that student by attributing characteristics of a particular label to him. Certain of these self-concepts will be more or less relevant depending on the social situation. If a student is faced with a problem in science class, his self-concept relative to being a good or poor science student is more likely to affect his achievement in science than his self-concept as a good football player. This notion of a composite self-concept is supported by Brookover (1962, 1965, 1967), who found that the specific self-concept of ability in science was a better predictor of grades in science than general self-concept.

Because of the nature of science education, with its "hands-on" approach, it appears to be a fruitful area in which to examine self-concept with respect to decision making in a specific area of study.

Scientific Attitude and a Science Classroom

The literature seems to indicate that many ence educators now agree that affective intents should be given consideration when planning instruction (Bloom, 1971; Nay and Crocker, 1970; Klopfer, 1976). Their consensus focuses on the notion that students should leave their classrooms with an appreciation for scientific methodology and logic, an awareness of technological application, and the ability to make meaningful decisions regarding science and society.

One major intent of science education is to develop positive scientific attitudes in students (Fraser, 1978). That is to say, the intent of the teacher would be to have students develop those attributes of science that are most often exemplified by scientists at their work. Such attributes would include honesty, open-mindedness, suspended judgement, willingness to change opinion, respect for evidence, and questioning attitude, as well as others.

Justification for the importance of scientific attitudes seems to appear in two basic forms. In the first form, it is reasoned that adoption of positive scientific attitudes as a classroom intent by a teacher would give students a better understanding of the nature of scientific processes. This assumes, to some extent, that the student is experiencing the fundamental essence of what the role of the scientist is, and that his decision making is directed by such activities.

Another assumption behind this argument is that scientists in their scientific work exemplify the presence of positive scientific attitudes. Studies by

Cohen (1971), Lawson (1959), and Brown and Brown (1972), indicate that scientists profess a high regard for scientific attitudes, but the degree to which this expressed preference is related to decision making has not been investigated to a great extent for scientists or science students (Mulkay, 1976).

The second reason for the importance of scientific attitudes is that positive scientific attitudes influence students in their everyday lives (Brown, 1976). Blough (1960) argued that under the influence of positive scientific attitudes, problems will be approached and ideas and information will be viewed from one's perspective in order to make sense of a scientific problem. Another implication of this position is that by incorporating scientific attitudes into one's perspective, a student will show more interest in attempting to find answers to problems, more tolerance to other points of view, less tendency to jump to conclusions or accept superstitious beliefs (Kurtz, 1976).

In consideration of the reasons for the importance of scientific attitudes discussed above as a classroom intent, it is not unreasonable to assume that a significant positive relationship may exist between self-concept in science and a positive scientific attitude. The way in which people feel about themselves in a specific subject area may influence the perspectives they hold on the real world and, in turn, influence their willingness and desire to hold a high regard for positive scientific attitudes.

Research examining the existence of any relationship between scientific attitudes and cognitive variables such as science achievement has apparently not been examined very closely, as evidenced by the lack of literature on the subject. It is the purpose of the present study to examine if a relationship exists between self-concept in science and science achievement, as well as any relationship that may exist between scientific attitudes and science achievement.

Statement of the Problem

The purpose of this study is to determine if:

(a) self-concept in science can be used as a predictor of achievement in science on process and content test items.

(b) scientific attitude can be used as a predictor of achievement in science on process and content test items.

(c) self-concept in science can be used as a predictor of scientific attitude.

Research Questions

The present study attempts to focus on the following research questions:

(a) are there any relationships that exist between self-concept in science and process and content achievement, and if so are these relationships affected by mental ability as expressed by an I.Q. score?

(b) are there any relationships that exist between self-concept in science and process and content achievement, and if so are these relationships affected by gender?

(c) are there any relationships that exist between self-concept in science and process and content achievement, and if so are these relationships affected by grade level?

(d) are there any relationships that exist between scientific attitude and process and content achievement and if so are these relationships affected by mental ability as expressed by an I.Q. score?

(e) are there any relationships that may exist between scientific attitude and process and content achievement, and if so are these relationships affected by gender?

(f) are there any relationships that may exist between scientific attitude and process and content achievement, and if so are these relationships affected by grade level?

(g) are there any relationships that may exist between self-concept in science and scientific attitude, and if so are these relationships affected by mental ability as measured by an I.Q. score?

(h) are there any relationships that may exist between self-concept in science and scientific attitude, and if so are these relationships affected by gender?

(i) are there any relationships that may exist between self-concept in science and scientific attitude, and if so are these relationships affected by grade level?

Need for the Study

Educators have expressed concern about the development of students' self-concept in science as a mode of achieving cognitive intents. The writings of Brookover (1963), Purkey (1978), and Vargo (1974) indicate that a strong self-concept in a specific subject area is an essential component for the personal development of a student.

At the same time, educators have expressed concern for the need to develop positive scientific attitudes in students. Nay and Crocker (1970) point out that a student's understanding of the scientific attributes that compose the scientific attitude is important in understanding scientific concepts. Explicit in the writings of Nay and Crocker (1970) and Gauld (1975) is the notion that students displaying positive scientific attitudes will be better able to appreciate the workings of science, which will ultimately lead to a deeper understanding of the content and processes of science.

The impetus for this study arises from the need to determine if a positive relationship exists between self-concept in science and science achievement as well as scientific attitude and science achievement. If it is found that a significant positive relationship exists between self-concept in science and science achievement as well as scientific attitude and science achievement, then teaching strategies for enhancing self-concept in science (Purkey, 1978; Manning, 1972; Inglis, 1976) and teaching strategies for developing positive scientific attitudes (Nay and Crocker, 1970; Klopfer, 1966; Conant, 1957) may be employed by teachers. Support for conducting this study arises from the lack of literature and research on the topic indicating that the problem needs to be examined more closely, and the desire for ways of knowing how to bring to fruition, intents such as increased content and process achievement.

A further justification for this study is that it will attempt to develop a revised version of the Test on Scientific Attitude (Kozlow and Nay, 1976). This revision will be done in order to update the test items, improve upon the test items in terms of wording and to improve the item analysis statistics of the test.

This instrument will be available to those teachers wishing to use the instrument as one way of determining their students' scientific attitude as it is being displayed in a science classroom.

The study is also significant in view of the increasing concern for development of scientific literacy (Page, 1979). If it is assumed that students should be able to read and discuss scientific information found in common literature and to interpret common scientific phenomenon with facility and confidence, then teachers must be able to use existing teaching strategies and research to help them examine fundamental ways of attaining student growth in science.

Definitions of Terms

Self-Concept in Science

A student's self-concept in science refers to the perception the student has of his ability to achieve and function in science and to perform well according to the expectations of his science instructors. The student's self-concept in science will be measured by the Self-Concept in Science Scale (Doran and Sellers, 1978).

Process Achievement

This will refer to the score obtained on the Processes of Science Test (Biological Sciences Curriculum Study, 1965).

Processes of Science

This will refer to the process skills used by scientists. The following processes of science are outlined in the curriculum guide of Junior High School Science (Alberta Education, 1978) and are the ones tested for in the Processes of Science Test (Biological Sciences Curriculum Study, 1965).

quantifying	interpreting data
communicating	designing an investigation
inferring	processing of data
predicting	identifying problems
observing	seeking further evidence
defining terms	formulating hypothesis
classifying	

Content Achievement

This will refer to the score obtained on the Senior High School Biology Achievement Test (Alberta Education, 1975).

Mental Ability

This will refer to a student's I.Q. score as measured by the Canadian Lorge Thorndike Measure of Mental Ability Test.

Scientific Attitude

An attitude is a relatively enduring organization of beliefs around an object or situation predisposing one to respond in some preferential manner (Rokeach, 1968). In the present study, scientific attitudes are further defined in terms of the following three components:

(a) Cognitive Component

The student's understanding of the significance of the scientific attributes in a scientist's work.

(b) Intent Component

This component refers to the student's tendency to show approval or disapproval of scientific attributes of scientists at their work.

(c) Action Component

This component refers to the student's tendency to exhibit the scientific attributes of a scientist in his work (Kozlow and Nay, 1976). In the present study, the scientific attributes refer to honesty, openmindedness, suspended judgement, willingness to change opinion, respect for evidence, and critical mindedness.

Hypotheses to be Tested

H_1: The prediction of a student's process achievement score is not significantly enhanced by the inclusion of the student's self-concept in science score in the prediction equation.

H_2: The prediction of a student's content achievement score is not significantly enhanced by the inclusion of the student's self-concept in science score in the prediction equation.

H_3: The prediction of a student's process achievement score is not significantly enhanced by the inclusion of the student's scientific attitude score in the prediction equation.

H_4: The prediction of a student's content achievement score is not significantly enhanced by the inclusion of the student's scientific attitude score in the prediction equation.

H_5: The prediction of a student's scientific attitude score is not significantly enhanced by the inclusion of the student's self-concept in science score in the prediction equation.

Delimitations

1. The study was restricted to those schools that were on a semester program offering Biology in the first semester.

2. The study did not consider variables other than mental ability, grade, and gender that may have affected the relationships under study.

3. The sample was restricted to intact classes of Biology 10, 20 and 30 students.

4. The study was delimited to two senior high schools within the Edmonton Public School system.

5. The study examined the research problem utilizing only the empirical-analytical research paradigm.

Limitations

1. Because of the selected sample, the present study has limited generalizability.

2. The interpretation of the results will not necessarily have specific transferability outside the geographic location of the study.

CHAPTER II

REVIEW OF THE RELATED LITERATURE

Introduction

The literature review presented in this chapter is discussed under the following topics: Self-Concept and Achievement, Self-Concept and Science Achievement, Scientific Attitude in the Classroom, and Research Examining Scientific Attitude and Other Variables.

Self-Concept and Achievement

A review of the literature and research shows a perserverant and significant relationship between general self-concept and academic achievement. This relationship appears to be more prominent and significantly more positive for males than females. Both Campbell (1965) and Bledsoe (1967), using self-report inventories, found a stronger relationship between self-concept and achievement in males than females, indicating that differences in gender affect the relationship between self-concept and achievement. The observation concerning the effect of gender on the relationship between self-concept and achievement was more prominent in the area of underachievement. Male students who are considered by their teachers to be underachievers tend to have a more negative self-concept than their female counterparts. The reason for this may be partly explained by examining a study by Baum (1968).

Baum used the Self-Concept as Learner Scale developed for his study and found that females, both high and low achievers, report a higher self-concept than males.

Shaw, Edson, and Bell (1960) conducted a study to determine if differences exist in the way achievers and underachievers felt about themselves. The students in the study were from twelve to eighteen years of age. The Sarbin Adjective Checklist (Sarbin, 1955) was written by the students participating in the study. A major conclusion of the study was that male students, considered by their teachers to be normal achievers, felt relatively more positive about themselves than male underachievers. No simple generalizations could be made about the female groups.

A related study considering the relationship between self-concept and achievement was done by Fink (1962). The study consisted of two groups of grade nine students paired for academic ability. One member of each group was considered to be a high achiever and the other member was considered to be a low achiever.

The self-concept of each person was judged by three separate psychologists using information obtained from the California Psychological Inventory (Holland, 1959), The Gough Adjective Checklist (Gough, 1956), a personal data sheet, and a student essay entitled "What I Will Be In Twenty Years".

The combined ratings of the three psychologists showed highly significant differences in the relationship between self-concept and achievement between the individuals in each pairing. Fink (1962) concluded that there is a strong relationship between self-concept and academic achievement. He also concluded that this relationship is more significant in males than females.

Brookover, Thomas and Patterson (1964) conducted a study which had three purposes:

(1) to determine whether the student's self-concept of ability in school is related to academic achievement.

(2) to determine if self-concept is differentiated into specific self-concepts which correspond to specific subject areas.

(3) to determine if self-concept is related to a student's perception of how significant others view his ability.

Each child in the study was administered the Self-Concept of Ability Scale, developed by the authors of the study, to determine his self-concept of his general ability, as well as his self-concept in specific subjects.

After the mental ability, as measured by I.Q. scores, was factored out statistically, the students' self-concept and their grade point average were significantly and positively correlated. Brookover (1964) and his associates concluded that the relationship mentioned above is substantiated when subjects from a selected range of I.Q. scores are used. Further, it was shown that there are specific self-concepts of ability which differ from the self-concept of general ability. In summarizing their research to 1964, Brookover, Patterson and Thomas (1965) concluded that self-concept of academic ability is associated with academic achievement at each grade level.

Self-Concept and Science Achievement

It appears that few researchers have utilized Brookover's (1964) findings and have attempted to further investigate the relationship between a student's self-concept in a specific subject area and his achievement in that area, particularly in science.

Brookover (1967) guided several studies that investigated the relationship between a student's self-concept of ability in a specific subject area and achievement in that subject. He found that for males specific self-concept of ability in science was a better predictor of grades in science than was the student's general self-concept of ability. This conclusion could not be drawn for the female groups. Brookover's (1967) research is significant in light of the present study, as it supports the use of gender as a separate variable and the use of specific self-concept instrumentation.

Vargo (1974) investigated the relationship between self-concept of ability in science and science achievement with a sample of 205 grade nine earth science students. Vargo developed a Self-Concept in Science Semantic Differential instrument, to measure self-concept in science. He concluded that self-concept in science was significantly and positively correlated (+0.23) with the final grade in the science course.

Using the Instructional Objective Exchange (1972) "Self Appraisal Inventory", Alvord and Glass (1974) found that subscale scores of general, peer group and family, as well as the composite self-concept score, decreased in their potential for predicting science achievement, as measured by items from the National Assessment of Educational Progress Test Battery.

Doran and Sellers (1978) investigated the relationship between a student's self-concept in science and his science achievement using mental ability and gender as the independent variables. Utilizing the Self-Concept in Science Scale with a group of grade ten students (N=300) this study attempted to answer two questions:

(1) Is there a relationship between students' mental ability, gender, biology achievement, process achievement and their self-concept in science?

(2) Is there a relationship between students' differential achievement in biology, process achievement, gender and their self-concept in science?

The results of the data for question 1 indicate that mental ability, gender, and measures of science achievement were useful in predicting students' self-concept in science. It was concluded that the higher the level of process achievement and biology achievement, the higher the level of student self-concept in science. It was also found that when the mental ability contribution was statistically removed, the relationship between self-concept and science achievement was severely reduced.

In the second part of the study, the effect of mental ability was controlled in order to study the relationship of achievement to self-concept in science. From the data, it was concluded that gender differentiation was not useful in the prediction of self-concept when mental ability was partialled out. Since the existence of the relationship between the complete set of independent variables and the criterion variable was not established, research question 2, stated in the null form, was not rejected.

Summarizing from the brief review of the literature on self-concept in science studies, one may tentatively state that self-concept is positively related to achievement, and that gender and mental ability may be important variables to consider when studying the relationship between self-concept in science and academic achievement.

Scientific Attitude in the Classroom

In order to explicitly present the concept of scientific attitude as used in the present study, it should be distinguished from the ability to use scientific procedures. A student may be able to demonstrate effectively many of the process skills that are often utilized in science classrooms, but may not possess a positive scientific attitude. In other words, although a student may possess the ability and skills required to do science work, the fact that he does not use these skills from day to day in his science class suggests that he does not possess a positive scientific attitude (Martin, 1972).

For Brown (1970), the contrast is between what a person can do (ability) and what a person prefers to do (attitude) in a science activity. That a student prefers to perform certain deeds in science assumes that he understands why it is that a particular action is the preferred one to take in any given situation. Dewey (1934) supports Brown's (1970) distinction by describing the scientific attitude as the will to use scientific attributes in the science classroom and everyday life, which are those attributes displayed by scientists at their work. Such attributes would include: questioning attitude, critical mindedness, suspended judgement, open mindedness, willingness to change opinion, respect for evidence, and honesty.

Although the distinction in the literature is often made between attitudes and abilities, it is often overlooked by many researchers (Renner and Stafford, 1972; Baumel and Berger, 1965). For example Baumel and Berger (1965) show the lack of awareness between attitude and ability by representing their four components of scientific attitude as abilities.

In attempting to determine the nature of the scientific attitude as it relates to the present study, further distinctions have been made in an attempt to define explicitly what is meant by scientific attitude.

Gardner (1975) has suggested that scientific attitude refers to attitudes toward science or how people feel about some aspect of science. He further suggests that scientific attitudes should be called styles of thinking because there seems to be no identifiable components of the scientific attitude that can be labelled. Gardner (1975) maintains that there are too many variables to be able to accurately define his notion of scientific attitude.

Klopfer (1971) and Sears and Kessen (1964) have taken a different perspective on the interpretation of scientific attitude. They suggest that scientific attitude represents an attitude towards certain affective decision making procedures of science, which includes such traits as curiosity, open mindedness, objectivity, intellectual honesty, willingness to suspend judgement, and respect for evidence, as well as others not mentioned here.

Klopfer (1976) adds to this distinction of scientific attitude as opposed to attitude toward science. He points out the difference between enquiry procedures as they occur in science as a discipline (Schwab, 1962), and enquiry procedures as they are incorporated into the subject of science.

In Klopfer's (1976) scheme, a student's preference for reading about experiments performed by scientists would be related to his attitude toward science, while a student's preference for doing experiments in the manner that scientists perform them would relate to the extent to which he adopted the scientific attitude. The area of research surveyed in the present study refers to the extent to which students demonstrate the willingness to perform classroom experiments in the manner that scientists do, and the degree to which they understand the reason for doing so, rather than the attitude they have toward science.

Nay and Crocker (1970) have made a further distinction with respect to the nature of the scientific attitude. Their main thesis states that it is generally recognized that scientists exhibit a number of attributes in their research activities. Based on this notion, Nay and Crocker (1970) constructed an inventory of attributes of scientists at their work, and attempted to show their relationship to the knowledge and process dimension of science teaching. The inventory of attributes to determine the manner in which scientists do their work was constructed on the basis of interviews with scientists, and by surveying the literature on the nature of science. The result of the inventory was a comprehensive, but not exhaustive, list of attributes of scientists at their work. The list of attributes of scientists at their work was categorized into several sub-components which are as follows:

interests
operational adjustments
attitudes or intellectual adjustments
appreciations
values or beliefs

The sub-components that compose the inventory of attributes of scientists at their work do not form a hierarchy and no claim was made by Nay and Crocker (1970) that any sub-component of the inventory was more important than any other sub-component.

Kozlow and Nay (1976) have taken the sub-component of attitudes or intellectual adjustments and have labelled this the scientific attitude. The scientific attitude is defined as being composed of eight identifiable components which are as follows:

respect for evidence
objectivity
openmindedness
willingness to change opinion
honesty
suspended judgement
questioning attitude
critical mindedness

The components are not all inclusive of the original attributes identified by Nay and Crocker (1970), but are the ones tested for in The Test on Scientific Attitude (Kozlow and Nay, 1976). The Test on Scientific Attitude is being used in the present study and will be discussed in Chapter III.

The definition of scientific attitude, as used in the present study, may be displayed graphically (Figure 1).

In summary, scientific attitude as used in the present study is a collection of components that combine to form one of the several affective attributes of scientists, as identified by Nay and Crocker (1970). In this study, scientific attitude will be measured by the use of a revised version of The Test on Scientific Attitude, which was originally developed by Kozlow and Nay (1976).

FIGURE 1

Graphic Representation Depicting the Definition of Scientific Attitude

Nay and Crocker (1970)

↓

Attributes of Scientists

- Interests
- Operational Adjustments
- Appreciation
- Values and Beliefs
- Attitudes → Kozlow and Nay (1976)

↓

Scientific Attitude

- respect for evidence
- objectivity
- openmindedness
- willingness to change opinion
- honesty
- suspended judgement
- questioning attitude
- critical mindedness

Research Examining Scientific Attitude and Other Variables

Working with elementary school children, Clarke (1972) found no difference between higher I.Q. and lower I.Q. children in their scientific attitude. At the high school level, Meyer (1959) found no relationship between scientific attitude and intelligence. This study was supported by Wynn and Bledsoe (1967) and Wick and Yager (1966) who found no relationship between scientific attitude and achievement in test items. Both of these studies used gain scores as measures, which can lead to problems of unreliability (Ferguson, 1976). The studies mentioned above do not suppor the use of mental ability as a separate variable in this study. However, it is felt by this author that the lack of in-depth literature on the topic would warrant further investigation into the effect that mental ability may have, when considering the relationship that may exist between scientific attitude and cognitive variables such as achievement.

Some studies have reported positive relationships between scientific attitude and cognitive variables. Nutall (1971) reports a high positive correlation between scientific attitude, as measured by the Science Attitude Questionnaire (Billeh and Zakhariades, 1975), and examination grades in science. Channon (1971) reports similarly high positive relationships using the Science

Attitude Questionnaire and various achievement tests of convergent and divergent thinking.

It would seem that from the limited amount of literature on the relationship between scientific attitude and achievement in science, more research is necessary to gain a better understanding of the relationship that may exist between scientific attitude and cognitive variables.

Gauld and Hukins (1980) report, in a review of the literature on scientific attitude, that gender is probably the single most important variable related to a student's scientific attitude. This report is supported strongly by Kruglak (1978) and by Hukins (1963) who concluded in their studies that gender was an important variable when considering students' scientific attitude. The two studies showed that males were more likely to have a higher positive scientific attitude than females. The research of Kruglak (1978) and Hukins (1963) seems to indicate the use of gender as a separate variable in the present study.

Summary

If research into scientific attitude is to be of value to the classroom teacher, the pertinent literature suggests that more attention needs to be devoted to examining scientific attitude and its relationship to such cognitive variables as achievement.

CHAPTER III

EXPERIMENTAL PROCEDURES AND DESIGN

Introduction

Data collection in the present study made use of four test instruments which provided a measure of the students' Biology content achievement, process achievement, scientific attitude and self-concept in science. Content achievement was measured by the Senior High School Biology Achievement Test and the scores obtained were correlated with final grades from their Biology courses.

Before using the Test on Scientific Attitude in the present study, it was felt that major revisions of the original test were necessary. The description of the procedures used in producing the revised version of the Test on Scientific Attitude are discussed in this chapter.

The experimental design and the statistical procedures used to analyze the data are also discussed in this chapter.

Sample

The population from which the sample was drawn consisted of three Biology 10, 20 and 30 classes in the

Edmonton Public School system. After consulting a number of teachers regarding the study, the sample was selected on the basis of those teachers who agreed to lend their classes to the study. The selected sample consisted of students in Biology 10, 20 and 30 classes from two schools in the Edmonton Public School system. The number of students completing the testing battery may be found in Table I. This table also indicates the sample breakdown according to grade level and gender.

Instrumentation

The Self-Concept in Science Scale (SCSS), the Processes of Science Test (POST), the Senior High School Biology Achievement Test (SHSBAT), and the Test on Scientific Attitude (TOSA) were administered to students as part of the data collection of this study. Students' scores on the Canadian Lorge Thorndike Measure of Mental Ability Test were obtained from the student files. Students' scores as a measure of their final grades in their respective Biology courses were obtained from their teachers.

Self-Concept in Science Scale (SCSS)

The Self-Concept in Science Scale was developed by R. Doran and B. Sellers (1978) to measure a student's self-concept in science. The instrument is built upon two major dimensions which include:

TABLE I

Sample Breakdown Based On Grade Level And Gender

Grade Level	Total Number of Students	Total Number of Male Students	Total Number of Female Students
Biology 10	68	34	34
Biology 20	67	32	35
Biology 30	89	32	57
TOTAL	224	98	126

(1) operations of learning in a science classroom
(2) self-concept

The "operations of learning in a science classroom" dimension is divided into:

(a) processes of science
(b) methods

The processes of science upon which the SCSS was built are:

observing	classifying
inferring	communicating
predicting	processing of data
quantifying	concluding

The methods and techniques involved in learning upon which the SCSS was built are:

reading	individual projects
listening	multi-media presentations
taking notes	memorizing
demonstrations	class discussions
class interaction	reference and library work
test taking	working with materials and equipment
field trips	

Both major subdivisions of the operations of learning subscale emphasize many of the things a student should be able to do in the science classroom (Doran and Sellers, 1978).

The self-concept dimension of the scale is composed of the three sub-elements of the self as postulated by Fitts (1971). These three sub-elements are:

(a) identity
(b) self-satisfaction
(c) decision making

The sixty-three statements used in the instrument include one statement for each of the twenty-one operations of learning at each of the three sub-elements of the self. Student response is on a five point Likert scale. (See Appendix I for a copy of this instrument.)

Content validity was ascertained by careful adherence to a specific definition of self-concept, processes of science and methods of learning. A panel of nine judges (university professors, science teachers and doctoral students) judged each statement as to the sub-element of self and the operation of learning under which each item would be categorized. The judges were in total agreement as to the categorization of the statements in the SCSS.

Concurrent validity of the SCSS total and subscale scores was established by correlations with the Tennessee Self-Concept Scale. The correlation coefficients were:

(1)	identity	.43
(2)	self-satisfaction	.44
(3)	decision making	.42
(4)	total score	.48

The KR-20 is used as a measure of internal consistency and is given at 0.80. The test-retest correlation coefficient is used as a measure of test stability and is given at 0.82 with a four week delay between tests.

Processes of Science Test (POST)

The Processes of Science Test (Biological Sciences Curriculum Study, 1965) was initially developed as one phase of the Biological Sciences Curriculum Study (BSCS) evaluation program. In preparing POST, the focus was on the intellectual history of Biology and science as inquiry. The concerns of the authors were with the methodology of science, the bases for judging facts, principles, and concepts, the extent to which the student had developed standards for judging or appraising data, the student's ability to interpret qualitative data, and his ability to screen and judge the design of experiments. The test measures the ability of students to recognize adequate criteria for accepting or rejecting hypotheses, and to evaluate the general structure of experimental design in science, including the need for controls, replication, adequate sampling and careful measurement.

The POST consists of forty multiple choice items designed to provide a standardized estimate of the processes of science. Since this test was specifically prepared by the Biological Sciences Curriculum Study to appraise a student's understanding of general scientific principles and scientific reasoning ability, it is also useful for courses other than Biology where the understanding of the processes of science is important.

Two types of reliability are presented for POST. A split-half internal consistency correlation coefficient of 0.82, corrected by the Spearman-Brown formula, was obtained. The test-retest measures are correlations between two administrations of POST with one school year between testing. This correlation coefficient is given at 0.72.

Senior High School Biology Achievement Test (SHSBAT)

The Senior High School Biology Achievement Test (Alberta Education, 1975) was designed by the Department of Education based on the Course of Studies for Alberta Schools (1970). It consists of three sections (A, B and C) each of which contains forty items. Each section of the test contains test items relevant to each grade level of the High School Biology program. This multiple choice test is designed to measure a student's knowledge of Biology content.

The KR-20 reliability coefficients for the questions pertaining to each grade level are as follows:

Biology 10	0.82
Biology 20	0.83
Biology 30	0.89

Content validity with respect to the individual school or classroom necessitates the judgement of the teachers concerned. The teachers who participated in the present study were unanimous in their agreement that the content of the test was valid in view of the present day curriculum. To lend support to the content validity claim made by the teachers, the score obtained on the SHSBAT was correlated with the student's final grade in Biology. The Pearson r correlation coefficient was found to be 0.79. Assuming that the teachers who participated in the study covered the topics outlined in the Alberta High School Biology Curriculum Guide, a correlation coefficient of 0.79 would indicate that the SHSBAT was a valid instrument to use as a content measure in the present study.

Test On Scientific Attitude (TOSA)

Revision Procedure

After examining the original Test On Scientific Attitude (Kozlow and Nay, 1976), it was felt that a revision of this instrument was necessary. The major factor that led to the decision that the test be revised was the reliability coefficients given for the original test. The KR-20 reported for TOSA was 0.55 and the test-retest reliability was given at 0.71. Although these figures may be considered acceptable for an attitude measure, this writer felt that revisions might result in an improved test.

A second factor indicating necessity of revision was that item analysis revealed some of the test items to be poorly worded or had distractors which were not psychometrically sound. The above decisions and subsequent revisions were made in close collaboration with the original authors.

The first step in the revision procedure involved the construction of twenty new test items, ten of which were discarded after preliminary analysis. It was felt by this writer and the original authors of TOSA that the ten discarded items did not adequately represent what the test purported to measure.

The second step in the revision procedure was to examine the item analysis of the original test to determine those items in need of revision. Questions requiring revision were modified so that they were deemed to be acceptable by the authors. The criterion used to decide whether or not a test item should be modified were as follows:

(1) the difficulty index of the item could not lie outside the range of 0.20 to 0.80.

(2) the discriminating power of the item had to be above 0.10.

(3) all of the distractors had to have drawn at least two percent of the responses.

(4) the point biserial correlation had to be above 0.100.

The fifty item test was then presented to a panel of judges. The panel consisted of the two original authors, three professors of science education at the University of Alberta, and two science teachers who were working towards graduate degrees in science education. The purpose of the panel of judges was to validate the instrument by:

(1) establishing the appropriate response for each test item.

(2) classifying each item into its appropriate sub-test.

(3) establishing which attitudes were being displayed by each test item.

Appropriate Test Item Response

The appropriate response for each test item was established by unanimous agreement by the panel of judges on all but seven questions: 9, 13, 16, 26, 30, 37 and 50. On four questions, 16, 26, 30, and 37, one panel member disagreed with the rest of the panel. On three questions, 9, 13, and 50, two panel members disagreed with the rest of the panel. All but two of the disagreements were resolved through a discussion of the intentions of these test items. The disagreements on questions 30 and 50 were not resolved, so it was decided to accept the response that the majority of panel members had made.

Sub-Test Classification

The fifty items which were used in TOSA were divided into two sub-tests of twenty-five items each. The stems of the items in the Cognitive Component

Sub-test (CCS) describe a situation a scientist might encounter in his work. The student is asked to select the course of action which he believes would be most appropriate for the scientist. These kinds of items are designed to measure the student's understanding of the role attitudes have in influencing scientists' actions (Kozlow and Nay, 1976).

The stems of the items in the Intent Component Sub-test (ICS) present a situation which the student might encounter in the science classroom or in everyday activities. The student is asked to select a course of action which best describes his reaction to the situation.

The classification of the items into their appropriate sub-tests was established by unanimous agreement by the panel of judges on all but four questions: 31, 43, 47, and 49. When those panelists who were not in agreement with the rest of the panel were consulted, and the nature of the sub-test explained, unanimous agreement was obtained on the item to sub-test classifications.

Classification of Attitudes Being Tested

The third task of the panel was to relate an attitude or attitudes to each test item. A question was said to be testing an attitude or attitudes if five or more of the panel members responses agreed. Panel members were given a description of behavioral intents developed by Kozlow and Nay (1976) to guide them in this task. The distribution of attitudes as given by the panel is summarized in Table II.

When the test items were written, an attempt was made to prepare equal numbers of items for each of the six attitudes and two sub-tests. Since several of the behavioral intents defining the attitude are listed under more than one attitude (Kozlow and Nay, 1976: 152-153), the questions based on these behaviors are likewise associated with more than one attitude. Another factor contributing to the uneven distribution of questions amongst components of the scientific attitude is that items were associated with only one intent when they were written. Closer inspection of the question stems revealed that for some questions, the keyed response was related to one attitude, while other alternatives were related to other attitudes.

Administration of the pilot test took place in December of 1980. One hundred and eighteen students wrote the exam, thirty-one Biology 20 students, thirty-two Physics 20 students, and fifty-five Chemistry 20 students.

TABLE II

Summary of Panel Responses Relating Test Items To Attitude

Attitude	Question Number
Critical Mindedness	3, 8, 9, 11, 19, 21, 22, 27, 30, 31, 32, 47, 49.
Suspended Judgement	1, 2, 6, 7, 8, 10, 12, 13, 14, 15, 24, 26, 29, 34, 35, 40, 41, 44, 45.
Respect for Evidence	3, 4, 10, 13, 14, 15, 17, 19, 20, 21, 22, 24, 26, 28, 32, 35, 38, 41, 42.
Honesty	4, 23, 25, 33, 36, 46, 47, 50.
Objectivity	7, 16, 17, 18, 27, 28, 29, 30, 35, 37, 42, 43, 35, 48, 49.
Willingness to Change Opinion	6, 11, 12, 15, 20, 29, 39, 48.

Results of the TOSA Pilot Study

Descriptive Statistics

For the one hundred and eighteen students tested, the means for TOSA, CCS and ICS are 54.4, 50.0 and 59.0 percent respectively. The standard deviations are 8.9, 11.2 and 10.8 respectively. The correlation between the CCS and the ICS is 0.22. This low correlation supports the division of the questions into the two sub-tests as it indicates that they are measures of different entities.

Item Analysis

Students were allowed sufficient time to complete all items of the test. Most of the alternatives proved to be acceptable distractors. Out of the two hundred alternatives analyzed for the fifty questions, six alternatives received less than three percent of the responses. The distractors that received one to two percent of the responses were in relatively easy questions where the difficulty index was 0.80 or higher. It is possible that the nature of the sample which was tested may have contributed to raising the difficulty index of some of the easier questions. Chemistry, Physics and Biology are not compulsory courses, therefore, most of the students registered in these courses are taking the course by choice or as a prerequisite to further study in the subject. Also, a certain amount of screening is done before students can take these courses.

Reliability

The KR-20 coefficient is used as a measure of internal consistency and the test-retest correlation coefficient is used as a measure of test stability. For the sample of one hundred and eighteen students, the KR-20 coefficients for TOSA, CCS and ICS are 0.55, 0.42 and 0.36 respectively. A number of factors may have contributed to these coefficients. There is some evidence that some of the questions are not related to the rest ot the test. In the construction of the test, no attempt was made to ensure that the item difficulties would be near 0.50. The fact that six of the questions have difficulty indices above 0.75 or below 0.25 will tend to lower the KR-20 coefficients. The coefficients will also be affected by test length and reduced because the sample was homogeneous (Gullicksen, 1950).

The test-retest correlation coefficients for TOSA, CCS and ICS are 0.86, 0.83 and 0.79 respectively. These correlations were calculated from scores for one hundred and six students for a test-retest period of five weeks.

Validity

The content validity can be argued on the basis that the attitudes which the test is designed to measure were from a list of affective attributes of scientists and were validated by a panel of judges. The behavioral specifications of these attitudes were selected on the basis of the responses of the same panel of judges. The content of the items describe science related situations, and the content of the items is comparable with the ideas expressed in a wide variety of science reading material. The validity of the keyed responses has been demonstrated by the same panel of judges.

Summary

TOSA is a fifty item multiple choice test originally constructed by Kozlow and Nay (1976) and revised for the present study. The test is composed of two subtests of twenty-five items each. Each question is scored 1-0 with one keyed response for each question. The test statistics were discussed earlier in this chapter. (See Appendix II for a copy of the instrument.)

Data Collection

Three intact classes of Biology 30 students from one Edmonton Public School participated in the study. Three intact classes of Biology 10 and Biology 20 students from a second Edmonton Public School also participated in the study. The distribution of students by grade level and gender was given in Table I.

The testing battery was administered during a two week period within two weeks of the end of the first semester. Testing was done at the end of the semester to allow the teachers participating in the study to use parts of the testing battery in the calculation of their final grades. It was felt by this writer that if the students knew that the results were being used in the calculation of their final grades, they would participate in the study in a more serious fashion, thus enhancing the validity of the results.

The mental ability scores used in the present study were obtained from the students' files. The files contained the results from the Canadian Lorge Thorndike Mental Ability Test, written by the students in their final year of Junior High School. Students whose mental ability score could not be obtained were not used in the present study.

All of the tests were administered under the supervision of this researcher and the classroom teacher. The test battery was administered in the following order:

1. Self-Concept in Science Scale
2. Processes of Science Test
3. Test on Scientific Attitude
4. Senior High School Biology Achievement Test

All of the students were allowed to complete each of the tests. The students indicated their answers to the test items on the University of Alberta, Computing Services, general purpose optical scoring sheet. Student responses were scored using the Optical Scale Score Program at the University of Alberta, Computing Services Division.

The raw scores for all of the tests were used in the analysis of the data with the exception of the scores obtained on the SHSBAT. The raw scores on this test were first converted into percentile scores. The conversion was done according to the norms in the test manual.

Statistical Procedures

Where intact classrooms are employed, a statistical rather than experimental method may be used to adjust for the effects of uncontrolled variables and allow for a valid evaluation of the outcomes of the study (Ferguson, 1976).

In certain education research problems, particularly those involving prediction, it is often desirable to determine the correlation between a criterion variable and a combination of predictor variables each of which correlates to some degree with the criterion. The statistical procedure used to test the major hypothesis in the present study was the stepwise multiple regression procedure. This procedure yielded a multiple regression equation that combined the predictive value of several variables into a single formula. This assumed that those variables entering the regression equation accounted for a significant portion of the criterion variance. The stepwise multiple regression equation weighed each variable in terms of its importance in making the desired prediction. From this procedure, it was possible to tell whether or not the predictor variables under study enhanced the efficacy of prediction of the criterion variable.

The stepwise regression procedure used in the present study was carried out by the MULR06 program of the D.E.R.S. Library at the University of Alberta. Further discussion of the details of this procedure may be found in Draper and Smith (1966). When a significant positive correlation was found between the criterion variable and the predictor variable under study, an attempt was made to determine the nature of this relationship. Partial correlation was employed in the present study in order to individually rule out the effects of mental ability, gender and grade level. This was done in an attempt to clarify the effects of the predictor variable under study upon the criterion behavior pattern, and thus answer the associated research question outlined in Chapter I.

The partial correlation procedure used in the present study was carried out according to that procedure outlined in <u>Statistical Analysis in Psychology and Education</u> (Ferguson, 1976: 453-456).

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

Chapter IV presents the results of the present study in three separate sections. The first section reports the statistical results computed from the students' test data, used in determining the value of self-concept in science as a predictor of process achievement and of Biology content achievement. The second section reports the statistical results computed from the students' test data, used in determining the value of scientific attitude as a predictor of process achievement and of Biology content achievement. The final section reports the statistical results computed from the students' test data, used in determining the value of self-concept in science as a predictor of scientific attitude. The presentation of the statistical data is followed by a brief discussion of the results in each section.

Statistical results for the regression analysis were computed by the Division of Educational Research Services documented computer programs. Partial correlation coefficients calculated in the present study were done as outlined in Statistical Analysis in Psychology and Education (Ferguson, 1976). In the statistical analyses, probability levels for the partial correlation coefficients and for the variables entering the regression equation are considered to be statistically significant at the $p < 0.05$ level of probability.

The Use of Self-Concept in Science as a Predictor of Science Achievement

The Relationship Between Self-Concept in Science and Process Achievement

Hypothesis 1 states that prediction of a student's process achievement score will not be significantly enhanced by including that student's self-concept in science score in the regression equation. In order to establish whether or not self-concept in science was a good predictor of process achievement, the stepwise regression analysis described in Chapter III was carried out. The results of this statistical procedure are presented in Table III and Table IV.

Table III reports the intercorrelations generated between all of the variables examined in the present study, as well as the means and standard deviations of these variables.

Table IV reports the order of the predictor variables entering the regression equation, the associated F values for the last variable entering the regression

TABLE III

Intercorrelations, Means, And Standard Deviations of Gender, Grade Level, Mental Ability, Biology Content Achievement, Process Achievement, Scientific Attitude And Self-Concept In Science

	1	2	3	4	5	6	7
1. Gender	1.00						
2. Grade Level	0.12	1.00					
3. Mental Ability	-0.08	-0.04	1.00				
4. Biology Content Achievement	0.04	0.03	+0.28	1.00			
5. Process Achievement	0.03	+0.48	+0.25	+0.43	1.00		
6. Scientific Attitude	+0.19	+0.30	+0.19	+0.32	+0.57	1.00	
7. Self-Concept In Science	0.00	0.06	+0.14	0.06	0.06	+0.14	1.00
Mean			113.9	59.9 / 100	23.6 / 40	25.3 / 50	202.6 / 260
Standard Deviation			12.5	14.1	5.4	5.2	15.9

+$p < 0.05$

TABLE IV

Stepwise Prediction Of Process Achievement Scores From The Predictor Variables of Gender, Grade Level, Mental Ability, Biology Content Achievement, Scientific Attitude, And Self-Concept In Science

Predictor Variable Entering	F Value For Last Variable Entering	Total F Value	Probability Level For Last Variable	Percent Of Variance Accounted For
Scientific Attitude	107.1	107.1	0.001*	32.
Grade	41.6	84.2	0.001*	43.2
Biology Content Achievement	37.1	77.7	0.001*	51.4
Mental Ability	7.1	61.7	0.05*	52.8
Gender	3.4	50.5	0.1*	53.7
Self-Concept in Science	1.2	42.3	0.5*	53.9

* $p < 0.05$

equation, the total F value and its associated probability level, as well as the percent variance accounted for by each predictor variable entering the regression equation.

On the basis of the data presented in Table IV Hypothesis 1 is not rejected. Thus, on the basis of the data collected in the present study, self-concept in science is not significantly related to process achievement and including a student's self-concept in science score in the regression equation would not enhance the efficacy of prediction of a process achievement score for that student.

The first variable to enter the regression equation is scientific attitude, which is able to account for 32.5 percent of the variance. The next variable to enter the regression equation is grade level, which increases the variance to 43.2 percent. The third variable to enter the regression equation is content achievement, which raises the variance to 51.4 percent. The final variable to enter the regression equation significantly at the $p < 0.05$ level of probability is mental ability, which increases the variance to 52.8 percent. The above predictor variables have 52.8 percent common variance with the process achievement variable, and will permit fairly accurate prediction of process achievement (Borg and Gall, 1979).

The weighted regression equation for the prediction of process achievement generated as a result of the data analysed in the present study is as follows:

$$y = 0.36X_1 + 2.45X_2 + 0.10X_3 + 0.05X_4 - 25.22$$

where X_1, X_2, X_3, and X_4 are scientific attitude scores, grade level, Biology content achievement scores, and mental ability scores respectively.

The predictor variables of gender and self-concept in science did not increase the percent variance accounted for significantly at the $p < 0.05$ level of probability and thus were not considered in the regression equation. This was the major factor that led to the decision that Hypothesis 1 should not be rejected.

Since the present study did not find the existence of any significant positive relationship between self-concept in science and process achievement, the associated research questions as to what effect mental ability, gender, and grade level have on this relationship cannot be answered on the basis of the data collected.

The Relationship Between Self-Concept in Science and Biology Content Achievement

Hypothesis 2 states that prediction of a student's Biology content achievement score will not be enhanced by including that student's self-concept in science score in the regression equation. In order to establish whether or not self-concept in science was a good predictor of Biology content achievement, the stepwise regression analysis described in Chapter III was carried out. The results of the regression analysis are presented in Table III and Table V.

Table V reports the order of the predictor variables entering the regression equation, the associated F values for the last variable entering the regression equation, the total F value and its associated probability level, as well as the percent variance accounted for by each predictor variable entering the regression equation.

On the basis of the data presented in Table V, Hypothesis 2 is not rejected. Thus, on the basis of the data collected in the present study, self-concept in science is not significantly related to Biology content achievement and including a student's self-concept in science score in the regression equation will not enhance the efficacy of prediction of a Biology content achievement score for that student.

The first variable to enter the regression equation is process achievement, which is able to account for 18.5 percent of the variance. The next variable to enter the regression equation is grade level, which increases the variance to 22.9 percent. The third variable to enter the regression equation is mental ability, which raises the variance to 24.7 percent. The above predictor variables have 24.7 percent common variance with the Biology content achievement variable. This

TABLE V

Stepwise Prediction Of Biology Content Achievement Scores From The Predictor Variables of Gender, Grade Level, Mental Ability, Process Achievement, Scientific Attitude And Self-Concept In Science

Predictor Variable Entering	F Value For Last Variable Entering	Total F Value	Probability Level For Last Variable	Percent Of Variance Accounted For
Process Achievement	50.5	50.5	0.001*	18.5
Grade	12.4	32.7	0.001*	22.9
Mental Ability	5.4	24.1	0.05*	24.7
Scientific Attitude	2.6	18.7	0.05*	25.6
Gender	0.6	15.2	0.05*	25.8
Self-Concept in Science	0.1	14.7	0.07*	25.2

*$p < 0.05$

percentage of common variance will not permit highly accurate prediction, but does indicate that the combined predictor battery will give a better estimate of prediction than any single predictor. The relatively low common variance between the criterion variable and the battery of predictors significant in the regression equation is quite likely, due to the fact that these predictors do not correlate well individually with the Biology content achievement variable (see Table III). Better estimates of prediction are usually obtained with multiple regression when individual predictors correlate 0.35 or greater with the criterion variable and do not correlate well with each other (Borg and Gall, 1979).

The weighted regression equation for the prediction of Biology content achievement generated as a result of the data analysed in the present study is as follows:

$$y = 1.3X_1 - 3.5X_2 + 0.16X_3 + 49.7$$

where X_1, X_2, and X_3 are process achievement scores, grade level, and mental ability scores respectively.

The predictor variables of scientific attitude, gender, and self-concept in science did not increase the percent variance accounted for significantly at the 0.05 level of probability and thus were not considered in the regression equation. This was the major factor that led to the decision that Hypothesis 2 should not be rejected.

The decisions made in the present study regarding

Hypotheses 1 and 2 do not support previously reported research. For example, Brookover (1965, 1967) and Doran and Sellers (1978) found that self-concept in a specific subject area was a valid predictor of achievement.

It may be possible that the opposition in findings between the present study and those in previous studies is due to weaknesses inherent in some of the testing instruments. Specifically, the Self-Concept in Science Scale seems to have some of the weaknesses that are common to Likert tests.

Likert scales have the inherent weakness that combinations of positions on the scale can yield equal score values without necessarily indicating equivalent positions of self-concept in science. This may account for the relatively low standard deviation and high mean for the self-concept in science variable, as shown in Table III (Best, 1977).

It is also possible that individuals participating in the study may have responded to items on the test according to the way they thought they should feel, rather than how they really felt about themselves in science. These apparent weaknesses of the Self-Concept in Science Scale may have led to high self-concept in science scores for those students who scored poorly on the process and Biology content items. If such was the case, this would partly account for the low zero order correlations between the predictor variable of self-concept in science and the criterion variables of process achievement and Biology content achievement.

Since the present study did not find the existence of any positive relationship between self-concept in science and Biology content achievement, the associated research questions as to what effect mental ability, gender, and grade level have on this relationship cannot be answered on the basis of the data collected.

The Use of Scientific Attitude As a Predictor of Science Achievement

The Relationship Between Scientific Attitude and Process Achievement

Hypothesis 3 states that prediction of a student's process achievement score will not be significantly enhanced by that student's scientific attitude score in the regression equation. In order to establish whether or not scientific attitude was a good predictor of process achievement, the stepwise regression analysis described in Chapter III was carried out. The results of this statistical procedure are presented in Table III and Table IV.

On the basis of the data presented in Table IV, Hypothesis 3 is rejected. This suggests, to an appreciable extent, that scientific attitude and process achievement are related and that scientific attitude is a good predictor of process achievement.

The first variable to enter the regression equation is scientific attitude, which accounts for 32.5 percent of the variance. This indicates that scientific attitude has 32.5 percent variance in common with process achievement. This shared variance would allow for reasonably accurate prediction of process achievement when scientific attitude is used as a single predictor. The weighted regression equation for the prediction of process achievement from the single predictor of scientific attitude is:

$$y = 0.59X_1 + 8.7$$

where X_1 is the student's scientific attitude score.

The second, third, and fourth variables to enter the regression equation as significant predictors of process achievement are grade level, Biology content achievement and mental ability, respectively. The variance contributed by each variable as it enters the regression equation and the statement of the regression equation have been discussed earlier in this chapter in the section entitled "The Relationship Between Self-Concept in Science and Process Achievement". It appears that in this instance, the variable of scientific attitude fits the criterion outlined by Draper and Smith (1966) for being a good predictor variable. From Table III it can be seen that scientific attitude correlates highly with process achievement, and at the same time does not correlate highly with other predictor variables. This suggests that the predictive information contained in the scientific attitude variable is not redundant with other predictor variables. If the correlation between the scientific attitude variable and other predictor variables was high, the multiple regression equation combining the two predictor variables would yield no improvement over the use of each variable by itself as a predictor (Borg and Gall, 1979).

Since the existence of a significantly positive relationship between scientific attitude and process achievement was established in the present study, further investigation into the nature of this relationship was necessary in an attempt to answer the associated research questions outlined in Chapter I. Specifically, the investigation examined the influence that the variables of mental ability, gender and grade level had on the degree of correlation between scientific attitude and process achievement.

The statistical procedure of partial correlation was employed in the present study and is described in Chapter III. The use of this statistical procedure was necessary in order to rule out separately the influence that mental ability, gender, and grade level had on the relationship between scientific attitude and process achievement.

The Relationship Between Scientific Attitude and Process Achievement with the Effect of Mental Ability Removed

The zero order correlation coefficients for this and subsequent problems in this section are found in Table III. The zero order correlation coefficient between scientific attitude and process achievement is 0.57. With the influence of the mental ability variable eliminated, the partial correlation is 0.55 ($p < 0.05$). Apparently, the variable of mental ability is not a significant factor affecting the relationship between scientific attitude and process achievement. This is most likely the case, as mental ability does not correlate highly enough with scientific attitude or process achievement to have any great effect when it is removed.

The Relationship Between Scientific Attitude and Process Achievement with the Effect of Gender Removed

When the influence of the gender variable is removed from the interaction between scientific attitude and process achievement, the partial correlation is 0.57 ($p < 0.05$). This represents no change from the zero order correlation coefficient between scientific attitude and process achievement. Apparently, the variable of gender is not a significant factor affecting the relationship between scientific attitude and process achievement.

It is worthy to note that further examination of the zero order correlations between the variables of scientific attitude, process achievement, and gender reveals that gender is significantly and positively correlated with the criterion variable. Such a case suggests that the gender variable may be a suppressor variable in this instance. If this were the case, then it would follow that a slight increase in the relationship between criterion and predictor would be noticed.

In order to further examine the notion that gender was acting as a suppressor variable, a partial correlation coefficient was calculated between process achievement and gender eliminating the influence of scientific attitude. The partial correlation for this calculation is -0.09 ($p > 0.05$). Since this partial correlation coefficient is a negative real number that is not statistically significant, it indicates that the gender variable is only verging on being a suppressor variable.

The correlation between the two predictor variables of scientific attitude and gender is significant and positive. The correlation between gender and the process achievement variable is not statistically significant. This suggests that the predictive information contained in the gender variable is contained in the scientific attitude variable and thus it does not appear in the regression equation.

The Relationship Between Scientific Attitude and Process Achievement with the Effect of Grade Level Removed

When the influence of the grade level variable was removed from the interaction between scientific attitude and process achievement, the partial correlation is 0.51 ($p < 0.05$). Apparently, the variable of grade level has no significant effect on the relationship between scientific attitude and process achievement.

Although the zero order correlation coefficients between scientific attitude and grade level and process achievement and grade level are significantly positive, it would appear that even when the grade level effect is eliminated, enough common variance is shared between grade level and process achievement for grade level to appear in the regression equation.

The Relationship Between Scientific Attitude and Biology Content Achievement

Hypothesis 4 states that prediction of a student's Biology content achievement score will not be significantly enhanced by including that student's scientific attitude score in the regression equation. In order to establish whether or not scientific attitude was a good predictor of Biology content achievement, the stepwise regression analysis described in Chapter III was carried out. The results of this statistical procedure are presented in Table V.

On the basis of the data presented in Table V, Hypothesis 4 is not rejected. Thus, on the basis of the data collected in the present study, scientific attitude is not a good predictor of Biology content achievement.

The discussion of the sequence of variables used in developing the regression equation may be found in the section in this chapter entitled "The Relationship Between Self-Concept in Science and Biology Content Achievement".

Apparently, the degree to which a student understands and practices those attributes of a scientist at his work is not directly related to that student's achievement on Biology content test items. It appears from data in the present study that developing a student's scientific attitude will not directly enhance his Biology content scores.

Although scientific attitude does not appear in the regression equation for the prediction of Biology content achievement, the zero order correlation between these two variables is 0.32 ($p < 0.05$). This indicates that some kind of relationship exists between these two variables. In an attempt to discover the nature of this relationship, partial correlation coefficients were calculated in order to determine the effect that the variables of mental ability, gender, and grade level had on the relationship between scientific attitude and Biology content achievement. Since process achievement correlated highly with scientific attitude, the effect of this variable was also examined.

The Relationship Between Scientific Attitude and Biology Content Achievement with the Effect of Mental Ability Removed

The zero order correlation coefficients necessary to compute the partial correlations for this and subsequent problems in this section are found in Table III. The zero order correlation coefficient between scientific attitude and Biology content achievement is 0.32 ($p < 0.05$). With the influence of the mental ability variable eliminated, the partial correlation coefficient is 0.31 ($p < 0.05$). It appears that the variable of mental ability is not a factor directly affecting the relationship between scientific attitude and Biology content achievement.

The Relationship Between Scientific Attitude and Biology Content Achievement with the Effect of Gender Removed

When the influence of the gender variable is removed from the interaction between scientific attitude and process achievement, the partial correlation is 0.31 ($p < 0.05$). This indicates that this relationship is independent of gender. This is probably due in part to the fact that the gender variable does not correlate well with either the predictor variable or the criterion variable.

The Relationship Between Scientific Attitude and Biology Content Achievement with the Effect of Grade Level Removed

When the effect of the grade level variable is eliminated from the relationship between scientific attitude and Biology content achievement, the partial correlation coefficient is 0.32 ($p < 0.05$). Examination of the zero order correlations between scientific attitude and Biology content achievement, combined with the fact that no change was observed between the partial correlation coefficient and the zero order correlation coefficient, seems to indicate that grade level may be a suppressor variable in this case.

In order to determine if grade level was a suppressor variable, a second partial correlation coefficient was calculated between Biology content achievement and grade level, eliminating the effect of scientific attitude. The partial correlation coefficient is -0.07 ($p > 0.05$). This indicates that the grade level variable is verging on acting as a suppressor variable but since it appears in the regression equation for prediction of Biology content achievement, other factors must be significantly affecting the nature of the influence of this variable. This is a problem which requires further investigation, and is beyond the scope of the present study.

The Relationship Between Scientific Attitude and Biology Content Achievement with the Effect of Process Achievement Removed

When the influence of the process achievement variable is eliminated from the relationship between scientific attitude and Biology content achievement, the partial correlation coefficient is 0.10 ($p > 0.05$). This suggests that the relationship that exists between scientific attitude and Biology content achievement depends to a large extent upon process achievement. Closer examination of the data in Table III reveals that the correlation between scientific attitude and process achievement is relatively high. As the correlation between two predictor variables increases, the predictive information contained in one of the variables becomes increasingly redundant with the predictive informat[illegible] contained in the other variable. If the correlation becomes too high, as appears to be the case in the present study, the multiple regression equation combining the two variables yields no improvement over the use of each variable as a predictor by itself. This is probably the reason why the scientific attitude variable does not appear in the regression equation for the prediction of Biology content achievement, even though it correlates significantly with Biology content achievement.

The Use of Self-Concept In Science As a Predictor of Scientific Attitude

The Relationship Between Self-Concept in Science and Scientific Attitude

Hypothesis 5 states that the prediction of a student's scientific attitude score will not be significantly enhanced by including that student's self-concept in science score in the regression equation. In order to establish whether or not self-concept in science is a good predictor of scientific attitude, the stepwise regression analysis described in Chapter III was carried out. The results of the regression analysis are presented in Table VI. On the basis of the results presented in Table VI, Hypothesis 5 is rejected. This suggests to some extent that, on the basis of the data collected in the present study, including a student's self-concept in science score in the regression equation enhances the efficacy of prediction of scientific attitude scores.

The first variable to enter the regression equation is process achievement which accounts for 32.5 percent of the variance. The next variable to enter the regression equation is gender, which raises the variance to 35.7 percent. The third variable to enter the regression equation is self-concept in science, which increases the variance to 36.9 percent. It is worthy to note that because of the weaknesses discussed

TABLE VI

Stepwise Prediction of Scientific Attitude Scores From The Predictor Variables of Gender, Grade Level, Mental Ability, Biology Content Achievement, Process Achievement, And Self-Concept In Science

Predictor Variable Entering	F Value For Last Variable Entering	Total F Value	Probability Level For Last Variable	Percent Of Variance Accounted For
Process Achievement	107.1	107.1	0.001*	[illegible]5
Gender	10.7	61.2	0.001*	35.7
Self-Concept in Science	4.2	42.8	0.05*	36.9
Biology Content Achievement	2.1	32.8	0.2*	37.4
Grade Level	0.29	26.2	0.6*	37.5
Mental Ability	0.08	30.8	0.8*	36.0

$*p < 0.05$

earlier, concerning the self-concept in science instrument, and because including self-concept in science in the regression equation increases the total variance 1.2 percent, the question of practical significance must be raised. Apparently, the correlation between self-concept in science and scientific attitude (Table III) is too low to be considered practically significant. A correlation of 0.14 indicates that these two variables have only 2 percent of their variance in common at best, which does not allow for solid prediction to be made (Borg and Gall, 1979).

The weighted regression equation for the prediction of scientific attitude as a result of the data analyzed in the present study is as follows:

$$y = 0.54X_1 + 1.86X_2 + 0.04X_3 + 2.3$$

where X_1, X_2, and X_3 are process achievement scores, gender and self-concept in science scores respectively.

Since the existence of a significantly positive relationship between self-concept in science and scientific attitude was established in the present study, further investigation into the nature of this relationship was necessary in an attempt to answer the associated research questions outlined in Chapter I.

The statistical procedure of partial correlation was employed in the present study to eliminate the influence of the variables of mental ability, gender, and grade level.

The Relationship Between Self-Concept in Science and Scientific Attitude with the Effect of Mental Ability Removed

The zero order correlations necessary to compute the partial correlation coefficients for this and subsequent problems in this section are found in Table III. The zero order correlation coefficient between self-concept in science and scientific attitude is 0.14. With the influence of the mental ability variable eliminated, the partial correlation coeffic[illegible].11 ($p > 0.05$). Apparently, this relationship is dependent upon mental ability. This is probably due to the fact that a high degree of correlation exists between mental ability and scientific attitude and self-concept in science.

The Relationship Between Self-Concept In Science and Scientific Attitude with the Effect of the Gender Variable Removed

Since self-concept in science has 0.00 correlation with gender, no difference in the partial correlation from the zero order correlation was observed. Such an incidence suggests that self-concept in science and gender interact with the scientific attitude variable independently of one another. This is probably one reason why both variables appear in the regression equation.

The Relationship Between Self-Concept in Science and Scientific Attitude with the Effect of the Grade Level Variable Removed

When the effect of the grade level variable is eliminated, the partial correlation coefficient between self-concept in science and scientific attitude is 0.13 ($p < 0.05$). It appears that the relationship that exists between self-concept in science and scientific attitude is not dependent upon grade level. This is probably due in part to the fact that there is a very low correlation between grade level and self-concept in science. This would mean that the shared variance amongst these three variables is not statisically significant enough to have an impact on the relationship under study, when the effect of the grade level variable is eliminated.

CHAPTER V

SUMMARY AND CONCLUSIONS

Introduction

In this chapter a brief summary of the study will be presented. It will be followed by the conclusions of the investigator regarding the decisions to reject or hold tenable the research hypotheses. During the course of the investigation, it became evident that other aspects of the area of study needed further research. These areas of investigation will be outlined in the final part of the chapter as recommendations for further research.

Summary

The study was designed to determine whether or not a significant and positive relationship existed between the following variables:

(1) self-concept in science and science achievement

(2) scientific attitude and science achievement

(3) self-concept in science and scientific attitude

The study also determined, in part, the nature of the significantly positive relationships found between the predictor variables and the criterion variables under study. This was done by selectively removing the effects of the variables of mental ability, gender, and grade level from the interaction between those variables whose relationship was under study.

The sample consisted of two hundred and twenty-four high school Biology students from grades ten, eleven, and twelve, selected from the Edmonton Public School system. The test battery was administered during the last two weeks of the first semester (January 12 - 23, 1981). Four test instruments were used in the study. The Self-Concept in Science Scale is a five-point Likert scale and was used to determine how students felt about themselves in science (Doran and Sellers, 1978). The Processes of Science Test (Biological Sciences Curriculum Study, 1965) was used as a measure of the level of competence achieved by students in identifying and utilizing various process skills in solving science problems. The Test on Scientific Attitude (Kozlow and Nay, 1976) was revised for use in the study. This test was used as a measure to indicate whether or not the students understood, and were willing to display in their science work, those attributes of science commonly displayed by scientists at work. The Senior High School Biology Achievement Test (Alberta Education, 1975) was used as a measure of Biology content knowledge of the students. All of the tests were administered under the direct supervision of the classroom teacher involved or this researcher.

In addition to the test score data, mental ability scores, as measured by the Canadian Lorge Thorndike Measure of Mental Ability Test, were recorded. Gender and grade level were also recorded for each student.

In order to test each of the major hypotheses in the study, a stepwise multiple regression analysis was carried out. The predictor variable of self-concept in science was examined to determine its effectiveness in predicting process achievement and Biology content achievement. The predictor variable of scientific attitude was examined to determine its effectiveness in predicting process achievement and Biology content achievement. Finally, the predictor of self-concept in science was examined to determine its effectiveness in predicting scientific attitude.

In order to investigate, in part, the nature of the relationships of the variables under study, partial correlation coefficients were calculated to eliminate the effects of selected variables. Where a significant positive relationship was found between the predictor variable and the criterion variable, the effects of the variables of mental ability, gender and grade level were eliminated. This procedure was carried out to determine if these variables were affecting the relationships.

that existed between the variables under study in the major hypotheses.

Conclusions

Table VII summarizes the decisions the investigator made as to whether or not to reject the research hypotheses of the study.

As can be seen from Table VII, Hypotheses 3 and 5 were rejected, while a decision was made to hold tenable Hypotheses 1, 2 and 4.

On the basis of the results presented in the study, there does not appear to be a relationship existing between self-concept in science and process achievement that would enhance the efficacy of prediction of a student's process achievement score. Therefore, it is the conclusion of this study that self-concept in science is not a valuable predictor of process achievement. Apparently, developing a student's self-concept in science is not a useful intent by itself for enhancing process achievement in the classroom.

On the basis of the results presented in the study, there does not appear to be a relationship existing between self-concept in science and Biology content achievement that would enhance the efficacy of prediction of a student's Biology content achievement score. Therefore, it is the conclusion of this study

TABLE VII

Summary of Decisions Made Concerning the Major Hypotheses of The Study

Hypothesis	Decision: Tenable	Decision: Reject
H_1: The prediction of a student's Process Achievement Score is not significantly enhanced by including his Self-Concept in Science Score in the regression equation.	+	
H_2: The prediction of a student's Biology Content Achievement Score is not significantly enhanced by including his Self-Concept in Science Score in the regression equation.	+	
H_3: The prediction of a student's Process Achievement Score is not significantly enhanced by including his Scientific Attitude Score in the regression equation.		+
H_4: The prediction of a student's Biology Content Achievement Score is not significantly enhanced by including his Scientific Attitude Score in the regression equation.	+	
H_5: The prediction of a student's Scientific Attitude Score is not significantly enhanced by including his Self-Concept in Science Score in the regression equation.		+

that self-concept in science is not a useful intent by itself for enhancing Biology content achievement in the classroom.

The results of the study that led to the decision to hold tenable Hypotheses 1 and 2 disagree with those results of Doran and Sellers (1978). They found that self-concept in science was statistically, significantly, and positively related to process achievement and Biology content achievement. The Pearson r correlation coefficients between the variables in the study conducted by Doran and Sellers (1978) were low, and not practically significant in this author's opinion (0.26 for self-concept in science with process achievement, 0.28 for self-concept in science with Biology content achievement). The reason for this may have been due, in part, to the fact that self-concept in science was used as the criterion variable and process achievement and Biology content achievement were used as the predictor variables. It would follow that predictor variables having a low correlation with the criterion variable could still appear in the regression equation if the percent variance accounted for was greater than that contributed by other variables used in the study. Such appeared to be the reason for the low correlation between self-concept in science and process achievement and Biology content achievement in the Doran and Sellers (1978) study. The low correlation found by Doran and Sellers (1978), along with the decision to hold Hypotheses 1 and 2 tenable, does not satisfy the present investigator that one can determine the nature and usefulness of self-concept in science on the basis of one test instrument. It appears from the present study that a student's self-concept in science is too complex to make definitive conclusions about its nature without utilizing the findings of research emanating from other research paradigms.

On the basis of the results presented in the study, there appears to be a significant and positive relationship existing between scientific attitude and process achievement. Therefore, it is the conclusion of this study that scientific attitude is a valid predictor of process achievement. This indicates that encouraging scientific attitude within the classroom may be a useful intent to enhance process achievement. This generalization is supported by the statistically significant partial correlation coefficients between scientific attitude and process achievement, as well as the fact that scientific attitude appears in the regression equation for the prediction of process achievement.

On the basis of the results presented in the study, there appears to be a significant and positive relationship between scientific attitude and Biology content achievement. However, this relationship is heavily dependent upon the process achievement variable. This indicates that encouraging scientific attitude as a classroom intent may not be useful to directly enhance Biology content achievement. There is a high correlation between scientific attitude and Biology content achievement, which becomes statistically non-significant when the effect of the process variable is eliminated. There is also a high correlation between scientific attitude and process achievement, which means that a large portion of the variance of one variable is also contained in the other variable. In this case, process achievement has a higher correlation with Biology content achievement than scientific attitude, and so it appears in the multiple regression equation. Combining the two variables in the multiple regression equation yields no improvement over the use of each variable by itself as a predictor, and so scientific attitude does not appear in the regression equation. This suggests that scientific attitude may be a valid predictor of Biology content achievement if process achievement is not included in the same regression equation.

On the basis of the data presented in the study, there appears to be a significant and positive relationship between self-concept in science and scientific attitude. However, in the opinion of this author, the relationship is weak and is influenced by other variables, such that a generalization having any practical value cannot be made.

It is worthy to note that the researcher recognizes that all of the above generalizations have limited value outside the sample used in the study.

Associated Research Questions

The study found that self-concept in science was not significantly related to process achievement or Biology content achievement. Therefore, the associated research questions for Hypotheses 1 and 2 were not relevant.

The study did find, however, that scientific attitude was significantly and positively related to process achievement. This relationship did not appear to be affected by eliminating the effects of the mental ability, gender, or grade level variables. Apparently, the relationship between scientific attitude and process achievement is acting independently of these variables. However, it was found that the gender variable was verging on acting as a suppressor variable.

The study did find a significant and positive relationship between scientific attitude and Biology content achievement. This relationship did not appear to be affected by the elimination of the effects of the mental ability, gender, or grade level variables.

Apparently, this relationship is acting independently of these variables.

A positive relationship between self-concept in science and scientific attitude was found to exist in the study. This relationship did not appear to be affected by gender or grade level. It did, however, appear to be dependent upon the mental ability variable, as the partial correlation between self-concept in science and scientific attitude was statistically non-significant when the effect of mental ability was eliminated.

Recommendations For Further Research

As the study was being conducted, it became apparent to the investigator that a number of other areas related to the study needed further investigation.

1. Since the generalizations drawn in the study cannot be considered the final word on the subject, it is necessary to investigate the problems of the present study in other areas of science.

2. It is necessary to investigate the problems in the present study utilizing different instrumentation. The present study used one instrument to measure each of the variables examined, and thus the nature of the relationships reported in the present study cannot be said to have been examined fully.

3. The predictive value of instruments like the Test on Scientific Attitude could be further investigated. Tests of this type could possibly be used to predict achievement in other areas of science.

4. It is necessary to investigate the effect that variables other than the ones used in the present study would have on the reported relationships. The study seemed to indicate that a complex network of variables is affecting those relationships investigated.

5. An extension of the study would be to examine possible teaching strategies for developing a positive scientific attitude in students. Research might determine whether teachers could effectively teach scientific attitude as defined in this study.

6. It is necessary to investigate the problems of the study taking a perspective other than the empirical-analytic. Such an investigation would undoubtedly give a much broader picture of the nature of the relationship between the variables examined.

CHAPTER VI

POSTSCRIPT

I would like to use this space to reflect upon some of the events that have taken place during the writing of the manuscript which you have just read. It is my intent to share with you some of my thoughts regarding what it meant to me to experience the trials and tribulations of the thesis portion of my graduate program. Most of the passages that you will read are accounts of events extracted from my journal, which I kept during the time that I was doing my graduate work. There is no chronology associated with the reflections that appear here, as quite often I wrote in my journal many thoughts as they came to mind, totally devoid of any perspective of time.

One of the main reasons for writing this postscript comes about as a result of a sense of growing dissatisfaction with the underlying principles of the empirical-analytic framework which I used to conduct my study. It is not so much that I denounce this paradigm as a way of interpreting the real world, but in retrospect I don't feel that it was the paradigm I should have used to study such humanistic entities as self-concept or scientific attitude.

I suppose my personal background was a dominating factor that was responsible for me choosing to do technical research. I have always been under the impression that one of the reasons for graduate course work was to aid a person in preparation for his thesis work. Of the three compulsory courses in my program, two and one half of those courses were embedded in empirical-analytic theorizing. I felt that this was the only tool I had to work with, and that trying to do situational research without the proper background would be a dangerous task to attempt.

Without question, a second factor that contributed to my selection of the empirical-analytic paradigm was my own idea of what research was about. Now that I think about it, I was more ends-means oriented several months ago than I thought. I suppose it just came naturally that planning technical research was easier than attempting to plan situational research. It seems that it is always easier to maintain the status quo than to change your way of viewing things. I never thought that I would learn anything about myself from this experience, but it has been a somewhat self-enlightening experience. It seems that often we learn things about ourselves when situations do not work out the way we plan them. I can't help thinking that such has been the case in this instance. I sense that one of the things that has bothered me the most about utilizing the empirical-analytic paradigm for my study is the opposing direction I took in relation to the philosophy of education of some of the staff members of the Department of Secondary Education. Their work, utilizing other research paradigms, was beginning to make much more sense to me in terms of interpreting the real world than mine did; and this was a source of internal conflict for me. My one wish is that I had made this realization sooner. It seems to me that one of the intents of some of the staff of the Department of Secondary Education is to expose the student to new and different ways of thinking and studying problems in education. One of the things I learned about myself through all this is that I have not made that fundamental breakthrough necessary to examine the real world from other perspectives.

We seem to spend a lot of time talking about sense-making of the real world when doing research. I felt that when I started my research project I was going to add to the sense-making of student achievement in a very significant way. I know that my expectations of myself were very high early in the project, and I suppose I thought I was more important than I actually was. As I recall, I had to eat humble pie more than once, and it didn't take long for me to realize that my project was only one of many. I suppose I have added to the sense-making of student achievement in a small way, but much of my own dissatisfaction seemed to result because of my own exuberance for the ideal and what became a reality.

As the reality of my project began to unfold, I became much more aware of the major weaknesses of the technical way of knowing. The more I think about it, the more apparent it seems that the data I collected in the technical mode had little resemblance to the actual situation I was trying to make sense of. First of all, the data are second order descriptions of what the real world is like for students. I have much more difficulty now understanding how a forty or fifty multiple-choice test can be used to describe a situation where many different individuals are involved. The experience of working with the students and the data made it quite clear to me that a technical description of a situation does not give a complete picture, and that other perspectives must be taken to view the problem. The point I find most frightening is that many important factors are deemed irrelevant by the researcher when tests alone are used to describe a situation. I realized this point during the writing of my third chapter as I was describing the test instruments.

By this time, though, it was too late to do anything about it. I remember the sinking feeling I had when it suddenly became apparent to me that an empirical examination of the problem could not fully answer all the questions in the study.

There are too many factors that compose a student's perspective of the real world to get a clear picture of that perspective from a test paper. In order to gain a better understanding of those factors in relation to any problem being investigated, it would seem obvious that there is a need for dialogic communication between researcher and subject somewhere in the research design.

When I took the second order descriptions of the students and applied them to mathematical idealizations, I felt as though I was losing more information about the students. I remember being quite elated when I had collected all my data and put it into my computer file. I felt that my project was progressing well, inasmuch as my data collection was complete. As I prepared my data for statistical analysis, I experienced a feeling as though a dark cloud had passed by me. Again, I sensed flaws in my research and again I was in no position to do much about it, except continue on the best way I could. The first problem was that I had just reduced my two hundred and twenty-four subjects to five pages of numbers. This was disconcerting for me because I like to think that I take a humanistic approach to education. Suddenly, I felt as though I was becoming the teacher as technician -- a situation which I have tried to avoid since my days as an undergraduate.

The second problem that I had to deal with to my own satisfaction was the notion that I had to make generalizations and conclusions about those students who participated in my study. Thinking about how I might answer related questions on my oral exam made me realize that it is very difficult to make statements about large groups of individuals on the basis of numerical data. Since I was having difficulty in my own mind justifying the generalizability of empirical-analytic research, it seemed even more obvious to me that situational research would be just as valid as a way of interpreting the real world. I couldn't help thinking that a reductionist view of the real world, such as the one I had just taken, would not totally lend itself to sense-making of any given problematic situation. I sensed that I was no longer dealing with a second order typification of a problem, but the order of magnitude had become higher. I was continually asking myself questions like "where is the connection?" and "why am I putting so much emphasis on the theoretical world of second or third order schemes?"

Early in the writing of my manuscript I felt that a number of holes inherent in technical research had appeared in my study. Many of these holes seemed to centre around the weaknesses associated with the test instruments. I previously believed that when you administered a test to gather information it would be written by a sincere group of individuals, and all of your questions would be answered. One of my biggest mistakes was thinking that my self-concept in science instrument was the end-all of test instruments for measuring self-concept in science. Statistically it was sound, but statistics don't necessarily reflect how seriously a given sample of students will take the test. I think that because of the inherent weaknesses of the Likert test, students did not answer honestly, and I got "taken for a ride", if you will pardon the vernacular. I remember feeling quite disappointed as my computer printout came off the printer and I found that self-concept in science was not related to achievement. Common sense had told me that this relationship should exist, but since it didn't I felt as though I had just wasted a lot of time. I still think the problem has to be investigated much further to get a clearer picture of the relationships that were studied in this project.

The Test On Scientific Attitude was another instrument that was cause for concern as I tried to write my manuscript. I was quite proud of this test, as I had a hand in its revision. I felt quite confident that this test would measure accurately a student's scientific attitude, and I still believe that it does reflect the concept of scientific attitude as used in this study. The problem is that this instrument reflects only one philosophical approach to scientific attitude, and undoubtedly there are others. Again, it seems to me that research from the technical paradigm tends to narrow the focus of study in cases like this, and ignores many other factors that may be relevant to interpreting a total situation. Factors such as the components that interact to give a clearer picture of the student's scientific attitude become much more important when you are trying to get a clear picture of the whole, rather than one of its parts. It seems to me that individuals work as a complete entity, rather than in parts; and by trying to make sense of the real world by examining only parts of it, described via mathematical idealizations, is a difficult task.

During the writing of the thesis I had many thoughts about graduate work in general, most of which emanated from the experience of trying to put together a manuscript that would be acceptable to me and to those people whose ideals I had begun to accept.

Starting the writing of the thesis was most difficult for me. As I sat down to begin writing my thesis, the task of putting together a scholarly document seemed insurmountable. I felt as though I was embarking on a project that would take forever. Fortunately I had a colleague and friend who was enduring a similar experience, and this provided me with the realization that I wasn't the only person in graduate school that was going through moments of doubt. Because of a few bad experiences in the past, I had very little confidence in my ability to write. It seemed as though everybody else did good work, but it seemed that I had a poor self-concept of my ability as a writer, and that I had a lot of trouble getting things down on paper. For a long while I was even scared to let my adviser read my material. As things turned out, I eventually had to let somebody read the manuscript; and I did get "hassled" a lot about my writing, but I also got a lot of very constructive criticism. It is a bit ironic that I should have been studying a self-concept problem, and at the same time have been experiencing one myself.

As I worked through my project and completed Chapters I, II, and III, I began to feel as though I could complete the manuscript, even if it didn't please my adviser. I remember wondering if I cared any longer, and I often thought how easy it would have been to quit and work at something less challenging. Obviously, this was a brief moment of weakness since, at the same time, I began to sense that the whole situation was improving and that some light was beginning to appear at the end of the tunnel. My adviser had just gotten back from a ski trip so he was in a fantastic mood -- complete with words of encouragement and advice. Once again things began to unfold and I continued to progress.

As I continued, I ran into a problem in analyzing my data. The way I had originally proposed to analyze my data was not working out, and I was lost as to what to do. I was getting advice from several different people, much of which didn't make sense to me. I am not sure if these people didn't fully understand my project, or if I just didn't understand their approach; but at any rate I was rapidly becoming frustrated. I finally approached another faculty member on the advice of my committee chairman, and was bailed out of my predicament. This whole experience was interesting, as I felt as though I had been backed as far into a corner as could be, and then finally given an escape route. As I think back, this sort of experience occurred several times during my stay as a graduate student. Because of these experiences, I have often wondered if one of the intents of graduate school is to see how much pressure you can endure.

One of the things I realized during the writing of Chapter IV on the results was that several different interpretations can be made from the same data, and that numbers can be manipulated in many ways to mean different things to different people. I suspect that this type of problem is not unique to the empirical-analytic paradigm insofar as situational research allows for many different interpretations of data, based on the researcher's own perspective. At this ~~point, I~~ am not sure how to handle this particular problem.

Once I finished the rough draft of the manuscript I felt as though a great weight had been lifted from my shoulders. I was now beginning to feel as though I could finish the project, in spite of all the times I felt I should give up. However, this feeling of joy was mixed with the wish that I had done a project that was somewhat more timely and impressive. Throughout the latter parts of the writing of my thesis, I remember feeling as though this was a project that had to get done, rather than something I wanted to do. I suppose by this time, a certain amount of paranoia had set in; and I sensed that I had let down a lot of people. It seemed to me that several people had placed their confidence in me to do quality graduate work. Again, I could see some of the people whose work I admired in the Department of Secondary Education heading in one direction, and me in another. At this stage, being helpless to do anything about it, I began to feel somewhat behind the times.

It is funny to think back to some of the thoughts and emotions you experience when enduring difficult moments. Now that all is said and done, I can honestly say that this has been a valuable learning experience for me. I have gained a number of insights into problems associated with research in education. In spite of the fact that I have been able to identify in my own mind some of the weaknesses regarding technical research, I still think that it has its place as a valid way of viewing the world. I also now believe that in order to be able to criticize something, you must first have experienced that entity in order to capture the fundamental essence of that which you are critizing.

I don't think I can count the number of times I felt like quitting my program. Some of the time I am not even sure why I wanted to quit, but I am glad that I was able to overcome those hurdles which gave me a lot of trouble. It is a great feeling when the light at the end of the tunnel becomes the end of the tunnel.

BIBLIOGRAPHY

Alberta Education. Junior High School Science Curriculum Guide, 1978.

Alberta Education. Senior High School Biology Achievement Test. Department of Education, 1975.

Alvord, D. and L. Glass. "Relationships Between Academic Achievement and Self-Concept", Science Education, 58: 175-79, 1974.

Aoki, T. (ed.) Curriculum Evaluation In a New Key. The Monograph Series, Centre For The Study Of Curriculum And Instruction, University of British Columbia, 1978.

Baum, M. Unified Effort Of A Junior High School Faculty To Encourage Success For Seventh Graders, Reporting Research, Oregon Board of Education, October, 1968.

Baumel, H.B. and J.J. Berger. "An Attempt to Measure Scientific Attitudes", Science Education, 49: 267-69, 1965.

Best, J.W. Research In Education. Englewood Cliffs, New Jersey: Prentice Hall Inc., 1977.

Billeh, V.Y. and G.A. Zachariades. "The Development And Application Of A Scale For Measuring Scientific Attitudes", Science Education, 59: 155-65, 1975.

Biological Sciences Curriculum Study. Processes of Science Test. New York: The Psychological Corporation, 1965.

Bledsoe, J. "Self-Concept of Children and Their Intelligence, Achievement, Interests, and Anxiety", Childhood Education, 43: 436-38, 1967.

Bloom, B.S., J.T. Hastings, and G.F. Madaus. Handbook on Formative and Summative Evaluation of Student Learning. New York: McGraw-Hill Book Co., 1971.

Blough, G.O. Developing Science Programs In The Elementary School, In Henry. 1960: 112-135, 1960.

Borg, W.R. and M.D. Gall. Educational Research New York: Longman Incorporated, 1979.

Brookover, W.B., L.E. Erickson, and L.M. Joiner. Self-Concept of Ability and School Achievement. : Relationship of Self-Concept To Achievement in High School. U.S. Office of Education, Cooperative Research Project No. 2831. East Lansing: Office of Research and Publications, Michigan State University, 1967.

Brookover, W.B., et al. Self-Concept of Ability and School Achievement. II: Improving Academic Achievement Through Students' Self-Concept Enhancement. U.S. Office of Education, Cooperative Research Project No. 1636. East Lansing: Office of Research and Publications, Michigan State University, 1965.

Brookover, W.B., A. Patterson, and S. Thomas. "Self-Concept of Ability and School Achievement", Sociology of Education, 37: 271-78, 1964.

Brookover, W.B., A. Patterson, and S. Thomas. Self-Concept of Ability and School Achievement. U.S. Office of Education, Cooperative Research Project No. 845. East Lansing: Office of Research and Publications, Michigan State University, 1962.

Brown, S.A. "Attitude Goals In Secondary School Science", Stirling Educational Monographs, No. 1, Stirling, University of Stirling, 1976.

Brown, S.B. and L. Brown. "A Semantic Differential Approach To The Delineation of Scientific Values Possessed By Professors of Science And Humanities", Journal of Research In Science Teaching, 9: 345-51, 1972.

Campbell, P.B. Self-Concept and Academic Achievement In Middle Grade Public School Children. Ph. D. dissertation, Wayne State University, 1965.

Channon, C.E. Convergent and Divergent Abilities: The Role Of Situational Stress And Personality Variables, unpublished M. Phil. thesis, University of Nottingham, 1971.

Clarke, C.O. "A Determination Of Commonalities Of Science Interests Held By Intermediate Grade Children In Inner-City, Suburban, And Rural Schools", Science Education. 56: 125-36, 1972.

Cohen, D. "Can Scientific Attitudes Be Evaluated?" R.P. Tisher (ed.) Research 1971, Brisbane: Australian Science Education Research Association, 135-134, 1971.

Combs, W. and D. Snygg. Individual Behavior (2nd ed.) New York: Harper and Row, 1959.

Conant, J.B. Science and Commonsense. New Haven: Yale University Press, 1951.

Dewey, J. "The Supreme Intellectual Obligation", Science Education, 18: 1-4, 1934.

Doran, R.L. and B. Sellers. "Relationships Between Students' Self-Concept In Science And Their Gender", Journal of Research in Science Teaching, 15: 527-33, 1978.

Draper, N.R. and H. Smith. Applied Regression Analysis. New York: Wiley Publishing Company, 1966.

Ferguson, G.A. Statistical Analysis in Psychology And Education. New York: McGraw-Hill Co., 1976.

Fink, M.B. "Self-Concept As It Relates To Academic Achievement", California Journal of Educational Research, 13: 57-62, 1962.

Fraser, B.J. "Development Of A Test Of Science Related Attitudes", Science Education, 62: 509-15, 1978.

Gardner, P.L. "Attitudes to Science: A Review", Studies in Science Education, 2: 1-41, 1975.

Gauld, C.F. "Science, Scientists, and "Scientific Attitudes'", Australian Science Teachers Journal, 19: 25-32, 1973.

Gauld, C.F. and A.A. Hukins. "Scientific Attitudes: A Review", Studies in Science Education, 7: 129-61, 1980.

Gough, J.C. California Psychological Inventory. Palo Alto, California: Consulting Psychologist Press, 1956.

Gullicksen, H. Theory of Mental Tests. New York: John Wiley and Sons Incorporated, 1950.

Habermas, J. Knowledge and Human Interest. Boston: Beacon Press, 1972.

Holland, J.L. "The Prediction of College Grades From the California Psychological Inventory and the Scholastic Aptitude Test," Journal of Educational Psychology. 50: 135-42, 1959.

Hukins, A.A. A Factorial Investigation of Measures of Achievement of Objectives in Science Education In Science Teaching. Unpublished Ph. D. Thesis, University of Alberta, 1963.

Inglis, S.C. The Development And Validation Of An Instrument To Assess Teacher Invitations And Teacher Effectiveness As Reported By Students In A Technical And General Post Secondary Education Setting. Unpublished Doctoral Dissertation, University of Florida, 1976.

Klopfer, L.E. "A Summary of Research in Science Education - 1977", Science Education, 63:4, 1979.

Klopfer, L.E. "A Structure For The Affective Domain In Relation To Science Education", Science Education, 60: 299-312, 1976.

Kozlow, M.I. and M.A. Nay. "An Approach To Measuring Scientific Attitudes", Science Education, 60: 147-172, 1976.

Kruglak, H. "Deprogramming Student Attitudes Toward Astrology". The Physics Teacher, 16: 27-31, 1978.

Kurtz, P. "The Scientific Attitude Vs. Antiscience And Pseudoscience", The Humanist, 36: 27-31, 1976.

Lawson, D.E. "Truth, Values And Scientific Attitude", Educational Forum, 24: 85-93, 1959.

Maslow, A.H. Motivation and Personality. New York: Harper, 1954.

Manning, D. Toward a Humanistic Curriculum. New York: Harper and Row, 1972.

Martin, B.R. A Study of the Effect of the Blue, Green and Yellow Versions of B.S.C.S. Biology on the Scientific Attitude of Tenth-Grade Students. Unpublished Ed. D. Dissertation, The American University, 1972.

Meyer, G.B. "Factors Related To Scientific Attitudes Within The Secondary Schools In An Australian City", Australian Journal of Education, 7: 21-40, 1963.

Mulkay, M.J. "Norms And Idealogy In Science", Social Science Information, 15: 637-56, 1976.

Nay, M.A. and R.K. Crocker. "Science Teaching and the Affective Attributes of Scientists", Science Education, 54: 59-67, 1970.

Nutall, D. Administrator's Manual For Science Attitude Questionnaire, Slough, NFER, 1971.

Page, J.E. A Canadian Context For Science Education. A Discussion Paper Prepared For The Science Council of Canada, October, 1979.

Purkey, W.H. Self-Concept And School Achievement. Englewood Cliffs, New Jersey: Prentice Hall, 1970.

Renner, J.W. and D.G. Stafford. Teaching Science In The Secondary School, New York: Harper and Row, 1972.

Rogers, C.R. Client Centered Therapy. Boston: Houghton Mifflin Co., 1951.

Rokeach, M. Beliefs, Attitudes and Values. San Francisco: Jassey-Bass Inc., 1968.

Sarbin. T.R. "Contributions To Role-Taking Theory: IV, Method For Obtaining A Quantitative Estimate Of Self", Journal of Social Psychology, 42: 71-81, 1955.

Schwab, J. "The Concept of the Structure of a Discipline", Educational Record, July, 1962.

Sears, P.B. and W. Kessen. "Statement of Purposes and Objectives of Science Education in School", Journal of Research in Science Teaching, 2: 3-6, 1964.

Shaw, M.C., K. Edson, and H. Bell. "The Self-Concept Of Bright Underachieving High School Students As Revealed By An Adjective Checklist", Personnel And Guidance Journal, 39: 193-96, 1960.

Vargo, R.A. Pupil Science Teacher Interpersonal Compatability And Science Attitudes. Paper presented at the NARST Convention, Chicago, Illinois, April, 1974.

Wick, J.W. and R.E. Yager. "Some Aspects Of The Student's Attitudes in Science Courses", School Science And Mathematics, 66: 269-73, 1966.

Wylie, R.C. The Self Concept: A Critical Survey of Pertinent Research Literature. Lincoln, Nebraska: University of Nebraska Press, 1961.

Wynn, D.C. and J.C. Bledsoe. "Factors Related To Gain And Loss Of Scientific Interests During High School," Science Education, 51: 67-74, 1967.

APPENDIX I

SELF-CONCEPT IN SCIENCE SCALE

Instructions

On the separate answer sheet fill in the heading according to the directions given by your examiner. Write only on the answer sheet, please.

The statements on the following pages are to help you describe yourself as you see yourself in science. Please respond to them as if you were describing yourself to yourself. Do not omit any item. Read each statement carefully, then select one of the responses listed below.

On your answer sheet, darken the circle of the response number that you have chosen for each statement. Please use the pencil provided for you. If you decide to change an answer, erase your first answer completely and then darken in the circle of your new response.

The responses are as follows:

Completely False	Mostly False	Partly False and Partly True	Mostly True	Completely True
1	2	3	4	5

Remember, please respond to the statements as if you were describing yourself to yourself <u>in science</u>.

You will find the response numbers repeated at the bottom of each page to help you remember them.

PART I

1. I measure things as well as I would like to.
2. I am a person who can think about what I have observed and come up with a good conclusion.
3. I always try to carefully notice what we do in class.
4. I am satisfied with my ability to describe the differences and similarities between things.
5. I am a person who is able to put things into groups.
6. I try to measure things carefully.
7. I am satisfied with my ability to observe what is done in an experiment.
8. I am a good experimenter.
9. I am satisfied with my ability to make predictions.
10. I do well on number problems in class.
11. I wish I could make better conclusions based on what I have seen in class.
12. I am a person who works well with numbers.
13. I can compare things.
14. I give up when I have to classify things.
15. I am a good observer.
16. I am a person who is able to measure things.
17. I am satisfied with the way that I do experiments.
18. I know that I compare things very well.
19. I can make good generalizations.

RESPONSES

Completely False	Mostly False	Partly False and Partly True	Mostly True	Completely True

20. I am never satisfied with my ability to classify things into groups.

21. I can make predictions.

22. I am satisfied with my ability to work with numbers.

23. I am a person who is able to predict things.

24. I do experiments well in science class.

PART II

25. I am a loner in science class.

26. I try to learn a lot when I go on a field trip.

27. I wish that I could be a better reader.

28. I am satisfied with my ability to learn well from movies and filmstrips.

29. I try to take good notes in class.

30. I use the science books that we have in our library.

31. I am the kind of person who does well on individual projects.

32. I ought to do better than I do on my science tests.

33. I do well when I just have to memorize something.

34. I am a good reader.

35. I ought to listen more closely to what my teacher says in class.

36. I am <u>not</u> the type of person who gains a lot from going on a field trip.

37. I wish that I could do better in class discussions.

38. I learn well from other students.

RESPONSES

Completely False	Mostly False	Partly False and Partly True	Mostly True	Completely True

39. I am the type of person who learns from watching demonstrations.

40. I am <u>not</u> a good note taker.

41. I am satisfied with my ability to memorize.

42. I never put materials and equipment together for science experiments.

43. I learn well when I listen to my teacher.

44. I am satisfied with what I learn from the demonstrations given in science class.

45. I discuss well in class.

46. I sometimes do poorly in reading.

47. I wish that I could take better notes.

48. I do my best work when I am working on an individual project.

49. I am <u>not</u> satisfied with the way that I put materials and equipment together for science experiments.

50. I am able to learn well from listening to my teacher.

51. I wish I could gain more from going on a field trip than I do.

52. I do as well as I want to on individual projects.

53. I know that I put materials and equipment together well for science experiments.

54. I do <u>not</u> understand some things in class because I do not pay attention to the demonstrations.

55. I am a person who has the ability to use science reference books.

56. I wish that my classmates liked me better.

RESPONSES

Completely False	Mostly False	Partly False and Partly True	Mostly True	Completely True

57. I know that I have the ability to learn well from movies and filmstrips.

58. I am a good test taker.

59. I always try to learn from movies and filmstrips in science class.

60. I am a person who could just about memorize anything.

61. I am satisfied with the way that I can use science reference books.

62. I give up when I take tests.

63. I am the kind of person who does poorly in class discussions.

RESPONSES

Completely False	Mostly False	Partly False and Partly True	Mostly True	Completely True

APPENDIX II

TEST ON SCIENTIFIC ATTITUDE

G. Andruski
M.J. Kozlow
M.A. Nay

Directions:

1. Each question or incomplete statement is followed by four possible answers. Read each question and decide which ONE of the four alternative answers you think is best. Mark your answers on the separate answer sheet. Make certain that the number on the answer sheet corresponds to the number of the question that you are answering.

2. Do not write in this test booklet.

3. Read each question carefully but do not spend too much time on any one question. Answer all questions.

4. Mark only ONE answer for each question.

Example:

Answer Sheet

200. A person who dedicates his life to the study of chemistry is a

A. biologist C. chemist

B. physicist D. zoologist

200. A1 B2 C3 D4

1. Suppose you live near a large industrial plant. You find that the rose bushes in your yard die in a short while after they are planted, but your lawn remains in perfect condition. You suspect that the fumes from the industrial plant are the cause of the death of the roses. Which one of the following would be the most reasonable course of action for you to take?

   A. Study the effect of the fumes on healthy rose bushes.

   B. Stop growing rose bushes.

   C. Start legal action against the plant for pollution control.

   D. Move away from the plant.

Questions 2 and 3 refer to the following paragraph.

The scientist, Schleiden, published a report in 1838 on the origin of plant cells. He made several observations on the reproductive cells of some plants which he explained as follows:

> It is an absolute law that every cell takes its origin as a very small bladder and grows only slowly to its defined size. The process of cell formation which I have just described . . . is that process which I was able to follow in most of the plants which I have studied. Yet many modifications of this development can be observed . . . Nevertheless, the general law cannot be questioned . . .

2. Which one of the following is generally true about scientists that was NOT demonstrated by Schleiden in the above situation?

   A. Scientists try to avoid making general statements based on limited data.

   B. Scientists are usually careful to report exactly what they observe.

   C. Scientists collect large amounts of data in order to develop a law of nature.

   D. Scientists may ignore observations which do not quite fit into their theories.

3. Some aspects of Schleiden's theory were later shown to be not accurate. The most probable reason for this is that he

   A. did not have modern instruments to use in his investigations.

   B. did not make his theory explain all of his observations.

   C. based his cell theory on too few observations.

   D. felt that his theory could not be questioned.

4. Suppose you wanted to determine which types of mosquitoes cause malaria. You obtained three kinds (Types A, B, and C) and examined the digestive tracts of each for malaria parasites. You found some parasites only in Type B mosquitoes. You concluded from this that malaria is spread by Type B but not by Types A and C mosquitoes. Which one of the following describes your conclusion?

   A. Your conclusion does not agree with the evidence.

   B. Your conclusion is valid in light of the evidence.

   C. Your conclusion is justified, but more evidence should be obtained.

   D. You did not obtain enough evidence to make a conclusion.

5. Quite often it is possible to give several different explanations for a particular set of observations. Which one of the following would NOT be generally true about such explanations?

   A. Only one of these explanations could be the true scientific one.

   B. The explanation which is the most widely used is likely to be the accepted one.

   C. The explanation which greatly stimulates further research is likely to be the one which most scientists will accept.

   D. All these explanations would be acceptable if they explain the observations adequately.

6. When Einstein published his theory of relativity, another famous scientist was reported to have said, "Dr. Einstein's new theory has shattered many of my scientific beliefs to smithereens!" This statement indicates that the scientist

   A. recognized that a scientific theory can change.

   B. held some wrong scientific beliefs without knowing it.

   C. did not believe in the old theory very strongly.

   D. did not have sufficient evidence to support his original beliefs.

7. A theory in science is generally accepted when it explains all of the observed properties of the substances involved. However, it is possible that undiscovered properties exist that cannot be explained by the theory. Which one of the following is the BEST approach to this situation?

   A. The limits under which the theory applies should be carefully stated and the theory should be used within these limits.

   B. Scientists should provide several theories to explain a given set of observations so that if exceptions to one theory are found, they will have others to rely on.

   C. Scientists should not accept a theory until they are certain that exceptions to it do not exist.

   D. When exceptions are discovered, scientists should abandon the theory and devise a new one.

8. Scientists recognize that a scientific theory

   A. should not be changed when it is based on a large amount of data.

   B. may have to be changed to keep up with a rapidly changing world.

   C. may have to be changed to explain new observations.

   D. should not be changed when it explains what happens in nature.

9. A boy goes skating on a pond and breaks through the ice. He is rescued and given a drink of hot chocolate by someone who is sneezing and coughing. A few days later the boy also has a cold. Which one of the following best describes the reason for the boy's cold?

   A. His cold is due to falling in the cold water and getting wet.

   B. He got the cold from the person who rescued him.

   C. He probably had a cold coming before he went skating.

   D. The reason why he got a cold is not yet determinable.

10. Scientists have questioned many religious beliefs. Which one of the following best expresses the way you feel concerning this matter?

   A. When scientific theories question religious beliefs, it is better to keep the religious beliefs.

   B. I question those religious beliefs upon which science has cast doubt.

   C. I have two separate thought compartments, one for my religious beliefs and one for scientific knowledge.

   D. I keep my religious beliefs until scientists prove them wrong.

11. A science magazine reports that a scientist produced a type of water that boils at 540 C at sea level. Another scientist reading this report would probably

   A. believe the report if it was written by a highly respected scientist.

   B. disbelieve the report because he would know that water boils at 100 C at sea level.

   C. do experiments to try to prove that water cannot boil at 540 C.

   D. neither believe nor disbelieve the report until other scientists study this problem.

12. In the research on genes (carriers of heredity), many scientists are currently doing experiments in which genetic material from two unrelated bacteria are combined to form a new cell with different and often unexpected traits. Some of these man-made bacteria have been found to be very useful. However, environmentalists have warned that bacteria may be produced that could cause grave harm to humans and the environment. Which one of the following courses of action in regard to such genetic experimentation would you favor most?

    A. Have experts prepare safety controls and regulations which the government would impose on such genetic research.

    B. Have the government stop this type of research because of the unknown danger to humans and the environment.

    C. Have no controls or regulations because the potential benefits of uncontrolled research outweigh the possible dangers.

    D. Have no controls or regulations because research is done best in an atmosphere of complete freedom.

13. Recently, a chemical company was accused of deliberately making false claims about the safety of some of its insecticides. On the basis of these claims the government permitted their use in the human environment. Now there is evidence that these insecticides have caused many people to suffer. Which of the following is the best way to handle this kind of situation?

    A. The chemical laboratory should be barred from developing new insecticides.

    B. The government should check more closely on the safety claims of such potentially dangerous chemicals.

    C. The false claims should be ignored until sufficient evidence is obtained that these insecticides harm humans.

    D. The false claims should be ignored since there is nothing to replace these useful chemicals.

14. A scientist was studying an ore from the moon in an attempt to obtain a new metal from it. He made several tests but did not find evidence of a new metal. However, he did identify a peculiar gas which he obtained during one of the tests. He probably would have

    A. reported that the ore did not contain a new metal but did contain a peculiar gas.

    B. reported only that portion of his investigation related to the gas.

    C. not made any report because he did not get any metal.

    D. not made any report until he was able to get another scientist to confirm his identification of the gas.

15. When you are evaluating the correctness of ideas in science textbooks, which one of the following is the most important consideration?

    A. How recently the book was published.

    B. Whether or not the author is a scientist.

    C. The extent to which the ideas have been simplified.

    D. How widely the ideas in the book are currently accepted by scientists.

16. Suppose you had worked several days on a chemistry experiment. You then accidentally added some sodium nitrate solution when you should have added silver nitrate. Which one of the following courses of action should you take?

    A. Start over again as soon as you realize your mistake.

    B. Continue with the experiment but if it doesn't turn out the way it should, start over again.

    C. Continue the experiment to see if the mistake makes any difference.

    D. As soon as you realize your mistake, add some silver nitrate solution and continue with the experiment.

17. If a scientist had to choose between two theories, he would probably support the theory which

A. most other scientists feel is more likely to be correct.

B. has more practical value.

C. is based on a larger number of observations.

D. explains the available observations more satisfactorily.

Questions 18 and 19 refer to the following paragraph.

Galileo gathered much evidence on stars, motion of objects, etc. which gave rise to ideas about the universe which were contrary to those held by some of the philosophers of his time. These philosophers forced Galileo to say that he was wrong and tried to stop him from practicing science.

18. Whi h one of the following best applies to this situation?

A. Galileo should have collected more evidence before disagreeing with the philosophers.

B. Galileo's ideas became wrong when he was forced to say that they were.

C. Galileo should have avoided those investigations which led to disagreement with the philosophers.

D. Galileo was justified in questioning the beliefs of the philosophers.

19. In their treatment of Galileo, the philosophers

A. showed that they did not have a proper respect for evidence.

B. seemed to think that they knew all that there was to know about the universe.

C. were not willing to change their ideas in the face of new evidence.

D. showed all of the above characteristics.

20. "People born when certain stars are becoming more prominent show the influence of these stars in their personalities." People who believe this statement

    A. probably have a special ability to understand such influence.

    B. are more imaginative than most people.

    C. are more open-minded than most people.

    D. do not take scientific evidence into account.

21. Suppose you did a chemistry experiment, but the results were not what you expected. Which one of the following would you do?

    A. Report the results which were predicted in the chemistry text.

    B. Copy the results from a friend.

    C. Report the results that you obtained.

    D. Report no results and tell the teacher that the experiment failed.

22. Quite often two groups of scientists will support two opposing theories on some aspect of nature. Which one of the following would be the MOST important point to consider in settling such a controversy?

    A. Both theories give satisfactory explanations for the observations, but one theory has more practical applications.

    B. One group of scientists believe more strongly in their theory.

    C. One group contains several scientists who have won the Nobel Prize for science.

    D. Different conclusions are reached when the two theories are applied to certain problems.

Questions 23 and 24 refer to the following paragraph.

Priestly and Lavoisier, both of whom lived 200 years ago, are often referred to as the "fathers of modern chemistry". Both of them did many experiments on burning, and believed in the phlogiston theory of combustion (all materials give off a substance call "phlogiston" when they burn). However, later Lavoisier became dissatisfied with the phlogiston theory and developed our modern theory of combustion in which he said that when a substance burns it combines with oxygen. Priestley never accepted Lavoisier's theory.

23. Which one of the following is generally true about scientists, but was NOT demonstrated by Priestly in the above situation?

A. Scientists believe very strongly in their theories.

B. Scientists demand an excessive amount of experimental evidence before changing their belief in a theory.

C. Scientists do not accept new theories when they are first published.

D. Scientists accept new theories when they are consistent with experimental data.

24. Which one of the following can be inferred from the above paragraph as NOT true about Lavoisier?

A. He believed that his theory of conbustion would never change.

B. He recognized that theories are likely to change.

C. He was prepared to consider ideas presented by others.

D. He developed a new theory to explain the evidence on burning.

25. Drs. Brown, Jones, and Smith are medical researchers. Each one independently investigated the cancer-producing effect on rats of compounds found in tar. Dr. Brown reported that there was <u>no effect</u>. Some time later, both Drs. Jones and Smith reported that these compounds were highly cancer-producing. Which one of the following was probably the MOST important reason for Dr. Brown's conclusion?

A. He did not consider all the evidence.

B. He did not do a sufficient number of controlled experiments.

C. He was in a hurry to report his results first.

D. He did not analyze his data properly.

26. Below are a number of points of view regarding the teaching of the theory of evolution in a biology class. In your opinion, this theory should be

A. omitted from the biology course.

B. presented to the class, but its controversial aspects should not be discussed.

C. discussed thoroughly in a democratic manner in class with all students present.

D. discussed openly in class, but those students who do not want to listen should be permitted to leave.

27. During a class discussion a student said: "The questions which are really important to man can never be solved by science." Which one of the following would be your reaction to this statement?

A. Disagree with him immediately.

B. Not pay any attention to this statement because it is not worth thinking about.

C. Ask him to present facts and arguments to support this statement.

D. Support him because you believe that the statement is true.

28. In [illegible] Lamarck presented his theory of inheritance of acquired characteristics (traits developed by an organism can be passed on to offspring). Darwin, who later developed the modern theory of evolution, called Lamarck's theory "rubbish". In a recent article, two scientists claim to have discovered evidence for Lamarck's theory. Of the following reactions to the newspaper article, which one is most scientific?

   A. "The discovery is tremendously important to the biology of heredity."

   B. "It is a nutty bit of research which I would not bother to read about."

   C. "The discovery by the two scientists does not so much attack Darwin's theory of evolution as it expands upon it."

   D. "This discovery is not surprising because in some ways Darwin's theory is incomplete."

29. "Many people have cycles of mental disturbances which correspond to the full moon." Which one of the following best represents your reaction to this statement?

   A. One should be willing to consider the possibility that there may be some truth to this superstition.

   B. Scientists could never prove or disprove this idea.

   C. This statement is true because people have believed in it for a long time.

   D. There is insufficient evidence to make such a claim.

30. Imagine you are living in a small town on the banks of a river not far from a large industrial city. Your town has just experienced a severe flood for the first time in its recorded history. Some people are saying that it was caused by increased rainfall due to the smog from the nearby industry. Which one of the following best expresses your evaluation of this claim?

    A. This is a popular opinion for which there is no proof.

    B. This is a popular opinion based on people's prejudice against smog.

    C. This is a valid conclusion based on sufficient evidence.

    D. This is a conclusion for which more evidence is needed.

31. In an experiment, students blew through limewater with a straw and noted that it turned milky. From this result most of the students concluded that their bodies gave off carbon dioxide. However, one girl wrote in her notebook that since there is carbon dioxide in the air we breathe the experiment proved nothing. Which one of the following best describes your evaluation of this situation?

    A. The students were justified in concluding that the body gives off carbon dioxide.

    B. The girl was justified in doubting the proof for the body giving off carbon dioxide.

    C. Neither side had sufficient evidence for their conclusions.

    D. Both sides were partly justified in their conclusions.

32. Which one of the following is NOT an important reason why scientists often repeat the experiments reported by other scientists?

A. A scientist could be so intent on finding a desired answer that he unconsciously observes only what he wants to see.

B. This helps to make a scientist more careful and honest when making observations and reporting results.

C. The first scientist might have used a faulty experimental procedure.

D. The first scientist might overlook a significant variable in his experiment.

33. A scientist shows that he is open-minded when he

A. discusses his ideas with other scientists.

B. evaluates ideas which do not agree with his theories.

C. agrees with ideas presented by other scientists.

D. asks other scientists to provide experimental evidence to support their ideas.

34. Because a scientist is human, he can never be totally objective (without bias) when doing and reporting his research. Yet when he does report his research findings, other scientists usually treat them as accurate and honest. Which of the following statements best explains this apparently contradictory situation?

A. From the report, scientists are able to tell whether there was any cheating.

B. A scientist's strong scientific interests and biases do not have any effect on his findings.

C. Scientists trust such reports because they know that the research can be repeated by other scientists working in the same field.

D. Biased research findings are often very useful in science.

35. For more than 100 years chemistry textbooks have presented Arrhenius's theory of ionization to explain the properties of acids, bases and salts. However, at the time Arrhenius first proposed this theory, very few scientists were willing to accept it. Which one of the following is the MOST important reason why the theory was not widely accepted when it was first proposed?

A. Arrhenius, in his theory, gave a different interpretation to the available data on acids, bases and salts.

B. The scientists who would not accept this theory were not as imaginative as Arrhenius.

C. Arrhenius did not have enough evidence to support his theory.

D. The scientists who would not accept this theory were less willing to be criticized.

36. Nuclear plants are becoming of increasing importance as a source of electricity in industrialized countries. However, dangerous radioactive wastes are produced which must be disposed of safely. Recently, a proposal was made to bury them deep in stable Pre-Cambrian rocks where they must lie undisturbed for hundreds of thousands of years. Which of the following reactions is the most reasonable one for you to take on this issue?

A. The proposal is sheer madness because this increases the risk of radioactive pollution.

B. Risks should be taken because the electricity from nuclear plants is badly needed.

C. The proposal should be shelved until studies are done on the success of long-term burial of radioactive wastes.

D. The industrialized countries should use less electricity so that nuclear plants would not be necessary.

37. A scientist had a theory for which he needed some evidence. He did experiments and found that some of the results did not support his theory. When he reported his theory, he omitted those results which did not fit. In this case, the scientist

    A. produced a theory which did not have any practical value.

    B. produced a theory which was not very important.

    C. made his theory explain part of the experimental results.

    D. made the experimental results agree with his theory.

38. A scientist should report his findings as accurately and honestly as possible

    A. so that his experiments can be repeated by others wanting to check his claim.

    B. so that it will be more difficult for other scientists to challenge his discoveries.

    C. so that he does not lose his scientific reputation.

    D. because it is expected of him by the scientific community.

39. "Light travels as a stream of particles."

    "Light travels as a wave."

    If you came across these two statements in two different science books, which of the following would you do?

    A. Ask your teacher to tell you which statement to accept.

    B. Check other science books for statements on this topic.

    C. Assume that scientists are not certain as to how light travels.

    D. Accept the statement in the newer book.

40. In many investigations in biology courses, live animals are subjected to conditions that appear distressing and painful, and often result in their death during the experiment. Which of the following best expresses your reaction to this type of research?

A. On humane and moral grounds such experiments should not be allowed.

B. Such experiments should be allowed since the knowledge gained from the animal's suffering outweighs the need to respect its comfort.

C. Such experiments should be allowed with live animals raised especially for this purpose.

D. Such experiments should be allowed only under careful supervision and when it is certain that the animals will not suffer.

41. During a discussion of current events in a science class a student reports that much of the research on paranormal power (eg. mental telepathy, clairvoyance, and fortune telling) gives false results. The main reason for these false results is the difficulty in devising proper research methods to study paranormal power. Students who believe in paranormal power upon hearing this report, should react in which one of the following ways

A. Continue to believe because eventually new research may show that some people do have paranormal power.

B. Stop believing in paranormal power until acceptable scientific evidence is obtained to support it.

C. Continue to believe because one knows from one's own experiences that some people have paranormal power.

D. Read the evidence for and against paranormal power so as to be able to decide whether to continue believing it.

42. A scientist withholds or suspends judgement on scientific conclusions when he

    A. collects as much data as possible before making conclusions.

    B. makes sure that the conclusions fit the facts (evidence).

    C. recognizes that knowledge is incomplete.

    D. reports observations even when they do not support his conclusions.

43. Suppose that you and a friend both did the same experiment to determine whether or not sunlight is required for plants to produce starch. Both of you tested a leaf from a plant that had been left in the dark for two days. Then you both tested a leaf from a plant that had been left in the sunlight. Your friend found starch in both leaves. You found starch only in the leaf from the plant that had been left in the sunlight. Which one of the following would be the most reasonable thing for you to do?

    A. Accept your own result because text books say that plants in the dark should not produce starch.

    B. Have both of you repeat the experiment.

    C. Accept the result obtained by the one who knows more about the experiment.

    D. Ask your teacher to decide which result should be accepted.

44. Consider the following data concerning fluoridation of the public water supply:

> Fluorides help prevent cavities in children's teeth.
>
> Small amounts of fluorides appear to have no long-term harmful effects on humans.
>
> The easiest and cheapest way to administer fluorides to children is through the public water supply.
>
> The fluoride content of lakes and oceans is increasing as a result of putting fluorides in the public water supply.
>
> It is safe to put acceptable amounts of fluorides in milk for children.

Which one of the following best describes your point of view after considering the above information?

A. You would be against putting fluorides into the public water supply.

B. You would be uncertain as to which side to support.

C. You would be in favor of putting fluorides into the public water supply.

D. You would lose interest in the problem because the evidence is too indefinite.

45. "Cloning" is one kind of experimentation with genes (carriers of heredity) in which identical copies of an organism are produced. This result of cloning has led to claims that it is possible to produce many copies of a human being. Which one of the following reactions do you favor?

A. Biologists have no business aspiring to "play God".

B. The possible bad results of duplicating human beings are scary.

C. Cloning of humans should continue because it may help in our understanding of the processes of life.

D. Society should protect the sanctity of life by forbidding the cloning of humans.

49. It has been stated that secrecy in research is necessary, one reason being that stealing of ideas occurs in science. Which one of the following is the LEAST important reaction to this situation?

A. Stealing of research ideas is desirable because it informs the wronged scientist that his research is important.

B. A certain amount of stealing of research ideas is tolerable since it tends "to keep scientists on their toes".

C. Stealing of research ideas is bad because it may prevent a scientist from getting proper recognition for his ideas.

D. Such stealing is harmful because it may prevent scientists from sharing ideas, hence slowing down scientific progress.

50. If you came across a scientific idea which goes against your common sense, which one of the following would you be inclined to do?

A. Disregard the scientific idea because it is better to rely on common sense.

B. Disregard common sense because it is not as reliable as scientific study.

C. Do an experiment to determine whether common sense or the scientific ideas is more acceptable.

D. Try to produce a compromise between the scientific idea and common sense.

46. Some medical researchers say that marijuana is more harmful to humans than alcohol, while others say that it is not. In the light of this information, which of the following would you be inclined to do?

A. Not smoke marijuana because it is probably harmful.

B. Ignore the evidence that marijuana might be harmful and smoke it if you wanted to.

C. Smoke marijuana because it is probably no more harmful than alcohol.

D. Put off any decision about smoking marijuana until more definite knowledge is obtained about its effects.

47. Imagine that you have just finished a laboratory investigation in which you took 8 measurements. Your measurements all agree except two. If you were unable to take more measurements, which of the following would you probably do?

A. Include the two odd measurements in your report but omit them from calculations.

B. Adjust the two odd measurements in your report to make them agree better with the others.

C. Do not include the two odd measurements in your report.

D. Use all the measurements as they are when making calculations in your report.

48. When observations are made that do not fit an accepted scientific theory, scientists usually

A. try to adjust the observations so that they fit into the theory.

B. keep the theory as it is since the new observations cannot be used to improve it.

C. try to change the theory so that these observations can be explained.

D. discard this theory and develop a new one to explain these observations.