A COMPARATIVE CONTENT ANALYSIS OF TEXAS AND THAI
HIGH SCHOOL BIOLOGY TEXTBOOKS

DISSERTATION

Presented to the Graduate Council of the
North Texas State University in Partial
Fulfillment of the Requirements

For the Degree of

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By

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Roadrangka, Vantipa., A Comparative Content Analysis of Texas and Thai High School Biology Textbooks. Doctor of Philosophy (Secondary Education), May, 1981, 303 pages, forty-four tables, fifteen appendices, bibliography, 108 titles.

There were two purposes of this study. The first was that of determining, through an analysis of Texas and Thai biology textbooks, which objectives -- cognitive, affective, manual skill, processes of scientific inquiry, and orientation—were emphasized in three major and twenty-seven minor fields of biology. The second purpose was to determine if significant differences exist in the frequency distribution of these objectives.

Only one biology program is used in schools throughout Thailand. This program, which was published by the Ministry of Education, consists of four textbooks with 1977 copyright date. The five Texas textbooks used in this study were those adopted under the provisions of the Textbook Law. The contents of each of the six texts included in the study were classified by using the criteria of Klopfer's Table of Specifications for Science Education. It was found that

1. The objectives of the Thai IPST biology program were 87.34% cognitive, 9.76% processes of scientific inquiry, 2.40% manual skill, and 0.50% orientation.

2. The objectives of the Cunningham program were 74.29% cognitive, 20.13% processes of scientific inquiry, 4.62% manual skill, and 0.95% orientation.
3. The objectives of the Oram program were 76.48% cognitive, 17.61% processes of scientific inquiry, 5.22% manual skill, and 0.70% orientation.

4. The objectives of the Otto program were 87.54% cognitive, 9.03% processes of scientific inquiry, 2.97% manual skill, and 0.46% orientation.

5. The objectives of the Smallwood program were 85.55% cognitive, 10.03% processes of scientific inquiry, 3.89% manual skill, and 0.53% orientation.

6. The objectives of the Weinberg program were 82.44% cognitive, 12.86% processes of scientific inquiry, 3.68% manual skill, and 1.02% orientation.

It was found that all programs lacked objectives related to Processes of Scientific Inquiry IV: Building, Testing, and Revising a Theoretical Model and Attitudes and Interests.

The Chi Square Test of Significance of Differences of Proportions from K Independent Samples, and Post Hoc Procedures for the K Sample Problem with Independent Proportions were used to determine the presence or absence of significant differences in the objectives derived from Texas and Thai biology programs. The statistical comparisons of total objectives established the presence of statistically significant differences between each Texas and Thai biology program (P ≤ 0.001).
It was recommended that further research in the Thai biology program be conducted to (1) determine whether questions in textbooks and teachers' questions facilitate the attainment of specifically documented objectives; (2) identify questions which measure student attitudes and interests toward science programs; (3) develop, implement, and evaluate a minicourse in laboratory techniques in biology; and (4) develop, implement, and evaluate a minicourse that emphasizes the means by which students transfer their knowledge and comprehension of science to other disciplines.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>LIST OF TABLES</th>
<th>iii</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAPTER</td>
<td></td>
</tr>
<tr>
<td>I. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>The New Thai Curriculum in Biology</td>
<td></td>
</tr>
<tr>
<td>Statement of the Problem</td>
<td></td>
</tr>
<tr>
<td>Purposes of the Study</td>
<td></td>
</tr>
<tr>
<td>Need for the Study</td>
<td></td>
</tr>
<tr>
<td>Definition of Terms</td>
<td></td>
</tr>
<tr>
<td>Delimitations</td>
<td></td>
</tr>
<tr>
<td>Assumptions</td>
<td></td>
</tr>
<tr>
<td>Organization of Remaining Chapters</td>
<td></td>
</tr>
<tr>
<td>II. REVIEW OF THE LITERATURE</td>
<td>17</td>
</tr>
<tr>
<td>The Aims of Science Teaching</td>
<td></td>
</tr>
<tr>
<td>Course Content and Textbooks</td>
<td></td>
</tr>
<tr>
<td>Science as Inquiry</td>
<td></td>
</tr>
<tr>
<td>The Affective Domain in Science Education</td>
<td></td>
</tr>
<tr>
<td>The Psychomotor Domain in Science Education</td>
<td></td>
</tr>
<tr>
<td>Science Education in Thailand</td>
<td></td>
</tr>
<tr>
<td>III. PROCEDURES</td>
<td>116</td>
</tr>
<tr>
<td>Selection of Textbooks</td>
<td></td>
</tr>
<tr>
<td>The Instrument</td>
<td></td>
</tr>
<tr>
<td>Collection of Data</td>
<td></td>
</tr>
<tr>
<td>IV. FINDINGS AND ANALYSIS OF THE DATA</td>
<td>144</td>
</tr>
<tr>
<td>Phase I</td>
<td></td>
</tr>
<tr>
<td>Content Emphasis of Textbook</td>
<td></td>
</tr>
<tr>
<td>Phase II</td>
<td></td>
</tr>
<tr>
<td>Analysis of Textbook Objections</td>
<td></td>
</tr>
<tr>
<td>Phase III</td>
<td></td>
</tr>
<tr>
<td>Comparison of Cognitive, Affective, Manual Skill, Processes of Scientific Inquiry and Orientation Distributions</td>
<td></td>
</tr>
</tbody>
</table>
V. SUMMARY, CONCLUSIONS, AND IMPLICATIONS . . . . 240

Summary
Conclusions
Implications
Recommendation for Further Research

APPENDIX A . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 255
APPENDIX B . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 256
APPENDIX C . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 259
APPENDIX D . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 260
APPENDIX E . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 262
APPENDIX F . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 263
APPENDIX G . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 268
APPENDIX H . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 269
APPENDIX I . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 271
APPENDIX J . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 273
APPENDIX K . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 276
APPENDIX L . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 278
APPENDIX M . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 280
APPENDIX N . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 282
APPENDIX O . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 284
BIBLIOGRAPHY . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 292
LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Classification of Content in Texas and Thai Biology Textbooks</td>
<td>146</td>
</tr>
<tr>
<td>II. Comparison of Frequencies and Percentages of Total Objectives for the IPST and Cunningham Programs</td>
<td>151</td>
</tr>
<tr>
<td>III. Comparison of Frequencies and Percentages of Total Objectives for the IPST and Oram Programs</td>
<td>153</td>
</tr>
<tr>
<td>IV. Comparison of Frequencies and Percentages of Total Objectives for the IPST and Otto Programs</td>
<td>155</td>
</tr>
<tr>
<td>V. Comparison of Frequencies and Percentages of Total Objectives for the IPST and Smallwood Programs</td>
<td>156</td>
</tr>
<tr>
<td>VI. Comparison of Frequencies and Percentages of Total Objectives for the IPST and Weinberg Programs</td>
<td>158</td>
</tr>
<tr>
<td>VII. Comparison of Frequencies and Percentages of Knowledge and Comprehension Objectives (A.O) for the IPST and Cunningham Programs</td>
<td>161</td>
</tr>
<tr>
<td>VIII. Comparison of Frequencies and Percentages of Knowledge and Comprehension Objectives (A.O) for the IPST and Oram Programs</td>
<td>163</td>
</tr>
<tr>
<td>IX. Comparison of Frequencies and Percentages of Knowledge and Comprehension Objectives (A.O) for the IPST and Otto Programs</td>
<td>165</td>
</tr>
<tr>
<td>X. Comparison of Frequencies and Percentages of Knowledge and Comprehension Objectives (A.O) for the IPST and Smallwood Programs</td>
<td>168</td>
</tr>
<tr>
<td>XI. Comparison of Frequencies and Percentages of Knowledge and Comprehension Objectives (A.O) for the IPST and Weinberg Programs</td>
<td>170</td>
</tr>
</tbody>
</table>
XII. Comparison of Frequencies and Percentages of Application of Scientific Knowledge and Method Objectives (F.O) for the IPST and Cunningham Programs ... 173

XIII. Comparison of Frequencies and Percentages of Application of Scientific Knowledge and Method Objectives (F.O) for the IPST and Oram Programs ... 174

XIV. Comparison of Frequencies and Percentages of Application of Scientific Knowledge and Method Objectives (F.O) for the IPST and Otto Programs ... 176

XV. Comparison of Frequencies and Percentages of Application of Scientific Knowledge and Method Objectives (F.O) for the IPST and Smallwood Programs ... 177

XVI. Comparison of Frequencies and Percentages of Application of Scientific Knowledge and Method Objectives (F.O) for the IPST and Weinberg Programs ... 179

XVII. Frequencies and Percentages of Attitude and Interest Objectives (H.O) in Texas and Thai Biology Textbooks ... 181

XVIII. Comparison of Frequencies and Percentages of Manual Skill Objectives (G.O) for the IPST and Cunningham Programs ... 183

XIX. Comparison of Frequencies and Percentages of Manual Skill Objectives (G.O) for the IPST and Oram Programs ... 184

XX. Comparison of Frequencies and Percentages of Manual Skill Objectives (G.O) for the IPST and Otto Programs ... 186

XXI. Comparison of Frequencies and Percentages of Manual Skill Objectives (G.O) for the IPST and Smallwood Programs ... 187

XXII. Comparison of Frequencies and Percentages of Manual Skill Objectives (G.O) for the IPST and Weinberg Programs ... 189
XXIII. Comparison of Frequencies and Percentages of Processes of Scientific Inquiry I: Observing and Measuring Objectives (B.O) for the IPST and Cunningham Programs 191

XXIV. Comparison of Frequencies and Percentages of Processes of Scientific Inquiry I: Observing and Measuring Objectives (B.O) for the IPST and Oram Programs 193

XXV. Comparison of Frequencies and Percentages of Processes of Scientific Inquiry I: Observing and Measuring Objectives (B.O) for the IPST and Otto Programs 195

XXVI. Comparison of Frequencies and Percentages of Processes of Scientific Inquiry I: Observing and Measuring Objectives (B.O) for the IPST and Smallwood Programs 196

XXVII. Comparison of Frequencies and Percentages of Processes of Scientific Inquiry I: Observing and Measuring Objectives (B.O) for the IPST and Weinberg Programs 198

XXVIII. Comparison of Frequencies and Percentages of Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It Objectives (C.O) for the IPST and Cunningham Programs 200

XXIX. Comparison of Frequencies and Percentages of Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It Objectives (C.O) for the IPST and Oram Programs 202

XXX. Comparison of Frequencies and Percentages of Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It Objectives (C.O) for the IPST and Otto Programs 204

XXXI. Comparison of Frequencies and Percentages of Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It Objectives (C.O) for the IPST and Smallwood Programs 205
XXXII. Comparison of Frequencies and Percentages of Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It Objectives (C.O) for the IPST and Weinberg Programs

XXXIII. Comparison of Frequencies and Percentages of Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalization Objectives (D.O) for the IPST and Cunningham Programs

XXXIV. Comparison of Frequencies and Percentages of Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalization Objectives (D.O) for the IPST and Oram Programs

XXXV. Comparison of Frequencies and Percentages of Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalization Objectives (D.O) for the IPST and Otto Programs

XXXVI. Comparison of Frequencies and Percentages of Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalization Objectives (D.O) for the IPST and Smallwood Programs

XXXVII. Comparison of Frequencies and Percentages of Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalization Objectives (D.O) for the IPST and Weinberg Programs

XXXVIII. Frequencies and Percentages of Processes of Scientific Inquiry IV: Building, Testing, and Revising a Theoretical Model Objectives (E.O) in Texas and Thai Biology Textbooks and Laboratory Manuals

XXXIX. Comparison of Frequencies and Percentages of Orientation Objectives (I.O) for the IPST and Cunningham Programs

XL. Comparison of Frequencies and Percentages of Orientation Objectives (I.O) for the IPST and Oram Programs
XLII. Comparison of Frequencies and Percentages of Orientation Objectives (1.0) for the IPST and Otto Programs . . . . . . . . . . . . . . . 224

XLIII. Comparison of Frequencies and Percentages of Orientation Objectives (1.0) for the IPST and Smallwood Programs . . . . . . . . . . . . . 226

XLIII. Comparison of Frequencies and Percentages of Orientation Objectives (1.0) for the IPST and Weinberg Programs . . . . . . . . . . . . . 228

XLIV. Chi Square Values of Objectives for Comparisons of Texas and Thai Biology Programs . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 231
CHAPTER I
INTRODUCTION

Historically, textbooks play an inordinately important role in science education programs at the secondary school level. They have an effect on both curriculum planning and implementation. Textbook content has reflected the cognitive, affective, and value objectives that have influenced teachers and learners. The changes in the status of science education, both in content and methodology, in the twentieth century suggest a reconsideration of these materials suitable for the needs of students, teachers, and the public. This is particularly true since the choice of science textbooks remains a source of controversy among the boards of education, the textbook adoption committees, and the public.

Santiesteban and Koran (15) found no evidence to support the differential efficacy of instructional methods for improving student's learning of written science materials. Their study analyzed the efficacy of various teaching aids, including advance organizers, adjunct questions, and behavioral objectives in science texts, laboratory guides, and worksheets. The investigators concluded that written materials occupy a major place in science instruction because the written materials stress the written word as the vehicle knowledge acquisition. In their view, the use of written materials
should continue, for it is difficult to imagine how a student can learn to read and learn from reading without actually reading.

If the student is to learn to live with the changes science brings, and if he is to make intelligent decisions about how great a share science should have in shaping his life, the textbooks he uses should include a discussion of events in science and their relation to changes in cultures, predominant religions, economic factors, and other conditions in life (6).

Besides presenting information, texts should pose problems which give students laboratory practice in the application of what they have learned. These problems should require the students to apply scientific principles to realistic situations. In addition, texts should give students opportunities to bring together concepts from different fields in dealing with a problem (18).

The New Thai Curriculum in Biology

Since the launching of Sputnik in 1957, American curriculum specialists have continually designed new science course materials, including textbooks, learning materials, teachers' guides, and laboratory equipment of all kinds. These programs have usually been designed to improve scientific literacy through the updating of science curriculum materials and the improvement of classroom instruction. One such program is the Biological Science Curriculum Study
(BSCS) for high school biology. The development of this curriculum was subsidized by the National Science Foundation (NSF) and was divided into the Green Version, the Blue Version, and the Yellow Version, for high school biology.

In Thailand, with the cooperation of the Thai Government, the United Nations Development Program (UNDP), and the United Nations Educational Scientific and Cultural Organization (UNESCO), the Institute for the Promotion of Teaching Science and Technology (IPST) was established in August, 1970. The major purposes of IPST were to promote the development of modern science and mathematics curriculum materials and to train teachers to use the materials effectively in the elementary and secondary schools (17).

The Thai Ministry of Education assigned to IPST the task of developing a new biology curriculum because the traditional biology curriculum was less popular among students than other branches of science; the students did not enjoy a curriculum that required much memory work and few laboratory experiments (9). The completed curriculum is known as the IPST Biology Program.

During 1971-1975, the Thai IPST biology materials in M. S. 4 and M. S. 5 level (grades 11 and 12) were developed by a curriculum design team composed of professional scientists from colleges and universities and teachers from secondary schools in Thailand. The team based its study on curricula prepared largely by BSCS in the United States, the
Nuffield Biology Project in the United Kingdom, Australian Biology, and High School Biology of the Philippines.

The content of the course is divided into a universal section and a local section by the proportions of 70 and 30 percent, respectively. The universal section includes, for example, the following concepts: photosynthesis, digestion, and respiration. These topics are taught in similar fashion in schools throughout the world. The local section includes only those biological concepts that are suitable to the region: for example, the concepts of ecosystems or populations.

The focus of the IPST biology program is on developing three main characteristics of biology as a science: (a) the gathering of scientific knowledge, (b) the practice of scientific processes, and (c) the development of scientific attitudes (9). According to Soydhurum (17), the inquiry method is used as the basis for developing of teaching strategies that encourage the student to examine the biology of his immediate environment.

The trial program began during 1973-1975 and a follow-up program was also carried out in the following year. The revision of each chapter of the student textbook and the teacher's guide was done immediately after the testing of those chapters in a secondary school classroom. The academic year 1975-1976 was devoted to the rewriting and preparation of the manuscripts for the commercial editions.
All of these materials became available for use in the upper secondary schools in Thailand in June, 1976 (17).

Statement of the Problem

The study was designed to determine whether the biology texts used in Texas differed substantially from those used in Thailand. It was felt that difference in content, form, and application might point up needed improvement and might be beneficial in determining which biology curriculum (if either) is more effective. The study focuses on the following research questions:

1. How many cognitive, affective, manual skill, processes of scientific inquiry, and orientation objectives are contained in each textbook?

2. How are the cognitive objectives distributed among the levels of the cognitive domain in each textbook?

3. How are the affective objectives distributed among the levels of the affective domain in each textbook?

4. How are the manual skills distributed within the manual skill domain in each textbook?

5. How are the inquiry objectives distributed among the processes of scientific inquiry in each textbook?

6. How are the orientation objectives distributed in each textbook?

7. Do the frequencies of cognitive objectives in each Texas textbook differ significantly from the frequencies of cognitive objectives in the Thai textbooks?
8. Do the frequencies of affective objectives in each Texas textbook differ significantly from the frequencies of affective objectives in the Thai textbooks?

9. Do the frequencies of manual skill objectives in each Texas textbook differ significantly from the frequencies of manual skill objectives in the Thai textbooks?

10. Do the frequencies of processes of scientific inquiry objectives differ significantly from the frequencies of processes of scientific inquiry objectives in the Thai textbooks?

11. Do the frequencies of the orientation objectives in each Texas textbook differ significantly from the frequencies of orientation objectives in the Thai textbooks?

Purposes of the Study

There were two purposes of this study. The first was that of determining, through an analysis of Texas and Thai biology textbooks, which student behaviors—cognitive, affective, manual skill, processes of scientific inquiry, and orientation objectives—were emphasized in three major and twenty-seven minor fields of biology. The second purpose was to determine if significant differences existed in the frequency distribution of these student behaviors.

Need for the Study

The results of this study will be used to develop and improve instructional materials and teaching effectiveness
in Thailand's biology program. Therefore, the significance of the present study is that it provides an analysis of cognitive, affective, manual skill, processes of scientific inquiry, and orientation objectives, in biology textbooks. In addition, this study provides comparisons of the frequency distributions of the various objectives and determines whether the distributions reflect similar cognitive, affective, manual skill, processes of scientific inquiry, and orientation emphases.

The traditional science course has been criticized for its presentation of a body of knowledge. As a result, many have felt that such programs have failed to involve the student in the real activities of science (13). Thus, educators have suggested that the science curriculum should concentrate on knowledge which has "survival value" and should seek to provide students with intellectual skills and social values relevant to the scientific world of the future (5).

Don Phillips states that

...science education, indeed all education, must develop in the students both an awareness of the difficulties facing our society and the capability to contribute toward their solution. A curriculum attempting to accomplish these ends must be multi-disciplinary and must concentrate on developing problem-solving capabilities... (14, pp. 1048-49).

Hurd states,

The broad goal of science teaching for the 1970's needs to go beyond the restrictive content of
the special disciplines and consider science in relation to the affairs of mankind, the activities of the "real" world, and the human condition (10, p. 5).

Schwab observes that

...the traditional curriculum is by no means the only version nor necessarily the most desirable version in all schools for all students. Of the two components--science as enquiry and the activity of enquiry--it is the former which should be given first priority as the objective of science teaching in the secondary school (16, p. 71).

Ausubel (1, p. 355) argues that the basic objectives of a high school biology course should be the teaching of those broad biological ideas that constitutes part of general education. He contends that there are organized bodies of knowledge that are worth teaching and learning. On the other hand, to Gagne (7) the purpose of science education is to teach the student the processes of science and to develop his science-relevant intellectual skills. He maintains that certain skills and processes are constant even though scientific concepts change. Gagne accepts Schwab's observations on the transient nature of scientific knowledge but, contrary to Ausubel, he emphasizes the development of intellectual skills rather than the transmission of organized bodies of scientific knowledge. Gagne argues that intellectual skills can be represented structurally in learning hierarchies and that these skills are not only transferable but of permanent worth to the learner. Content can be obtained from a reference
book, according to Gagne, but intellectual skills must be
developed so that they will be available when needed.

Some new science textbooks place a major emphasis on
the nature and structure of science and strive to bring out
the difference between observation and interpretation as
well as the difference between data and conceptual schemes.
They are organized around processes of scientific inquiry
and unifying conceptual ideas. Depth rather than breadth
is favored. Finally, in addition to broad statements of
biological concepts, recent developments in the science
ought to be an integral part of all textbooks rather than
merely included as extra chapters at the end of the text
(11).

The new science courses purport to emphasize a relation-
ship between and among cognitive, affective, manual skill,
processes of scientific inquiry, and orientation objectives,
according to Albert Baez's study (2, pp. 1-2). Baez, the
Chairman of the Commission of Science Education of the
American Association for the Advancement of Science (AAAS),
has proposed four C's as educational guidelines for science
education that will, he maintains, create a new generation
of people who understand the power, the responsibilities,
and the limitations of science. The four C's are curiosity,
creativity, competence, and compassion. Curiosity refers to
the spirit of inquiry that characterizes the approach of a
scientist. Creativity refers to the spirit of change
through creative design. Competence refers to the utilization of one's knowledge and skills to successfully complete a task. The final, but perhaps most important characteristic is compassion, which is important to insure that science is wisely used for the betterment of humanity.

It is important to analyze and evaluate new programs as they are developed. Soydhurum (17) indicates that evaluation of curriculum materials can be made in terms of objectives classified into three major categories—cognitive, affective, and psychomotor. Evaluation in each of these areas should involve analysis of responses from both teachers and students.

Evaluation in the cognitive domain usually includes the development and analysis of the achievement test data. According to Klopfer (11), each of the tests ought to include questions representative of the various levels of Bloom's taxonomy.

The cognitive domain includes provisions for intellectual growth that range from objectives which deal with the recall or recognition of knowledge to the development of highly complex intellectual functioning (4). The affective domain involves the provisions for development of feelings, interests, attitudes, and values (11, 12). According to Klopfer (11, p. 576), no comprehensive studies have yet been made of the manual skills involved in science laboratory work in schools. Yet, in his table of specifications, he
includes a section on manipulative skills necessary for students to adequately perform laboratory tasks.

The processes of scientific inquiry also are employed as discovery investigations. Goodlad emphasizes,

...striking similarity in the aims and objectives of nearly all (new curriculum) projects. Objectives, as they are defined in various descriptive documents, stress the importance of understanding the structure of the discipline, the purposes and methods of the field, and the part that creative men and women played in developing the field. One of the major aims is that the students get to explore, invent, discover, as well as sense some of the feelings and satisfactions of research scholars, and develop some of the tools of inquiry appropriate to the field (8, p. 54).

The new programs also tend to concentrate on fostering "scientific literacy" while several direct the student's attention to the complex relationships between science and society. Klopfer states, ...aspects of the new science program seem to call for competencies and understandings that enlarge the student's perspective of the world and help him to orient himself in it" (11, p. 579).

The new science programs developed in Thailand during the last decade were universally adopted in 1976 after being tested in the schools in 1973-1975. The investigator analyzed and compared these new biology textbooks in terms of their instructional objectives with the instructional objectives in biology texts adopted by the state of Texas.

For purposes of analysis and comparison, the investigator used Klopfer's Table of Specifications for Science
Education (Appendix A and B) to classify the instructional objectives into the following categories: (a) cognitive, (b) affective, (c) manual skills, (d) processes of scientific inquiry, and (e) orientation.

Definition of Terms

The definitions of terms for this study are presented below:

Cognitive objectives. -- Objectives include knowledge and comprehension as well as application of scientific knowledge and methods (11).

Affective objectives. -- Objectives which emphasize a feeling, an emotion, or a degree of acceptance or rejection (11).

Manual skill objectives. -- Objectives which focus on the student's manipulative skills in performing laboratory tasks (11).

Processes of scientific inquiry objectives. -- These include objectives such as observing and measuring, seeing a problem and seeking ways to solve it, interpreting data and formulating generalizations, and building, testing, and revising a theoretical model (11).

Orientation objectives. -- Objectives that help the student to a clearer perception of the world and a broader understanding of his orientation in it (11).

Inquiry. -- This includes activities in problem solving which involve questioning the student, allowing him to
discover, by means of his own thought processes, basic scientific principles and the rules for their application (3).

Program. -- In this study, the word "program" includes textbook and laboratory manual.

Delimitations

Generalizations and interpretations of this study are subject to the following limitations:

1. For this study the selection of content was based on five biology textbooks adopted for use in Texas schools 1977-1982 and editions of biology textbooks used in grades eleven and twelve in Thailand in 1977. The five biology textbooks used in Texas did not include all biology textbooks which were used in the high schools around the United States.

2. The analysis of textbook content in this study was made by the investigator by using Klopfer's Table of Specifications (Appendix A).

Assumptions

The design of the research required determination of the kinds of instructional objectives, and Klopfer's Table of Specifications for Science Education was used as the basis for cognitive, affective, manual skill, processes of scientific inquiry, and orientation classifications. It was assumed that Klopfer's table was a valid system for classifying the objectives in this study.
Organization of Remaining Chapters

Chapter II contains a review of literature related to this study. The method of selection of textbooks, instrumentation used, and procedures to answer the research questions are presented in Chapter III. Chapter IV presents an analysis and summary of the data gathered in the study. Chapter V provides a review of the complete study as well as the conclusions, implications, and recommendations for further study.
CHAPTER BIBLIOGRAPHY


CHAPTER II

REVIEW OF THE LITERATURE

This chapter presents a review of the literature of the aims of biology teaching since 1751 until the present time, reviewing investigations of criteria for the selection of course content and biology textbooks. In addition, it reviews research on scientific inquiry and affective development in biological science as well as the importance of the psychomotor domain. Finally, it presents the theoretical basis for education and the development of biology programs in Thailand.

The Aims of Science Teaching

Any study of the history of science education should reveal the conditions under which science teaching objectives have been developed and the conditions under which they change. Most educators agree that when developing or planning a science curriculum, it is important to understand the purpose for which the curriculum is being designed. With this in mind, the investigator has attempted to summarize the works that have been done on biological teaching objectives in America since 1751. The investigator agrees with Collette's view (22) that the goals of science teaching are still not clearly defined. As a result, they are discussed
Aims of Science Teaching from 1751 to 1890

There is no record of science being taught in the Latin grammar schools that dominated education in America from 1650 to 1750. Consequently, science instruction in this country had its real beginning in 1751 in the Philadelphia Academy established by Benjamin Franklin.

According to the Commission on Secondary School Curriculum (82), the aims of science instruction in those early years (1751-1890) were threefold: descriptive, utilitarian, and religious. The curriculum usually offered was natural philosophy, astronomy, chemistry, and geography, with some emphasis upon zoology and geology. Instruction was so organized that factual data were presented with little emphasis on understanding basic scientific principles. Because of the emphasis on memorizing facts, some of the early texts were written in the form of catechism. The most common method of teaching was to assign material to be learned and to hear recitations on the assigned material.

Noll (73) has found that the aims of science teaching before 1850 emphasized not only the informational value of the sciences, but the religious ones as well. By the end of the nineteenth century, however, the religious aims had gradually disappeared. The disciplinary aim had become prominent; and laboratory instruction had become very popular. It was
largely through the laboratory that the disciplinary values were expected to come.

**Aims of Science Teaching since 1890**

From 1890 to 1900 attempts were made by commissions, textbook authors, and curriculum workers to determine and outline the aims of science teaching. One such commission, the conference of the National Education Association's Committee on Secondary School Studies, 1892-1893, also known as the Committee of Ten (113), was established to determine science curriculum for American schools.

The Committee agreed that the study of botany and zoology ought to be introduced at the primary school level with no less than two periods per week until the students entered high school. The conference also suggested that students be made to express themselves clearly and exactly either in words or by drawings in describing the objects which they observed since the Committee believed that this practice would be found to be valuable in training the pupils in self-expression.

Hurd has summarized the reports of the Committee of Ten on the improvement of a biology curriculum, which stressed

1. The desirability of a continuous offering of biological science from the first grade through high school.

2. The establishment of a required course in biological science at the tenth-grade level.

3. The requirement of one year of biology for entrance into college.
4. The need for more uniformity of content in high school biology.

5. The teaching of biology as a laboratory science.

6. The need for an emphasis in biology teaching on the broader principles of the discipline.

7. The importance for all young people to receive instruction in hygiene and human physiology before completing high school (44, pp. 17-18).

C. W. Hunter (42) has described this decade (1890-1900) as a "period of the laboratory manual in biology teaching" (42, p. 27). This growth in popularity in laboratory work was directly influenced by the mental discipline theory of psychological development rather than by any careful consideration of subject matter. Laboratory work in science courses was seen as an excellent method of training and exercising the mental faculties involved in observation, will power, and memory.

In the decade from 1900-1910 the high school course in biology emerged. The subjects of botany, zoology, and physiology were beginning to lose enrollment both from the lack of pupil interest and inroads being made by the new course. The problems caused by (1) the failure to use student experiences, (2) the lack of an appropriate degree of rigor in the content of the course, (3) the limitations of the laboratory, and (4) the tendency to cover too much material, were analyzed by the Committee of the Central Association of Science and Mathematics Teachers in 1910. This committee suggested improvements in biology courses taking into consideration that
1. The problem-solving attitude on the part of the pupil is a thing to be striven for.

2. The pupil must be stimulated into the "problem-solving attitude."

3. Numerous applications of the subject to the present life and interest of the pupil and community should be made.

4. Abundant attention should be given to the natural questions of the pupils, as expressing this interest.

5. Suggestions of the present incompleteness of the subject, and slight glimpses into the great questions yet to be solved by the investigators.

6. The attempt to cover too much territory should be shunned; the course should progress no faster than pupils can go with understanding (38, pp. 809-810).

During this era, educators maintained that studying the sciences provided peculiar advantages to the students--advantages not to be found in the study of other subjects. The sciences were thought to provide "an unique opportunity for mental discipline by training the faculty of observation, promoting the concentration of thought and energy, and providing sense training through the manipulation of materials" (82, p. 8).

The developments in the teaching of biology from 1910-1920 reflected suggestions made by earlier committees and a rethinking of the basic issues. Hurd (44) has summarized this development, observing that during this period, several textbooks appeared on the market which purported to be concerned with biology. Teaching methods called for active participation by the student. Projects were geared to
increase student involvement. Courses were organized around problems and projects in an effort to help students understand the principles of science.

It was during this period that the high school enrollment increased. In addition, general science was introduced very rapidly in the 1920s in the curriculum at grade nine while biology courses were developed for grade ten, and physics and chemistry courses were instituted at grades eleven and twelve (22).

In 1913, the Committee on Natural Science of the National Education Association appointed a sub-committee of seventeen. These ten high school teachers, three university professors, three normal school instructors, and one physician, outlined aims, content, and methods of instruction in secondary school biology. They determined these objectives:

1. To train the pupil in observation and reasoning.

2. To acquaint him with his environment and with the common forms of plant and animal life, and especially with the structure, functions, and care of his own body, together with the general biological principles derived from this study.

3. To show him his place in nature and his share of responsibility for the present and future of human society (78, p. 45).

During 1914-1916, the same committee held a series of ten meetings. The committee revised its statement on the biology curriculum because it was found that the common practice of arranging elementary science into separate one-year
units was not working well. Despite the fact that many kinds of one-year units had been tried and proved unsatisfactory, the committee was finally able to set forth a course in elementary science which met the administrative and pedagogic needs of the situation. The objectives were stated as follows:

1. Biology should arouse interest in nature, by giving boys and girls first-hand acquaintance with their environment.

2. Biology should emphasize some of the most important applications of science to human welfare, and especially should familiarize the pupils with the structure and functions of their own bodies to the end that they may know how to live healthfully and happily.

3. Biology should give pupils some training in careful observation and in forming logical conclusions, through the solution of problems, and the carrying out of projects, etc.

4. Biology should make real to the pupils the value of intensive study of any given science as a means through which scientific progress is attained (79, pp. 502-503).

In 1918, the Commission on the Reorganization of Secondary Education of the National Education Association, appointed a committee to determine if the science curriculum met the terms of the Cardinal Principles of Secondary Education: health, worthy home membership, vocation, citizenship, the worthy use of leisure, and ethical character. This report was done in an attempt to shift the educational focus from the disciplinary emphasis to a broader view of science which stressed the practical requirements of the students. With these goals in mind, the committee recommended several
objectives for developing a biology curriculum:

1. The World War has emphasized health as a basic end of education. Since much of biology deals directly with problems of health, the course in biology must accept efficient health instruction as one of its chief and specific ends.

2. The biological sciences should develop the pupil's purposeful interest in the life of the environment by giving a first-hand acquaintance with plant and animal neighbors.

3. Biology should emphasize some of the most important applications of biological science to human activities and to general and individual human welfare, and especially should familiarize the pupil with the structure and functions of his own body, to the end that he may know why he must live healthfully in order to live happily and usefully.

4. Biology should train the pupil to observe life phenomena accurately and to form logical conclusions through the solution of problems and through projects essential to the productive work of agriculture, gardening, etc.

5. Biology should enrich the life of the pupil through the aesthetic appeal of plants and animals studied, to the end that he may appreciate and enjoy nature.

6. Biology should demonstrate to the pupil the value of intensive study of biological science as a means through which scientific progress is attained. In view of what science has meant to our present day civilization and in view of the measure in which the methods and results of scientific investigation are today reflected in intelligent thought and intelligent action, the need of the life sciences in the education of modern citizens can not be ignored (21, p. 30).

This report clarified educational thought concerning the developing of science curricula. Most important was the committee's attempt to determine social objectives for science instruction in terms of the seven cardinal principles.
The reports from the Committee on the Reorganization of Science led local committees to examine their own biology curricula with attention to the Cardinal Principles of Secondary Education. In 1927, the Committee on Standards for Use in the Reorganization of Secondary School Curriculum of the North Central Association described these objectives in their report:

I. The ultimate objectives of science teaching:

1. To maintain health and physical fitness.

2. To use leisure time in right ways.

3. To sustain successfully certain definite social relationships such as civic, domestic, community and the like.

4. To engage in exploratory-vocational and vocational activities.

II. The immediate objectives of science teaching:

1. Acquiring fruitful knowledge:
   a. which is preparatory to acquiring other knowledge.
   b. which functions directly in developing dispositions and abilities.
   c. which is useful in the control of situations of everyday life.

2. Developing attitudes, interests, motives, ideals and appreciations.

3. Developing definite mental techniques in perception, memory, imagination, judgment, and reasoning.

4. Acquiring right habits and useful skills (28, pp. 510-14).

This report caused many science teachers to recognize the opportunity to utilize a much wider range of material that could meet the specific needs of the students.
In 1927, a special committee of the American Association for the Advancement of Science issued the report entitled "On the Place of Science in Education" (76). The committee's suggestions included recommendations that teaching nationwide be re-examined to determine problems and that a national council of science teachers be organized. The committee also saw the scientific method as the primary objective of instruction.

From 1920 to 1930, many educators saw as the central purpose of education in science instilling in the student a clear understanding of the nature of science itself, its methods, attitudes and cultural impact. As a result, educational research in the years that followed was directed toward determining exactly what these elements of scientific methods and scientific attitudes were. In addition, immediate objectives of schools and colleges came to be the understanding and application of scientific methods to new situations (44). Yet the mastery of subject matter continued to be the primary aims of science instruction in the 1920's and 1930's, despite the fact that much work was done on the formulation of scientific generalizations that could be used as objectives for continuity in the science program (22).

In an attempt to achieve this continuity in science curricula, between 1930 and 1940 general science was introduced in the seventh and eighth grades. In addition, advanced general
science courses were developed for grades eleven and twelve to replace physics and chemistry. At the same time, biology became a basic science course.

In 1932, S. Ralph Powers directed a committee which developed a Program for Teaching Science. The committee, sponsored by the National Society for the Study of Education, presented the aims and objectives of science education as follows:

The principles and generalizations that ramify most widely into human affairs may be stated as objectives of science education and educational values from science teaching will have been attained if students acquire: (1) an ability to utilize the findings of science that have application to their experiences; (2) an ability to interpret the natural phenomena of their environment; and (3) an appreciation of scientific attitudes through an understanding of, and ability to use, some of the methods of study that have been used by creative workers in the field of science (71, p. 50).

The committee compiled a list of 38 generalizations designed to give direction to the science curriculum from grades one through twelve and, which, in addition, provided a balanced program of traditional subject matter areas. These objectives represented a broad approach to the problems involved in planning curricula (22). A brief quotation from the report will clarify this point:

The major generalizations and associated scientific attitudes are seen as of such importance that understandings of them are made the objectives of science teaching. These statements are so far-reaching in their implications that they may be said to encompass the fields of science. They touch life in so many ways that their attainment as educational objectives constitutes a
large part of the program of life enrichment
....In the light of the foregoing it is pro-
posed that the curriculum in science for a pro-
gram of general education be organized about
large objectives, that understanding and en-
largement of these objectives shall constitute
the contributions of science teaching to the
ultimate aim of education, and that the course
of study be so organized that each succeeding
grade level shall present an increasingly en-
larged and increasingly mature development of
objectives (82, p. 44).

The development of objectives for the teaching of biol-
ogy was particularly important to educators in the 1930s.
In 1933, the Office of Education, United States Department of
the Interior, reviewed science teaching practices, examining
thirty-two courses of study in biology for statements of ob-
jectives. They found 75 different objectives, some of which
were very specific, some quite general. These objectives
were then classified under the appropriate heading: knowledge,
exploration, abilities, attitudes, ideals and habits, or
interests. Among the objectives most frequently listed were
the following, which assumed that a course in biology should
allow the student

1. To acquire knowledge that will produce a better
   understanding of our environment.

2. To acquire knowledge which will function to
   achieve the Cardinal Principles of Secondary
   Education.

3. To develop an appreciation of nature and of
   one's responsibility in the world.

4. To acquire knowledge of the fundamental prin-
   ciples of biology.

5. To acquire an interest in nature.
To develop the ability to think scientifically (10, pp. 11-12).

The educators felt that the purpose of general education was to meet the needs of individuals in the basic aspects of living.

In 1932, the Progressive Education Association, through its commission on Secondary School Curriculum, established the Committee on the Function of Science in General Education (82). Three years later, the Commission on Secondary Curriculum published its report which stressed the need for a curriculum that would teach students practical application to the problems of living. The Commission also saw reflective thinking and the understanding of economic relationships as important objectives (22). Hurd summarized the report of the committee, citing the following as suitable aims and objectives of science teaching:

1. To acquire understanding in science as distinguished from information.
2. To develop the ability to think reflectively.
3. To develop particular skills or abilities related to problem solving.
4. To develop certain attitudes and dispositions useful to problem solving in science.
5. Meeting the needs of adolescents in personal living, immediate personal-social relationships, social-civic relationships, and economic relationships (44, pp. 63-64).

In 1938, the Committee on Secondary School Science, the National Association for Research in Science Teaching, published a report on methods and theories in the teaching of
science to secondary school students. They decided that the objectives of secondary school sciences were

1. To provide exploratory experience for the acquisition of new fields of interest.

2. To develop a mastery of those knowledges which are functional in aiding the individual to adjust himself in a more satisfying manner to the world about him.

3. To impart certain abilities to the student.

4. To develop certain attitudes or traits in the learner.

5. To develop an appreciation of the contribution of science to mankind (43, pp. 226-227).

The committees reporting in the 1930s emphasized the need for the study of science for all young people. They developed curricula which they hoped met the personal and social needs of the students and community. The objectives listed in their reports related not only to the acquisition of knowledge, but to the development of scientific thinking and principles.

From 1940 to 1950, science teaching was affected by the general education and consumer movements of the thirties as well as the technical manpower crisis resulting from World War II. Educators looked upon science as a means for meeting the needs generated by these forces. Because of this optimistic view of science and its application, the scientific attitude was recognized as a worthy goal for all students in science courses at all levels (44).

In 1944, the Educational Policies Commission of the National Education Association issued a report entitled
Education for All American Youth (31). This report represented three years of study during which time the commission developed a statement of general principles with suggestions for bringing these into school practice. It was recommended that

1. Science instruction should begin in the first grade and continue throughout the secondary school.

2. Not only the scientific facts should be taught but also the methods by which these facts were discovered; there is a real danger that pupils may learn to take science on the authority of the textbook and the teacher and fail to develop the attitude of critical inquiry which marks the scientific mind.

3. Students should practice scientific inquiry to develop knowledge of the experimental method, and understanding of the nature of truth and a respect for truth arrived at by rational processes.

4. Students should be stimulated to approve the way in which science has influenced man's way of living and thinking (31, pp. 129-132).

The Committee of the National Society for the Study of Education, Forty-sixth Yearbook, Part I, 1947, (72) proposed the types of objectives believed available. These included (1) functional information or facts, (2) functional concepts, (3) functional understanding of principles, (4) instrumental skills, (5) problem-solving skills, (6) attitudes, (7) appreciations, and (8) interests. Less emphasis was placed on rote memorization and more on the functional aspects of science. In addition, teaching students the basic general scientific principles and helping them to develop problem-solving abilities were stressed. At the same time, skill in problem-solving,
in gathering and testing data, in identifying and solving problems, and in examining the validity of conclusions was strongly encouraged as the primary aim of science education.

The decade from 1950 to 1960 saw drastic changes for science curricula. University scientists and mathematicians claimed that the college freshman were very poorly prepared in science and mathematics. These educators claimed that the high school courses "lacked rigor, were dogmatically taught, were content oriented, lacked conceptual unity, were outdated and had little bearing on what was really happening in the scientific disciplines" (22, p. 31).

This situation called for reform and change. The first major effort in this area was carried out in 1954 at the Southeastern Conference on Biology Teaching. The major objectives of the conference were to

1. Establish the proper role and major contributions of the fields of morphology, taxonomy, physiology, evolution and paleontology, genetics, ecology and conservation in the training of biology teachers.

2. Identify and select some of the major problems found in the teaching of high school and college biology ....

3. Develop suggestions and recommendations for the improvement of biology teaching in high school and college ....

4. Provide for preparation of state plans for implementation of the recommendations of the conferences ....(16, pp. 5-6).

The conference representatives felt that course objectives should embrace the principles of biology but provide
local applications. They saw field work and laboratory experience with living organisms as essential tools in teaching high school students the methods, approaches, and attitudes of biological scientists.

In 1955 the North Central Conference on Biology Teaching, conducted by the National Association of Biology Teachers, was held at Sheboygan, Michigan (2). The conferees were composed of 87 high school science teachers, college biology teachers, science education specialists, and public school administrators. The objectives of the conference were very similar to those selected for the Southwestern Conference.

In the study of biology, the conferees recommended that

1. There should be a year of biology in the ninth grade or preferably in the tenth grade, and use should be made of relevant extra-curricular community and organizational activities at all levels.

2. This general biology course should be designed for all students.

3. Teachers should recognize individual differences among the pupils, in ability, preparation, and background. They should make a reasonable effort also to identify similarities.

4. Teachers should provide a variety of materials and assignments to give full scope to individual differences.

5. Capable students interested in science should have opportunity to become acquainted with working scientist by obtaining their assistance on special projects, tours of scientific institutions, short intensive courses in special topics given for them in colleges, universities, research institutes and field stations, and summer apprenticeship programs.
6. Students interested in biology should be encouraged to take mathematics, chemistry and physics in high school, along with biology and work in other major areas. The school should make such a program available. Moreover, the students interested in biology should have an opportunity to develop through individualized work or advanced course, with credit, in the junior and senior years.

7. A possible approach to the general biology course would include student cooperation with teacher guidance of individual and group projects, the use of individual school and community resources in establishing the objective of the course, and evaluation scheme for the total performance of individuals (2, p. 49).

To meet the educational problems of effective laboratory work, the Sourcebook of Laboratory and Field Studies in Biology was prepared during a writing conference held at Michigan State University during the summer of 1957 (44). The writing team was composed of twenty high school biology teachers and ten biologists from colleges and universities. This team decided that

There are at least three dimensions in a study of biology. The three we use reflect the three objectives set for the high school course: (a) the processes of scientific investigation; (b) the variety of organisms; and (c) approaches, concepts and principles as developed in the outline. Others could replace them or be added to them, including levels of biological organization, dynamic relationships among these levels, types of approach, tools of investigation, disciplines, etc. (44, p. 129).

In 1955 an Education and Professional Recruitment Committee was appointed by the American Institute of Biological Sciences was charged with the development of a biological program in "new course content, laboratory manuals and teacher aids; the production of films, film strips, charts
and models; and a study of present in-service training of teachers to increase the effectiveness of biological education at all school levels" (44, p. 135).

These changes in science education were introduced gradually, but when, in 1957, the Russians launched Sputnik, a program of reform was sparked with aid from the National Science Foundation (NSF) and other federal agencies. NSF stated that its role was merely to support the development of materials, that the adoption or rejection of these materials rested with local school authorities. The course-content improvement program thus was designed to address problems in local schools. The science teacher was encouraged to develop student interest and to lead the student to a broader understanding of the whole scientific enterprise (68).

In 1959, the American Institute of Biological Science Education Committee sponsored the Biological Sciences Curriculum Study (BSCS). According to the AIBS grant proposal which was submitted to the National Science Foundation in September, 1958, the function of the NSCS was to improve education in biology at all levels: elementary, secondary, collegiate, professional, and graduate; to evaluate the content of present biology courses; to determine what biological knowledge could and should be learned at each level; and to recommend how this latter goal could best be achieved (40).

Moore, stating the objectives of the BSCS, observed that a biology course should provide the student with
1. An understanding of his own place in the scheme of nature; namely, that he is a living organism and has much in common with all living organisms.

2. An understanding of his own body, its structure and function.

3. An understanding of the diversity of life and of the interrelations of all cultures.

4. An understanding of what man presently knows and believes regarding the basic biological problems of evolution, development, and inheritance.

5. An understanding of biological basic of many of the problems and procedures in medicine, public health, agriculture and conservation.

6. An appreciation of the beauty, drama and tragedy of the living world.

7. An understanding of the historical development of examples of some of the concepts of biology to show that these are dependent on the contemporary techniques, technology, and the nature of society.

8. An understanding of the nature of scientific inquiry; that science is an open-ended intellectual activity and what is presently "known" or believed is subject to "change without notice"; that the scientists in his work strives to be honest, exact, and part of a community devoted to the pursuit of truth; that his methods are increasingly exact and the procedures themselves are increasingly self-correcting (66, p. 22).

Although between 1957 and 1965, federal funds were readily available from the National Science Foundation to implement changes in the public high schools' science and mathematics curricular, educators were ignoring social needs and problems. Instead, the objectives of science teaching were derived from the respective scientific disciplines. The curricular which had been developed before this time were undergoing scrutiny and criticism. However, the curriculum
reformers still emphasized the importance of students' understanding the nature of science and the scientific enterprise. Collette states that

...goals will be defined in the long run in intellectual competency terms with little or no emphasis on person-social goals. Goals will emphasize science as a way of thinking and obtaining information, therefore placing great importance on the processes of science. Less emphasis will be placed on facts and more emphasis will be on models and theories of science. Creativity, concept formation, abstract thinking, and discovery learning are gradually taking the place of role memorization of facts, concepts and principles. Goals dealing with science and general education will be emphasized. And there will be more stress on presenting the interrelationships of science as well as the broader meanings of science. The goals involving the relationship of science and other disciplines such as the humanities and social sciences will be given much attention. In general, the primary consideration in establishing goals for science teaching will be an education in science for change and for the future and not on education which focuses upon the problems of the world as it is at the moment (22, p. 37).

In 1964, The National Science Teachers Association (NSTA) brought together a group of scientists who agreed on major underlying conceptual schemes and major aspects of scientific process. With the central purpose of the National Science Teachers Association (NSTA) to improve the science instruction at all educational levels, NSTA committed itself to a concern not only with curriculum development in terms of course content, but also with teacher education, instructional materials, teaching methods, and adequate facilities.

The National Science Teachers Association agreed that an efficient school science program
1. Must start as early as kindergarten or first grade;

2. Must be articulated from one level to the next through grade twelve or higher;

3. Must encompass a full range of the contemporary knowledge and ideas which scientists employ;

4. Must result in understanding the nature of the scientific enterprise through direct student involvement in the processes of scientific inquiry;

5. Must involve the best that is known about child growth and development and the psychology of learning; and

6. Must be supported by first-rate staff, facilities, and instructional materials (69, p. 35).

In this same regard, Hurd has indicated that a theory of instruction and modern curriculum development should include the following aspects of instruction:

1. The nature of science: its structure, its processes of inquiry and its conceptual schemes.

2. The nature of the learner: his motives, cognitive style, emotional background, and intellectual potential.

3. The nature of the teacher: his cognitive style, ability to communicate, control pattern, educational philosophy, and understanding of science.

4. The nature of learning: its processes, contexts, conditions, and purposes.

5. The nature of curriculum: its organization, sequence, and its substantive, attitudinal, and procedural dimensions.

6. The nature of social structure: social and cultural forces with their demands and incentives (45, p. 13).
Bybee has emphasized that the structure of science education which underlies the organization of curriculum should be directed toward "(1) empirical knowledge of physical and biological systems; (2) scientific methods of investigation; and (3) personal development of the student" (19, p. 85). He further explains that the first of these aims includes such matters as facts, conceptual schemes, and the structure of a discipline, as well as the application of acquired knowledge; the second aim involves those processes scientists use to generate new knowledge; and the third aim takes into consideration the abilities and requirements (mental, emotional, physical, and social) of the students for assimilating the knowledge and methods of science (19).

The brief historical survey illustrates how science education has resulted from a conscious effort to meet the needs and demands of society, resulting in a continual process of reform within the community of science educators. The investigator ends this section in agreement with Bybee's conclusion that

1. Reform of curriculum materials and instructional techniques should start at the elementary level and continue up to the secondary schools and finally to higher education.

2. Initial effort should concentrate in the areas of environmental, earth, and biological sciences.

3. The curriculum should introduce scientific concepts fundamental to issues such as population growth, ecology, energy, technology, and economics.
4. The programs should incorporate the goals of personal development and problem-solving much more than they have in the past.

5. Instructional programs should extend the students' perceptions concerning the environment from the present to the future; they should develop a concern for both the individual and humankind; and, problems should be understood as both isolated phenomena and complex interacting systems.

6. Teaching should be personalized and emphasize elements of interpersonal and group dynamics.

7. Instruction should encourage the development of values through the presentation of attitudes inherent in the scientific enterprise; the clarification of personal values; the consideration of ethical choices and the re-evaluation of one's own moral positions.

8. Specific emphasis should be placed on the requirements of effective implementation of the new materials (20, p. 360).

Course Content and Textbooks

As has already been observed, science instruction in secondary education in the United States began in 1751 in the Philadelphia Academy founded by Benjamin Franklin. At that time the biological course was divided into natural history, botany, zoology, and physiology. Yet there was little continuity among the courses. The botany course covered such areas as gardening, planting, and innoculating and involved the reading of natural history, while zoology was offered as a part of the geography course.

As late as the 1800's textbooks were few. The impact of Asa Gray's college text on plant analysis, in 1842, was to influence the change from Linnaeus' classification system
to the natural system, a change which came primarily in the high schools.

Around 1875 there was a movement away from the natural history approach to the study of botany and zoology toward animal morphology and studies of internal anatomy. After the publication of the theory of evolution in 1860, the botany and zoology course began to focus on the study of structural types. Plant physiology came to be studied in high school botany courses at this time, too (116).

In 1893, the Botany Committee of the Committee of Ten suggested that curricula include a year of botany organized to include one lecture, three laboratory periods, and one quiz period per week.

The following subject sequence was outlined:

1. Green slimes
2. Green algae
3. Brown algae
4. Red algae
5. Fungi
6. Stoneworts: for example, Chara or Nitella
7. Bryophytes: liverworts and mosses
8. Pteridophytes
9. A gymnosperm

It was recommended that pupils study each type of plant life intensively, examining cell structure, development, reproduction, and life history, drawing representative sketches when possible.

At the same time the Zoology Committee of The Committee of Ten emphasized animal morphology. The committee further recommended that the course be organized to include laboratory
experiments and include a semester of anatomy, physiology, and hygiene. The following one-year sequence was recommended:

1. Protozoa
2. Porifera
3. Coelenterata
4. Echinodermata
5. Worms
6. Mollusca
7. Arthropoda
8. Insects: the grasshopper was recommended as a type; eight orders of insects were recommended for study.
9. Vertebrates:
   a. Fish
   b. Batrachians: frogs and toads
   c. Reptiles
   d. Birds
   e. Mammals: with some orientation toward man

From 1900 to 1920, the teaching of biology was influenced by developments in medicine, hygiene, and sanitation and applications of laws of heredity to eugenics and conservation. Hunter (42) claims that biology courses and their content were shaped more by the interests of the public and the teachers at this time than by the university committees. The findings and conclusions of committees like the Commission on the Reorganization of Secondary Education still had considerable impact on curriculum development, but with an eye to public opinion, they organized curricula to cover areas like health, economic importance, sanitation, vocational aspects, and appreciations.

The Society's Committee on the Teaching of Science, in 1932, agreed that the authors of textbooks should be

(1) subject-matter specialists who insure that the materials are accurate and up-to-date; (2)
classroom teachers and supervisors who refine the materials in the light of their appropriateness of content and difficulty; and (3) specialists in the teaching of science who contribute a knowledge of developments in the field with respect to educational research (71, p. 110).

The Committee did not feel that teachers were qualified to generate their own classroom materials. The Committee also felt that although university teachers had adequate knowledge of subject matter, they lacked the experience and training to meet the students' needs in practical classroom application while teachers lacked adequate background in subject matter to supplement the information in their texts (71).

The Committee determined that, in order to meet the needs of the students, the course content should be developed around the principles of biology. These principles were

1. Energy cannot be created or destroyed, but merely transformed from one form to another.

2. The ultimate source of the energy of all living things is sunlight.

3. Micro-organisms are the immediate cause of some diseases.

4. All organisms must be adjusted to the environmental factors in order to survive in the struggle for existence.

5. All life comes from previously existing life and reproduces its own kind.

6. Animals and plants are not distributed uniformly or at random over the surface of the earth, but are found in definite zones and in local societies.
7. Food, oxygen, certain optimal conditions of temperature, moisture, and light are essential to the life of most living things.

8. The cell is the structural and physiological unit in all organisms.

9. The more complex organisms have been derived by natural processes from simpler ones, these in turn from still simpler, and so on back to the first living forms (71, pp.224-226).

These principles were probably to be regarded as a series of more immediate or specific objectives under the major, general objective of acquiring knowledge. According to the committee, the teaching of principles was the most important step in developing in the student a clear understanding of the major generalizations relevant to scientific theory. The committee felt that such a position would call attention to the value of understanding underlying principles in the study of science. Understanding these general concepts could then make other experiences meaningful to the student and help him to determine appropriate action in any problem situation.

During the depression years (1930-1940) the emphasis in biology was on the welfare (personal, social, economic) of the individual student. Most textbooks stressed health education and consumer education, but the biology texts were still divided into their three traditional divisions: botany, zoology, and physiology. Yet, many research studies indicated that it was possible to help students in the sciences to develop skills in thinking, to change attitudes, to center instruction on principles, and to develop some self-direction (44).
Early in the 1940's a report of the Committee on the Teaching of Biology of the Union of American Biological Societies (87) circulated a questionnaire on high school biology teaching. The questionnaire received responses from 3,186 biology teachers and it was the consensus of the respondents that the greatest emphasis in any general biology course should be on the following topics:

1. Health-disease, hygiene
2. Physiology
3. Heredity
4. Conservation
5. Structure (87, p. 64).

The teachers gave the lowest rating (in terms of emphasis) to these topics:

1. Eugenics
2. Behavior
3. Scientific method
4. Photosynthesis
5. Biological principles (87, p. 64).

In 1945, the Harvard Report, General Education in a Free Society, was published (86). The report suggested a shift in focus with regard to the teaching of biology, maintaining that biology should be primarily a study of the work of great biologists. In such a curriculum, corresponding projects and field experience should parallel the work in the classroom. After the preparation (in 1932) of A Program for Teaching Science (71), curricula came to be centered less on the presentation of subject matter and more on achieving results in the lives of students. The Society's Committee on Science Education in American Schools (72), in 1947, agreed that high
school biology courses should include materials related to

1. Health (personal and public, including physical fitness, food and nutrition, disease, safety, mental health, etc.)

2. Reproduction, heredity, and the effect of the environment (as related to personal and social problems, individual and group differences, improvement of living organisms, etc.).

3. The conservation of living things.

4. The structure and functions of living things, especially of the human body.

5. The conditions necessary to support life, and adaptations of living things.

6. Living things of the past, and the changes that have occurred.

7. Relations between individuals, between groups, and among living things in general (72, p. 184).

Martin's study, The Major Principles of the Biological-Sciences of Importance for General Education published in 1948, attempted to identify important biological principles. Of the three hundred principles which were identified, the top ten principles were as follows:

1. The food requirements of every living thing are: fuels capable of yielding, when oxidized, the supply of energy without which life cannot continue; materials for growth and for replacement for the slight wearing away of the living tissue involved in any activity; minerals, the necessary constituents of cell structures, of cell products, and "accessory" food factors (62, p. 11).

2. The cell is the unit of structure and function in all organisms (62, p. 10).

3. The protoplasm of a cell carries on continuously all the general processes of any living body; the processes concerned in the
growth and repair or upbuilding of protoplasm (anabolism) and the processes concerned with the breaking down of protoplasm and elimination of wastes from the cell (catabolism). The sum of all these chemical and physical processes is metabolism (62, p. 7).

4. Reproduction is a fundamental biological process that provides for the continuance of life on the earth by providing new individuals (62, p. 14).

5. Circulation is carried on in all living organisms. With increase in size and complexity of the body of an organism there goes a corresponding elaboration of the transportation (circulatory) system (62, p. 12).

6. All living organisms (except viruses and bacteriophage) carry on the common life processes: reproduction, growth, nutrition, excretion, respiration, and irritability (62, p. 9).

7. In the presence of sunlight the chloroplasts of chlorophyll-bearing plants convert carbon dioxide and water into intermediate substances, and these into sugar, and sugar into starch, and liberate oxygen, thus directly or indirectly producing practically all the food of the world (62, p. 7).

8. A balance in nature is maintained through interrelations of plants and animals with each other and with their physical environment (62, p. 25).

9. Cellular respiration (aerobic decomposition) occurs in all living cells, and all organisms posses structures by means of which it can be carried on. Its first step is intake of oxygen either directly from the air or dissolved in water; its final product is carbon dioxide, and free energy is released. In the cells it is accomplished at ordinary temperatures by the intervention of special enzymes (62, p. 12).

10. Cells are organized into tissues, tissue into organs, and organs into systems, the better to carry on the functions of complex organisms (62, p. 10).
Martin's work had a significant influence on the writing of high school biology texts at that time. The "principle-centered" course had enjoyed popularity for sometime, but with Martin's work, it began to give-way to the "theme-centered" course.

Traditionally the teaching of science in the secondary school has been concerned with the products of science rather than theories or concepts. During the first third of this century the biology taught in schools followed a phylogenetic approach; the school biology of the mid-third of the century followed a presentation which is inaccurately called a principles approach, in which topics such as heredity, health, and biological organization, were superimposed on the phylogenetic approach (39). The result was that the content of the texts gradually shifted away from the character of biology as a science. In many classes a good portion of the time was devoted to health education, memorization of human structures, and determining the causes of various diseases (74).

Hurd (44) has presented some of the national committee reports derived from a meeting in the early 1950's. These reports focus on two central problems: (1) the content of high school biology texts failed to incorporate current knowledge in biology, and (2) an unfortunate emphasis on terminology and memorization gave the impression that biology could be reduced to a set of standarized principles. The teaching of biology has become what Joseph Schwab termed a "rhetoric
of conclusions in which current and temporary construction of scientific knowledge are conveyed as empirical, literal, and irrevocable truths" (89, p. 24).

Ausubel (7) summarized the dissatisfactions he inferred from the content of the committee's voluminous publications:

1. Conventional texts abound in outmoded ideas and incorrect information, and ignore important contemporary developments in the biological sciences.

2. They are written at a largely descriptive level, and contain relatively few explanatory concepts; too much stress is placed on structural detail, useless terminological distinctions and classification, whereby placing a premium on rote memory.

3. Their approach is too naturalistic, and insufficiently experimental, quantitative, and analytical.

4. They tend to focus excessively on the organ and tissue levels of biological organization, whereas recent biological progress has been greatest at the molecular (biophysical and biochemical), cellular, population, and community levels.

5. They are written at too low a level of sophistication and contain a profusion of elementary and self-evident generalizations.

6. Insufficient emphasis is placed in biology as a form of inquiry, as an experimental science, and as an ever-changing, openended discipline.

7. The biological ideas they contain are not presented in terms of their historical development, and are not related to the social and technological contexts from which they arise.

8. They lack organizing and unifying themes, present a mass of disconnected facts, and fail to integrate related concepts and different levels of biological organizations.

9. They place excessive emphasis on the application of biology to such areas as medicine,
public health, agriculture, and conservation, and insufficient emphasis on basic biological principles as ends in themselves (7, p. 177).

Because of this dissatisfaction, together with the advances in knowledge by 1955, the American Institute of Biological Sciences (AIBS) appointed a Committee on Education to study education in the biological sciences. The Biological Sciences Curriculum Study (BSCS) was developed as a result of the action by this committee. University biologists and high school biology teachers developed a complete package of materials for high school biology.

Voss (115) has summarized the major emphasis of the BSCS biology programs:

1. An investigative approach to modern biology in contrast to a descriptive approach in former biology programs. Inquiry is the methods by which knowledge about biology is acquired. Biology is an open-ended field of study, not a set of encyclopedic facts.

2. The BSCS has provided a pure science approach in response to major advances in molecular and cellular biology, population biology, genetics and metabolism. The books place an emphasis on these areas and de-emphasize contributions from nutrition, health, disease, conservation, and agriculture.

3. Molecular and cellular biology are emphasized much more than the organ and tissue level of biology.

4. The BSCS program has further stimulated the development of outdoor biology laboratories.

5. Laboratory work is more investigative and quantitative than the former programs. This program required more lab space, equipment and supplies. Greater emphasis is placed on use of living materials than preserved specimens.
6. The BSCS program has attempted to take a fragmented, factual, compartmentalized field of biology and tie it together by emphasizing a theme approach.

7. The BSCS program provides a complete program for all biology students through such features as the special materials program, lab blocks, materials for gifted students, teachers' guide, technique films, pamphlet series and tests.

8. The BSCS curriculum has added discussion of evolution and human reproduction in its text material. Fifteen years ago we did not find much about this in biology books. There seems to be more acceptance by society for allowing this information to be taught.

9. The testing program has developed test items which examine the higher mental abilities of students such as comprehension, analysis, synthesis, application of facts, and the understanding of the methods of science rather than the mere memorization of facts (115, p. 145).

Because of the possibility of approaching biology from more than one viewpoint, the BSCS materials were divided into three separate sets of biology texts: the Yellow Version, emphasizing cell biology, genetics, and evolution; the Blue Version, emphasizing physiology and biochemistry; and the Green Version, emphasizing ecology.

In addition, the BSCS issued a statement called the "Commitment Required for the Effective Teaching of Modern Biology." It is stated that the successful teacher of modern biology must willingly be committed to

1. teaching a biology course in which the content and procedures relate to appropriate overall conceptual themes,

2. teaching a biology course based on stated and specific objectives.
3. teaching biology as a laboratory-centered course,
4. student inquiry as the important part of teaching biology,
5. the student's mind as the most important factor in learning by inquiry (81, pp. 11-12).

The materials developed by the BSCS delineated the content, themes, and objectives thought significant with clear explanations of the ideas inherent in each topic. They outlined seven levels of biological organization with a brief description at each level and reference to accumulated knowledge and associated functions.

The BSCS outlined nine unifying themes to bind together the various materials. These resulted from consideration of two significant areas: the content and structure of modern biology and the needs of students. The themes were arranged so as to suggest their inter-connections: 1 - 5 are concerned with content, 8 - 9 involved the context of data and inference through which their content is conveyed, and 6 - 7 provide a transition concerning both structure (processes) and content.

1. Change of living things through time: evolution.
2. Diversity of type and unity of pattern in living things.
3. The genetic continuity of life.
4. The complementary of organism and environment.
5. The biological roots of behavior.
6. The complementary of structure and function.
7. Regulation and homeostasis: preservation of life in the face of change.


Non-BSCS commercial textbooks of this time included materials on cellular physiology, biochemical genetics, and ecosystem ecology. Most of them also retained the conventional taxonomic and systematic physiology material to a greater or lesser extent. The laboratory guides changed very little, relying on "show and tell" laboratory exercises. However, these texts made provision for utilizing living organisms rather than preserved materials (114).

Because the textbook is so important a tool for learning, and because the teacher uses the text for a guide, some suggestions have been given by Voss and Brown (116) for selecting a text:

1. The authors should be competent in the field of biology.

2. The text should be oriented toward inquiry; not all the problems in biology have been solved.

3. The text should adequately cover the field of biology. The structure of biology as discipline should be revealed.

4. The text should be up-to-date -- written within in the last five years.

5. The text should be suitable for the students. It should not be too difficult or too easy for them.

6. There should be adequate aids for the teacher in terms of summaries, study questions, film lists, teacher's guide, bibliography, and illustrations.
7. The text should present an authoritative picture of biology. Biology should be treated as a science. The book should be accurate.

8. The text should be written at a reading level appropriate for the majority of the students.

9. Some history of biology and discoveries of biologists should be included (116, pp. 125-126).

The proper use of these materials is, of course, important to furthering the abilities of the students.

Science as Inquiry

In many of the science curricula developed in the United States since 1957, the thrust of the program has been toward acquainting the student with scientific process by encouraging active involvement in investigation and inquiry. The modern view is that science education must present information that has survival value, utilizing strategies of inquiry that enable the student to adapt knowledge to new demands.

Thus recent texts stress the importance of teaching the inquiry processes. Inquiry skills provide help for the student to do independent research while developing his ability to formulate his own thought. A meaningful curriculum recognizes the thought processes occurring within the individual student. The Harvard Committee on Objectives of a General Education in Free Society, appointed by President James B. Conant in 1943, (86) states:

By characterization we mean aims so important as to prescribe how general education should be carried out and which abilities should be sought above all others in every part of it. These
abilities, in our opinion, are: to think effectively, to communicate thought, to make relevant judgments, to discriminate among values (86, pp. 64-65).

There is one major goal of science education which influence all other goals as well as all science educators. This goal "is to develop scientifically literate and personally concerned individuals with a high competence for rational thought and action" (70, p. 47).

In order to provide the student with an adequate grasp of science, a course must present the body of knowledge, the various sets of theories and conceptual schemes, and a process of inquiry.

J. Myron Atkin (4) has described the duality of content and the method of inquiry in the following manner:

No conception of science is complete unless we are aware that one of these parts represents an attempt to comprehend and explain nothing less than the entire universe and what happens in it, by seeking to derive fundamental generalizations that account for motion, for life, for all the changes we know. And no conception of science is complete unless we are also aware that a second element represents this search for understanding as a human activity, an activity that engages men....

The former element of science....is sometimes called the "content of science, or, less commonly, the "product" of science, or the "major concepts" of science.

The latter element is sometimes called "process" but it has had other names over the decades such as "problem solving," "scientific methods," and "inquiry" (4, p. 6).

The National Science Teacher Association holds that instilling scientific literacy involves the development of
attitudes, process skills, and concepts necessary to meet the more general goals of all education, such as

- learn how to learn, how to attack new problems, how to acquire new knowledge.
- using rational processes.
- building competence in basic skills.
- developing intellectual and vocational competence.
- exploring values in new experiences.
- understanding concepts and generalizations.
- learning to live, harmoniously within the biosphere (70, pp. 100-101).

Modern science curricula use a variety of educational objectives to achieve these goals, but perhaps a few work as well as does inquiry. When inquiry methods in science curricula were introduced into the high school, they were directly related to physics, chemistry, and biology. Of these programs, the Biological Science Curriculum Study (BSCS) is probably the best (46).

These materials were developed between 1959 and 1968 by thousands of college, university, and high school educators. The BSCS recognized that the most important aspect of implementing any curriculum is the relationship between teacher and student. To help educators achieve this cooperation, the BSCS Teacher Preparation Committee issued a special publication called New Materials and Techniques (81, pp. 13-18) and a second edition of the BSCS-Biology Teachers Handbook, edited by Evelyn Klinckman (54, pp. 25-43). Both publications included a variety of objectives and teaching strategies to help in this effort.
The thematic goals of BSCS were so developed that they could be elaborated upon by individual teachers. The following were presented as basic guidelines to achieve the general objectives of the BSCS themes; the student should demonstrate some of the following behaviors in the context of the theme in question.

1. Observe and record data.

2. Measure within specific limitation (imposed by the teacher, problem, etc.).

3. Communicate his data to other students and the teacher.

4. Operate various pieces of scientific equipment.

5. Interpret graphs and other forms of data.

6. Identify relationships.

7. Formulate hypotheses.

8. Design experiments.

9. Identify cause and effect relationships.

10. Identify causative and contributing agents.

11. Generalize and formulate tentative conclusions based on relevant data (81, p. 16).

In the following sections, the investigator examines the definition of inquiry, the reasons for inquiry, and models for understanding it. The empirical research concerning the use of inquiry is also considered.
Definitions of Inquiry

A variety of terms have been used to describe the complex methodologies used in the discover-inquiry method of teaching science. Heuristic, problem-solving, reflective thinking, scientific thinking, discovery and inquiry, are all terms associated with scientific investigation. But these terms overlap and it is not always easy to separate nuances of meaning. Bruner suggests that a significant relationship among problem-solving, inquiry and discovery exists. He states that

It is evident then that if children are to learn the working techniques of discovery, they must be afforded the opportunities of problem-solving. The more they practice problem-solving, the more likely they are to generalize what they learn into a style of inquiry that serves for any kind of task they may encounter. It is doubtful that anyone ever improves in the art and technique of inquiry by any other means than engaging in inquiry or problem-solving (17, p. 27).

Searles (92, p. 32) concludes that

The discovery and inquiry methods of investigation used by students in science education are now considered as synonymous. When a student undertakes an investigation, and inquiry, he is searching for information, knowledge or truth. At the moment he recognizes the information he was, or, as in the case of serendipity, was not seeking, he experiences the act of discovery. In this manner, an inquiry leads to a discovery. The discovery method is an attempt to reach the experience of discovery; the process of inquiry is therefore implicit in the method. The interrelationship of these two terms, inquiry and discovery, is such that they are considered interchangeable. Inasmuch as an inquiry does not always lead to a discovery, the inquiry method is to be preferred.
Atkin (3) outlines eight steps in scientific inquiry. They are (1) sensing a problem and deciding to find an answer for it, (2) defining the problem, (3) studying the situation for all factors bearing on the problem, (4) making the best tentative hypothesis as to the solution of the problem, (5) selecting the most likely hypothesis, (6) testing the hypotheses, (7) drawing a conclusion, and (8) making references based on the conclusion.

Curtis (23), through an analysis of the history of science, has determined the following techniques as characteristic of scientific inquiry. They include (1) locating the problems, (2) making hypotheses from given facts, (3) recognizing errors and deficits in the condition or experiment described, (4) evaluating data or procedures, (5) evaluating conclusions in light of the facts, (6) planning and making new observations, (7) inventing check experiments, (8) isolating the experimental factor, and (9) using controls.

Keesler (53) lists the following elements of scientific inquiry: (1) sensing a problem, (2) defining a problem, (3) studying the situation for all facts and clues bearing upon the problem, (4) making the best tentative hypothesis as to the possible solution of the problem, (5) selecting the most likely hypothesis, (6) inventing and planning one or more experiments to test the hypothesis, (7) testing the hypothesis by carrying out an experiment, (8) running check experiments involving the same experimental factors to verify the results
observed in the original experiment, (9) drawing a conclusion, and (10) making inferences based on this conclusion when facing new situations in which the same factors are operating.

Dressel and his colleagues (29), see the most common elements listed in the definitions of scientific inquiry as (1) recognition of the problems, (2) collection of relevant data, (3) formulation of hypotheses, (4) testing of hypotheses, and (5) drawing of conclusions.

BSCS and Mid-continent Regional Educational and Laboratory (McREL) gives the definition of inquiry as

Activities which are directed towards solving an open number of related problems in which the student has as his/her principal focus a productive enterprise leading to increased understanding and application (13, p. 1).

Anderson and Koutnik write,

Inquiry is a set of activities directed towards solving an open number of related problems in which the student has as his personal focus a productive enterprise leading to increased understanding and application (1, p. 4).

Massialas and Zevin note that

Inquiry, as we define it, is behavior which is characterized by a careful exploration of alternatives in seeking a solution to a problem (63, p. 7).

Sund and Trowbridge suggest simply that "inquiry is a search for knowledge or truth" (108, p. 37). Suchman states that "inquiry is a way to investigate causation" (107, p. 1). He also explains,

Inquiry can be divided into four main types of action: searching, data processing, discovery,
and verification. While none of these actions is unique to inquiry, they are all essential to it and, in combination, form a cycle of operations that characterize the inquiry process (107, p. 5).

Implicity in each definition is the assumption that inquiry is a function of the intellect. Inquiry skills and processes are those involving the gathering and processing of information by human beings. The emphasis of inquiry is on the acquisition of information so that one can make intelligent decisions (117).

**Reason for Inquiry in Science Instruction**

This use of the scientific process as a means to knowledge could be seen in curricula as early as 1924. The committee "On the Place of Science in Education" of the American Association for the Advancement of Science (76) conducted a study on the problems of teaching science. The report emphasized scientific thinking as an objective of teaching. The purpose of science instruction, according to the committee, was to provide a basis for observation and experimentation worthy of the spirit of science (76).

In 1947 the **Forty-sixth Yearbook** of National Society for the Study of Education (72) presented science as a functional understanding of concepts, principles, skills, a set of attitudes, appreciations and interests. It was seen to have value in teaching students to be thinking adults.

The Educational Policies Commission, in 1961, a Commission of the National Education Association of the United
States and the American Association of School Administrators, has stressed this point:

The purpose which runs through and strengthens all other educational purposes -- the common thread of education -- is the development of the ability to think. This is the central purpose to which the school must be oriented if it is to accomplish either its traditional tasks or those newly accentuated by recent changes in the world (31, p. 12).

Schwab also emphasizes,

...teaching science merely as authoritative facts and dogma has had an extremely bad effect on American attitudes towards science and scientists. Such methods of teaching science divorce the conclusions of science from the data and the conceptual frames that give conclusions their meaning (90, p. 130).

John Dewey spoke emphatically of the danger of developing a curriculum entered wholly on subject matter. As early as 1910 he stated,

...science teaching has suffered because science has been so frequently presented just as so much ready-made knowledge, so much subject matter of fact and law, rather than as the effective methods of inquiry into any subject-matter (26, p. 124).

He proposed that the reflective thinking must be an educational aim. In his own words,

...thinking enables us to direct our activities with foresight and to plan according to end-in-view, or purposes of which we are aware. It enables us to act in deliberate and intentional fashion to attain future objects or to come into command of what is now distant and lacking (27, p. 17).

Traditional courses in science often fail because they fail to get across to students the elements of scientific inquiry. Traditional courses do provide the student with
significant facts, important principles, and the capability of using previously discovered principles in new situations, but they fail to encourage him to acquire inquiry skills (37).

Recent developments in science curricula stress the teaching of science as inquiry. The inquiry method gives students more chances to think and learn how to think critically. The inquiry method forces students to see science as a continuing process, constantly clarified by the analysis of empirical evidence. As inquirers, students become independent scholars; they learn to examine, synthesize, or reject data presented to them (108).

The supporters of the inquiry process believe there is a need for a change from the dogmatic approach to the inquiry approach in the teaching of science. They recognize that the nature of the subject brings certain requirements (11, 83, 88). First, scientists are in demand, yet, traditionally, methods of teaching generally do little to encourage students to seek careers in science. Second, political leaders need to be educated to discriminate between good and wasteful projects which could promote (or retard) the advancement of science. Third, the public needs to understand that science is not infallible. Fourth, the high school science curriculum should be changed from the dogmatic approach to the inquiry method of teaching.

Gagne insists that inquiry is "one of the most essential objectives of science education" (37, p. 144). A
satisfactory science curriculum would, according to Gagne, be one which allows the student to apply the principles and methods of scientific inquiry to any new problem.

The problem in science education is teaching science as a series of foregone conclusions. Schwab states that

To teach science as inquiry means, first, to show students how knowledge arises from the interpretation of data. It means, second, to show students that the interpretation of data -- indeed, even the search for data -- proceeds on the basis of concepts and assumptions that change as our knowledge grows. It means, third, to show students that because these principles, and concepts change, knowledge changes too. It means, fourth, to show students that though knowledge changes, it changes for good reason -- because we know better and know more than we knew before (90, p. 131).

Schwab (89) sees separate forms of inquiry: stable and fluid. Stable inquiry utilizes principles for the identification of problems and the patterning of experiments to solve them. Stable inquiry, then, only concerns itself with filling gaps in the body of scientific knowledge. Fluid inquiry, on the other hand, involves the perpetual development of new principles and refinement of old ones to better enable researchers to pursue a new series of effective, stable inquiries. Fluid inquiry can follow no guidelines since it is basic research, concerned with the discovery and examination of new fields of investigation.

Teaching by means of inquiry is a technique not only accepted by modern educators, but one that is enthusiastically encouraged. Suchman states,
Inquiry training is not proposed as a new way to teach science, but as a way of teaching basic cognitive skills that are just as important to the intellectual development of the child as reading and arithmetic (106, p. 168).

Science educators generally believe that the inquiry approach allows students to make significant gains in the cognitive, affective and psychomotor domains (111). Because the inquiry method teaches that there are rational ways of testing ideas, students can use the rational tests to make decisions in all areas of their lives. They come to see that all knowledge is accessible and can be tested with regard to its validity. They learn to accept the individual's responsibility to find out which ideas are most appropriate to the solving of the problem he faces (103).

Klopfer believes that teaching students to understand and implement scientific inquiry is a far more important goal than teaching them general concepts. He states,

A major emphasis in education for scientific literacy must be placed on the processes of scientific inquiry (55, p. 88).

Bingman also observes,

The nature of inquiry is complex; inquiry engages the skills, interest, and attitudes of the person in an interaction with the substantive and cognitive demands of a problem as he makes efforts to rationally cope with it. Inquiry activities may vary in form and sequence from one problem to another and from one person to another person. Successful inquiry need not necessarily be terminated with the attainment of a solution to a problem, nor is the solution necessarily essential for inquiry to be deemed successful (13, p. 1).
The inquiry method of teaching has gained a great deal of attention during the last two decades. An increasing number of educational researchers conduct research in inquiry learning and an increasing number of teachers attempt to teach by the technique of inquiry. In his Inquiry Training Project at the University of Illinois, Suchman (107) found that (1) sixth grade Inquiry children achieved physical science concepts as well as, or better than, conventionally taught groups, (2) the Inquiry children were much more fluent in question asking than the controls, and (3) when the types of questions were analyzed, it was found that the Inquiry children had asked many more analytical questions, apparently reflecting an intense probing behavior.

Scott (91) compared the effect of inquiry and conventional methods of teaching on the Styles of Categorization by using a Style of Categorization Task (SCT) and examined sex differences among the variables of research. Of the three hundred fourth, fifth, and sixth graders who were participating in the study, Scott found that the girls were more inclined than boys to shift their attention from one stimulus to another. Scott observed also that the inquiry process encouraged an exploratory attitude and analytical mode on the part of the child that lead him beyond overt perceptual phenomena inherent in the physical world.

Additionally, Johnson, Ryan, and Schroeder (52) investigated the effects of different teaching situations on the
attitudes of sixth grade students toward science. They found that the students taught in an activity-centered, open-ended inquiry situation developed significantly more positive attitudes than the students studying similar subject matter from a textbook.

In an investigation of the Inquiry Role Approach (IRA) program of the Mid-continent Regional Educational Laboratory, Seymour and the others (94) found that the students in IRA program showed significantly higher inquiry skill and attitude development than students in similar non-IRA programs. Students also indicated a preference for the social behaviors, cognitive behaviors, and classroom procedures characteristic of the IRA inquiry classroom.

In a study comparing the acquisition of information and the understanding of significant concepts by the fifth graders who studied science from two different approaches, DeShields (25) found that the science programs which allowed students to discover solutions for themselves were more effective than a content-oriented approaches and that there was indeed a difference in achievement levels for students who studied science by using the process-discovery approach. The content-oriented approach places restriction on the student's threshold and does not utilize the importance of real life problem solving for fostering the developing of scientific thinking in children.

Cusimano's (24) investigation showed that science by inquiry was an effective learning experience. He found that
the students in the discovery group were able to identify problems, make observations, and draw meaningful conclusions from their laboratory experiences. The students in the traditional group relied on the teacher for information and regarded the acquisition of factual knowledge as the sole determiner of their achievement. The investigator concluded that if the goal of science education was the active involvement of the student in the process of science, the inquiry approach should be placed in science education programs.

The Arguments For and Against the Use of Inquiry

Obviously while one method of teaching may work well with one student another method may work more effectively with the student sitting across the isle. Robert M. Gagne, Jerome S. Bruner, and David P. Ausubel have provided science educators with three differing positions regarding the learning and teaching processes.

Bruner's theory, called discovery learning, focuses on the knowledge-getting process, encouraging a student to learn methods of acquiring new knowledge for himself rather than having him depend on rote memorization of presented subject matter. According to Bruner,

A body of knowledge, enshrined in a university faculty, and embodied in a series of authoritative volumes is the result of much prior intellectual activity. To instruct someone in these disciplines is not a matter of getting him to commit the results to mind; rather, it is to teach him to participate in the process that makes possible the establishment of knowledge. We teach a subject, not to produce
little living libraries from that subject, but rather to get a student to think mathematically for himself, to consider matters as a historian does, to take part in the process of knowledge-getting. Knowing is a process, not a product (18, p. 72).

Thus discovery learning begins with the presentation of a problem to be solved. The student must learn to apply his own views, perceptions, and models for comparison to the solving of the dilemma. He then can synthesize, analyze, search for new information, etc. According to Bruner, students who practice discovery learning will find suitable methods of acquiring, transforming, organizing, storing, and using all the information to which they are later exposed (82).

This theory has its opponents, however. B.F. Skinner (98), a pioneer in the development and implementation of programmed instruction, maintains that discovery learning is a "sink or swim" method which ignores the school's responsibility to provide instruction. He believes that students can be more effectively taught if they are presented information and are led, step by step, to achieve a series of goals set for them.

Gagne's "task analysis" (36) fundamentally agrees with Bruner that process should be given priority over the product. Task analysis begins with the question, "What is it you want the learner to be able to do?" The instructor must, after all, be able to answer the question specifically before he can be effective as a teacher. Next, diagnostic
pre-tests are administered. The results of the pre-testing can then be used to identify the position in the hierarchy at which the pupil could begin instruction.

It is important to keep in mind that the distinction between task analysis and discovery learning is that Gagne's sequence of instruction sees problem solving as the final step while Bruner uses problem solving throughout instruction.

Shulman has criticized Bruner's discovery learning and Gagne's task analysis, suggesting that

For Gagne instruction is a smoothly guided tour of a constructed hierarchy of learning task; for Bruner, instruction is a rollercoaster ride of successive disequilibria terminating in the attainment or discovery of a desired cognitive state (95, p. 37).

Ausubel (6) feels that science is a selectively and sequentially organized structure and his teaching theory of meaningful verbal learning reflects his view that science should be presented as a structure rather than as a method of inquiry. According to Ausubel, most people learn best, in or out of school, by being exposed to material which is presented in a relatively complete form. With this in mind, he suggested ways to organize subject matter for a more effective presentation. He proposes the theory of subsumption learning:

As meaningful new material enters the cognitive field, it interacts with and is appropriately subsumed under a relevant and more inclusive conceptual system.... the import of the new material becomes incorporated by the more generalized meaning of its subsumer, and is no longer dissociable from it (5, p. 223).
Collette concludes that

Ausubel, in contrast to Bruner, believes that problem solving should be minimized and that students should be given the information which they are to learn. He maintains that the most important goal of education is the mastering of organized bodies of subject-matter knowledge. Gagne agrees that strategies for problem solving are important, but he also states that in order for one to be a good problem-solver he must have an extensive content background which is structurally organized. Bruner does not deny the importance of learning facts, concepts, and principles as prerequisites to problem solving (22, p. 168).

Current research on discovery learning has tended to deal with the effects of a teacher's or experimenter's guidance. However, a careful analysis suggests that such learning procedures are limited as teaching tools more by the nature of the task performed than by the influence of an instructor.

The Affective Domain in Science Education

The affective domain has always been viewed as an important consideration in public education. However, traditionally, education has emphasized the three R's, mental discipline, and the cognitive domain to train the mind of the student. The affective domain may have just as powerful an influence on learning as the cognitive domain, for while the cognitive domain involves a student's recall and recognition of knowledge and also his intellectual abilities and skills, the affective domain deals with his attitudes and values.

In the 1920's and 1930's John Dewey and the "Progressive School" of philosophers focused educational attention on
student attitudes, and ideas which challenged traditional practice by providing a vision of a more humane, a more vital, a more meaningful education. Their views encouraged student guidance in achieving more significant and purposeful lives.

More recently, the recovery after World War II and the launching of Sputnik in 1957 have brought about emphasis in the teaching of science centered on the cognitive processes. Thus many curriculum reform projects were based on a cognitive approach. Yet there are some authorities who are against exclusive concern with the cognitive. Sears and Hilgard observe,

In these days of emphasis upon cognitive processes, it is quite possible for the pendulum to swing too far, and hence to defeat the attainment of the very cognitive goals that are being sought.... The teacher's awareness of the effective interaction with pupils is as important in a curriculum directed toward cognitive as one with other goals, such as those of social competence or personal adjustment (93, p. 147).

According to Jenkins,

School courses in science and history have largely ignored the study of this interrelationship between science, technology, and the society in which they function and have paid inadequate attention to the political, social, economic, moral, theological, or intellectual consequences of industrial advances in science and technology (51, p. 405).

Forsyth and Gammel indicate that the shift from cognitive to affective comes from cultural influences:

Changes in social relations and in the culture as a whole have caused educators in the last decade to reconsider, more than ever before,
the directions of education. Vast increases in childhood exposure to mass media, along with the related decline of the family and religion as strong influences in education have meant that 'character building' and emotional development have, often by default, become the business of schools. The worry over dehumanizing effects of our highly technology society and many other conditions have added urgency to the teacher's new role in affective education (35, p. 6).

Because the advances in science and technology are related to social concerns such as population control, pollution, drug usage, etc., the science teacher must deal with effect of these on social mores. Kuhn noted that the science teacher should provide the students with

1. opportunities to become aware of and clarify their attitudes toward social questions.

2. an understanding of how their attitudes and value systems were formulated.

3. a realization of how these value systems influence their judgement and behavior.

4. an environment in which to develop, modify and apply their value systems through a structured interaction with other students and use of appropriate curriculum materials (60, p. 350).

In the past several years, science education has placed its emphasis upon students' acquiring scientific literacy, a positive attitude toward science, and a clear concept of functional skills in the use of scientific methods. In all of these areas, the affective domain plays as important a part as does the cognitive one in determining a student's advancement.

The objectives traditionally included in the affective domain center on the development of students' interests,
attitudes, values, appreciations, and adjustments (14). But when Krathwohl and his colleagues (58) developed their taxonomy of affective objectives, they decided to avoid using the above categories because they felt that the variety of meanings associated with them made them too vague for use as basis for the construction of a continuum. Instead, they outlined a general classification scheme which could be applied to any subject. Their taxonomy defines the affective domain in the light of a value system and identifies students varying internalization from that of simple awareness of stimuli to adherence to an overall philosophy of life. They described the scheme as follows:

The process begins when the attention of the student is captured by some phenomenon, characteristic, or value. As he pays attention to the phenomenon, characteristic, or value, he differentiates it from other present in the perceptual field. With differentiation comes a seeking out of the phenomenon as he gradually attaches emotional significance to it and comes to value it. As the process unfolds he relates this phenomenon to other phenomena to which he responds that also have value. This responding is sufficiently frequent so that he comes to react regularly, almost automatically, to it and to other things like it. Finally the values are interrelated in structure or view of the world, which he brings as a "set" to new problems (58, p. 33).

Bloom (15) maintains that the main purpose of evaluation in the affective domain should be to aid in the evolution and improvement of teaching methods and materials rather than to serve as a basis for grading students. Eiss and Harback (33) saw a "credibility gap" between the instructor's belief in a theoretical affective objective and the perception of student
behavior which could be interpreted as evidence of that objective's being achieved. To close this gap, they compiled a list of sample affective goals and sample items, and presented a discussion of the use of affective objectives in science education.

Science educators have become increasingly aware of the importance of considering the affective domain in their teaching. Eiss has summarized the goals of scientific literacy in the affective domain which were agreed on by the NSTA Conference on Scientific Literacy. These have been arranged in the 29 categories suggested by Krathwohl and his associates (58).

**Awareness of conditions.**-- The scientifically literate person

- Acquire a knowledge of science careers
- Appreciates the interaction of science and technology
- Understand that science is generated by people with a compelling desire to understand the natural world
- Recognizes that science grows, possibly without limit
- Recognizes that the achievements of science and technology properly used are basis to the advancement of human welfare
- Recognizes that the meaning of science depends as much on its inquiry to process as on its conceptual patterns and theories
- Understands the role of the scientific enterprise in society and appreciates the cultural conditions in which it survives.

**Acceptance of values.**-- The scientifically literate person

- Rejects myths and superstitions
- Displays the habit of weighting evidence
- Realizes that science is a basic part of modern living.
Preference for values. -- The scientifically literate person

Exhibits:
- curiosity
- patience
- persistence
- open-mindedness
- tolerance
- willingness to be convinced by evidence
- confidence in "the scientific method"

Subscribes to:
- "the search for truth"
- "the importance of science for understanding the modern world"
- "the (value of) methods and procedures of science"

Appreciates the men who add to the storehouse of knowledge
Recognizes the intellectual satisfaction to be gained from the pursuit of science
Shares
- the excitement of discovery
- the desire to be creative
- faith in the logical processes of science

Enjoys science for intellectual stimulus, beauty of explanations, the pleasure from knowing, and the excitement of discovery

Appreciates the importance of narrowing the gap between frontier research and the popular understanding of new achievements.

Characterization by a value system. -- No objectives were found that might be classified in this category (32, p. 31).

In summary, it might be observed that nearly all those involved in science education have come to recognize that students' value systems and social awareness are relevant to their view of science. Thus the findings in a document published by the Mid-continent Regional Educational Laboratory and BSCS which identify affective behaviors as important to success as inquiry are hardly surprising (13). Ramsey and
Howe, in summarizing current educational research in this area, observe:

A student's attitudes toward science may well be more important than his understanding of science since his attitudes determine how he will use his knowledge. For this reason the development of attitudes as a part of science instruction is an area requiring increasing research (84, p. 68).

Mager (61) agrees that in any educational situation the student should leave a teacher's influence with as favorable an attitude toward the subject as possible. Since, as he observes, a favorable attitude contributes to the student's desire to learn.

In 1979, the National Assessment of Educational Progress (67) invited science educators to compile a list of objectives as well as lists of specific attitudes and areas of achievement critical to scientific literacy. The Science Advisory Group decided that attitudes and values were among the most important education priorities. Their assessment of the affective domain was comprised of eight logically organized sets of exercises, each of which measured attitudes considered important by science educators: (1) attitudes toward science classes, (2) vocational and educational intentions, (3) personal involvement in science, (4) tool-attributes, (5) confidence in science, (6) support of research, (7) controversial issues, and (8) awareness.

Klopfer (56) too has provided a classification scheme for science education aims in which those aims related to the subject matter of the course are clearly distinguished from
those aims which are affected by students' attitudes and interests. In addition, Klopfer's classification identifies the six distinct categories of affective aims in which distinctions are made between Attitudes Toward Science and Scientists (H.1), Attitudes Toward Inquiry (H.2), Adoption of "Scientific Attitudes" (H.3), Enjoyment of Science Learning Experiences (H.4), Interest in Science and Science-related Activities (H.5), and Interest in a Scientific Career (H.6).

Ogden and Jackson (75), in preparing a chronological history (1918-1972) of selected objectives for teaching biology in U.S. high schools, found that between 1954 and 1972 attitude and interest objectives showed a distinct increase in citations in the following periodicals: School Science and Mathematics (1918-1972); Science Education and The General Science Quarterly (1918-1972); The Science Teacher and The Illinois Chemistry Teacher (1934-1972); The American Biology Teacher (1939-1972); The Bulletin of the Atomic Scientists (1945-1972); and The Journal of Research in Science Teaching (1963-1972). According to their criteria, attitude and interest objectives are based on

...those concerned with developing an appreciation of the contribution of and nature of the scientific enterprise, desirable attitudes involving science and scientists, and lasting professional avocational interests in students. Types of objectives are: (1) scientific habits or attitudes; (2) appreciations; (3) interest and hobby development; (4) career development; and (5) the nature of science and scientists (75, pp. 293-294).
Ogden and Jackson also note that

...objectives in the Attitude and Interest category became the highest ranked (36.52 in subperiod 5 and 32.85 in subperiod 6). Individual objectives stressing "interest and hobby development," "career development," "scientific habits or attitudes," and "the nature of science and scientists," all reflected this general trend with the greater number of citations coming in the last three subperiods (75, p. 301).

The focus of modern science education is not only on the acquisition of scientific knowledge but also on the applications of this knowledge in assisting students to make better decisions. Stronck pointed out that

...through the media of television, radio, and the press, the students are well aware of the existence of major problems. These students are puzzled by the attitudes of those teachers who insist upon keeping the topics of each course entirely remote from the real world of conflicts and values. Educators in the United States must either seek to admit topics of the affective domain into the schools or witness a continued rebellion against our institutions (104, p. 108).

Stahl (102) has suggested that teaching students to understand and apply their scientific findings to the decision-making processes might be done by engaging students in issues involving their values or morals. To this end, he has presented specific guidelines for content-oriented science teachers to help students develop subject matter comprehension, decision-making skills, values/morals classification and reasoning processes. Kronin has suggested that high school science programs should focus on

1. providing students with the maximum number of experiences, options, or exposures possible, and
2. developing programs that have demonstrated application and value within the child's individual environment (59, p. 430).

Because so many modern educators feel that it would be injudicious not to include activities in biology instruction that allow students to examine moral questions (9), Rath, Simon, and their colleagues (85) have developed a method of using clarification strategies as techniques for introducing discussions of values into the classroom. The techniques in value clarification help students to examine their own beliefs about ethical/moral issues so that they can make appropriately rational judgments in everyday life.

Barman (8) used this same value clarification to measure student attitudes toward biology and achievement in the BSCS Yellow Version biology course. His experimental group instructed with value clarification lessons integrated with the BSCS material once a week for 18 weeks. Their performance was then assessed by the BSCS exam and the Self Evaluation Inventory (SEI). The results showed that the experimental group scored significantly higher than the control group which was taught units in ecology, cell biology, genetics, and evolution, using the BSCS Yellow Version (2nd. ed.). There did not appear to be any significant variation between groups in attitudes toward biology (as analyzed by the Schwirian Science Support Scale and the Affective Domain Measuring Scale). However, the results support the contention that the use of value clarification techniques did have a positive effect on achievement.
Current literature generally suggests that in recent years curriculum projects have leaned toward a more humanistic, multidisciplinary approach. To this end the concept of value education has been implemented by various techniques and approaches. The push to develop such new techniques illustrates the progression science education has made through the categories of receiving, responding, valuing, organization, and characterization by a value or values complex which appear in Krathwohl’s Taxonomy.

The Psychomotor Domain in Science Education

A far greater number of educators have considered the effects of cognitive and affective domains on instruction, curriculum, and research than have considered the role of the psychomotor domain. According to the definition given to the Taxonomy of Educational Objectives, Affective Domain, psychomotor objectives are those which emphasize some muscular or motor skill, some manipulation of material and objects, or some act which requires a neuromuscular coordination (58, p. 7).

According to Simpson, the psychomotor domain has relevance for education in general as well as for such area of specialization as industrial education, agriculture, home economics, business education, music, art, and physical education (96, p. 44).

Similarly, Singer states that Psychomotor activity is associated with military tasks, agriculture duties, industrial, professional, technical, and vocational skills, secretarial functions, business operations, home economics responsibilities, driving demands,
music, art, and dance works, as well as physical
education, sport, and recreation endeavors (97,
p. 7).

Surprisingly, science does not appear on Simpson's and
Singer's lists of those fields with psychomotor components.
This is probably because education in science has heretofore
been seen as primarily emphasizing cognitive goals even
though much of science education involves laboratory work.
As Ramsey and Howe observe, "The development of psychomotor
skills has been almost completely ignored by researchers in
science education" (84, p. 68).

Ironically, this lack of progress in developing schemes
for organizing laboratory objectives and thereby bringing the
psychomotor domain into clearer focus may be a result of an
inherent interaction among all three domains. Urbach ex-
plains:

The psychomotor domain is concerned with more than
human development. It is more than children play-
ing with blocks, or learning to play the piano.
It is more than physical fitness exercises or
training to work on an assembly line. A simple
theoretical definition of the psychomotor domain
remains elusive. A confounding factor is that the
psychomotor domain cannot be neatly separated from
the cognitive or affective components of man.
Psychomotor abilities are meshed with perception
of stimuli as well as the control of movement re-
sulting from those stimuli (112, p. 32).

In addition, Masters has emphasized that

Psychomotor skills need to begin with the basic
level; that is, with learning to be aware of one's
body and its needs and possibilities.... Thus the
psychomotor domain should include all sorts of
motor and manipulatory skills, building upon the
the basic awareness and responses which are so
essential to human learning (64, pp. 8-9).
Literature examining psychomotor aspects of science laboratory objectives is scarce. Most of the studies concern the relative effectiveness of laboratory and demonstration approaches (118).

Yet, the superiority of trained laboratory groups in practical manual performance can be clearly inferred from the study of Yager, Englen, and Snider (118), as well as from that of Pella and Sherman (80). Yager, Englen, and Snider developed as the first step in their process, a practical laboratory test to identify students' laboratory skills. The test measured (1) ability to focus a microscope at low and high power, (2) time involved in constructing a manometer, (3) ability to set up a workable manometer, and (4) ability to make coacervates. As might be expected, they found that students who had participated in several laboratories displayed more skill with laboratory materials and procedures than those who lack experiences in a laboratory or demonstration settings.

In much the same manner, Pella and Sherman (80) used the Laboratory Skill Test to measure the laboratory skills of students. The test consisted of designated laboratory exercises which each of the students was asked to perform. Each student was given five minutes to perform each laboratory skill in the laboratory. The results showed the manipulative method was significantly superior to the nonmanipulative method of utilizing the laboratory for the development of laboratory skills.
Presently there are no universally accepted criteria for evaluating students' science laboratory skills. Science teachers differ in the emphasis each puts on the student's equipment manipulation and laboratory techniques. Programs like the one at Syoset Senior High School (New York) are rare (65). There the laboratory-skills curriculum is offered as an elective course. The laboratory lessons in these courses use problem-solving as the means for the acquisition of scientific knowledge. Class meetings involve concentration in laboratory work on subjects like bacteriology, hematology, histology, and microbiology. In addition, students are taught related techniques, such as urinalysis, chromatography, and isolation of microorganisms. The students thus learn to perform a practical technique accurately and to develop adequate laboratory skills.

The same is true at Friends' Central School in Philadelphia (34). At this school there is a Biology II course open to 11th and 12th-graders, which includes such laboratory work as microtechniques, a study of blood with laboratory work, the chick embryo as an introduction to embryology, a unit on the invertebrates, and the use of the oil-immersion lens.

Klopfer (56), in speaking of the use of these psychomotor responses by science students, makes reference to a category labeled Manual Skills. He subdivides this category into two components: (1) development of skills in using common
laboratory equipment and (2) performance of common laboratory techniques with care and safety. The first category stresses such tasks as manipulating balances, microscopes, rulers, burners, and glassware. The second category is "concerned with the student's carrying out of a sequence of manipulations toward a desired end" (56, p. 576). Examples of behaviors within the latter category mentioned by Klopfer include collecting a sample of gas insoluble in water, preparing a thin section for microscope examination, dissecting an animal specimen, and finding the electrical resistance to wire. Additionally, Klopfer commented that these techniques should be performed carefully so that good results are obtained. Also, he notes that

No comprehensive studies have yet been made of the manual skills involved in science laboratory work in schools. Still, students do laboratory work; moreover, they are usually expected to manipulate apparatus with some facility, to avoid hurting themselves and others, and not to damage themselves and others, and not to damage the equipment (56, p. 576).

The investigator of this present work speculates that high school science teachers themselves are often not adequately prepared to use all of the scientific apparatus which might be found in their laboratories. This often results in their teaching laboratory exercises without emphasizing the manipulative skills that students should master. This speculation is supported by a study done by Biesenherz (12). He found that approximately fifty per cent of the techniques listed in the instrument he developed were reported to have
been acquired during undergraduate preparation by the teachers he interviewed. More importantly, less than one third of the techniques he listed had been required in a biological science course.

To determine teachers' views regarding the laboratory skills necessary for the successful teaching of high school biology courses, James (5) developed a list of laboratory competency techniques under the following headings: Techniques for Instruction, Laboratory Management, Laboratory Experiences, Maintaining Live Organisms in the Laboratory, Preparation of Materials in the Laboratory, Outdoor and Field Skills, Equipment, Safety, Identification, Microscopy, and Recent Developments in Curriculum. This instrument was sent to practicing Kansas biology teachers with a request that they rate competencies as to their appropriation for a preservice biology teacher. In addition, this instrument measured how these biology teachers rated their own competence with respect to each of these skills. The results of the study provided information useful in determining which laboratory skills should be included in preservice biology teacher preparations.

The area of psychomotor objectives in science education is one which needs further study and research. The investigator of this present study proposes that inquiry into this concern should stimulate the students' manipulative skills in
the laboratory-centered courses and determine which manipulative
skills a student could be expected to perform at each
grade level.

Science Education in Thailand

Very little science is taught in the primary or elementary schools in Thailand (grades 1 to 4). In grades 5 to 7, nature study, consisting of simple physical and biological science facts, is introduced. General science appears in grades 8, 9, and 10. Biology, Chemistry and Physics are offered to the science-prone students in grades 11 and 12, and physical science is offered as an alternative science course to the students at the same grade levels. Before the IPST curricula, teaching methods were based upon the principle of memorizing facts, theories, and laws in order to produce them on examinations. This meant that in practically all instances, the lecture and demonstrative techniques were utilized. Practice -- laboratory work and demonstrations -- consisted primarily of cookbook type experiments. They are performed in many instances by the teachers or a demonstrator to prove things already memorized. In visiting science programs in Thai schools, Koelsche observed the following fundamental problems in science education programs:

1. Inadequacy of teacher education programs and laboratory experiences, both pre-service and in-service.

2. Rigidity of school programs, course content, and methods of teaching.
3. The handicap of using results on national examinations as the sole basis for promoting pupils and awarding degrees.

4. The dictation of school policy by small groups of administrators.

5. Caliber of students entering the teaching profession.

6. Quality and quantity of science apparatus and the lack of appropriate lists of various courses.

7. Inadequacy of local manufacturing and distribution of science apparatus and supplies.

8. Inadequate facilities in the classroom, laboratory, libraries, etc.

9. Charging of fees by teachers for tutoring their own pupils.

10. Feeling of complete success upon receiving degree(s) and a government position. Teaching fits this category.

11. Ineffective use of native educators who have studied and obtained a degree abroad.


He also proposes that

1. Primary consideration should be given to the needs of the country and community in which a school system is located.

2. Aims and objectives for science education should be based upon these needs.

3. Curriculum should contain material essential to developing scientific literacy through an understanding of basic phenomena -- both traditional and modern.

4. Methods used should stimulate thinking, develop a keen power of observation, develop an ability to analyze and interpret data, and generate a lasting interest in science.
Individual laboratory work and demonstrations, performed by pupils, should constitute an integral part of the course work.

5. Auxiliary aids and techniques such as audio-visual materials, library books and periodicals, field trips and utilization of community resources give pupils many firsthand experiences in seeing applications of basic scientific principles.

6. Evaluation of the program and pupil achievement should be the joint responsibility of the local school personnel and the supervisory staff of the central educational agency (57, p. 350).

The reform and development of science and technology education have become a major policy concern in Thailand. A variety of programs have been developed and launched in an attempt to improve the quality of science and technology education and extend its reach to the rapidly broadening population in schools. The direction of national endeavors is clearly towards making education in science and technology relevant to national problems and realities. The Institute for the Promotion of Teaching Science and Technology (IPST) was established, in 1970, in cooperation with the Thai Government, the United Nations Development Program (UNDP), and the United Nations Educational Scientific and Cultural Organization (UNESCO) to promote the development of modern science and mathematics curriculum materials and to train teachers to use the materials effectively in elementary and secondary schools (99).
The Curriculum and Its Development

The IPST developed the science program for the following areas: general science, physics, chemistry, biology, and physical science.

The general science course was developed to be studied in the M.S 1 to 3 (grades 8 to 10). This is an integrated science program divided into six semesters. The first two semesters (studied in M.S. 1) are concerned with the science of the world around us, the next two semesters (in M.S. 2) take energy concepts as the integrating theme and the last two (in M.S. 3) focus on the environment of Thailand. These courses attempt to point to the need to balance agriculture, industry, and population growth with the sensible carrying capacity of the nation's natural resources and environment. Also, they are interest-motivated and involve students in active science projects in identifying problems, and in looking for methods of solving them (101).

Physics, chemistry, biology, and physical science were developed to be offered to the upper secondary students. Physics is comprised of mechanics, heat, light and sound, electricity and magnetism, and laboratory experiments. It is presented as a single, unified course. The equipment used in the course is inexpensive and is manufactured locally (101).

The chemistry course integrates a text and laboratory manual in an effort to encourage teachers to teach chemistry
as a learner-centered inquiry involving both theory and practice. The IPST-designed course in chemistry included experiments and an inexpensive kit that contains most of the equipment needed to perform these experiments. The team also introduces a study of Thai chemical industries and chemical problems that are relevant to the Thai society (101).

The biology course is based on an activities-centered approach. The course focuses attention on developing instruction that will get the student to examine the biology of his immediate environment (101).

The physical science course is offered as an alternative to the discipline sciences for students in grades 11 and 12. The course materials are presented in modular form. Each module is rated as one semester credit and is topic-centered, providing a broad coverage of science relevant to the educated citizen (101).

In each curriculum, four areas were developed concurrently: the writing of the students' texts and teachers' guides, the evaluation of student progress, training of teachers, and the development of science equipment.

To make clear how the IPST biology program was developed and how it played an important role in high school science programs, the investigator examined and traced the history of the IPST biology program from the beginning until the present time.
The IPST Biology Curriculum Development

From a ten-day workshop held at Chulalongkorn University, Bangkok, Thailand, in April, 1971 (47), the participants including biology teachers from the higher secondary school level, university and college instructors, and biologists from various institutes in the country discussed the validity of the objectives of science education which had been outlined in National Educational Scheme of 1960. These educators wanted to determine whether or not these objectives were still appropriate to the developments in education and society in the 1970s. The 1960 objectives which they examined (loosely translated) were

To provide the principles and generalizations leading to more intelligent choice of future studies.
To stimulate pupils to direct and purposeful activity leading to a more intelligent choice of future occupations.
To emphasize some of the most important applications of science to human welfare.
To develop skills and solve the problems by using scientific methods.
To acquaint each pupil with his environment and conservation of natural resources [writer's translation] (100, p. 1).

Because of the needs, the challenges of Thai society of the 1970s, and the progression in science and technological knowledge, the participants agreed that it was necessary to extend the meaning of those science education objectives which had been established in 1960. While the objectives in science education in 1960 included biology, chemistry, physics, and general science, the following explanation
considers only the objectives in biology programs.

The objectives of biology education should

(1) relate to people's standard of living both in urban and rural areas; (2) correlate with the unique aspects of culture; and (3) be clear enough to follow and practice. The participants extended these objectives into three areas: (1) content, (2) process, and (3) attitude. [writer's translation] (47, p. 1).

Content objectives:

1. The content objectives are concerned with accurate and up-to-date information; covering all the concepts and principles appropriate to further study in the higher level; usefulness to everyday life; importance and relationship to agriculture, medicine, hygiene, industry, sociology and population; promotion and way of living in different parts of the country; and emphasis on the values of conservation.

2. The content should consider the relationship between (a) each topic within biological areas: (b) biological knowledge and other areas; and (c) biological knowledge and Thai society and culture.

3. The content should be realized in the usefulness and application of its own subject. At the same time the student must understand the scientific method and realize the limitation of the knowledge that can be changed [writer's translation] (47, pp. 1 - 2).

Process Objectives:

More emphasis on reasoning out rather than memorization
More attention to developing a problem-solving attitude
More applications of the subject to the everyday life of the pupil and the community
More emphasis on how to use scientific equipment in experimentations [writer's translation] (47, p. 2).
Attitude Objectives:

To demonstrate the value of intensive study to the student
To develop an appreciation in the subject matter
To acquire an interest in nature
To understand the value of research study
To develop the ability to think scientifically, not to decide without appropriate data (47, pp. 2-3).

The content of the course is based on the following:

1. Cellular Biology
2. Taxonomy
3. Morphology and Anatomy
4. Physiology
5. Developmental Biology
6. Environmental Biology
7. Genetics and Evolution
8. Behavioral Biology (47, p. 3).

The method of teaching the new biology is based on inquiry. This method is problem-centered and the teacher serves as the guide who points out the importance of problems and suggests the application of the knowledge. In the inquiry process, the students will be able to exercise observations, to design experiments, to collect and analyze data, and to draw conclusions or find the answers to these problems by themselves (41).

The major purpose of the 1971 workshop was to collect data for subsequent high school biology curriculum development (99). The workshop team (which was composed of officials from high schools, colleges of education, and universities) was formed by the IPST to develop a biology program for the upper secondary school level. After the
Biology Design Team (BDT) studied the biology curriculum prepared by BSCS, Nuffield Biology, Australian Biology, Scottish Biology, and High School Biology of the Philippines, the team drafted M.S. 4 and 5 biology syllabi in accordance with the suggestions obtained from the workshops. The content of the course was separated into 70 per cent of the universal portion and 30 per cent of the local portion. The universal portion includes the topics that are similarly taught across the nation's schools, for example, photosynthesis, digestion, and respiration. The local portion, for example the topics of ecosystems or populations, contains only the biology that is suitable to the Thai region. It was agreed among the members of the BDT that the universal topics would be borrowed, translated, or adapted, but the local topics were to be written to suit the region (41).

Upon completion of these syllabi in 1972, another workshop, composed of twenty-four high school biology teachers, was held to select the writing team. Twelve high school biology teachers were appointed to the Biology Writing Team.

The writing started in May, 1972, with the BDT's outline. The BDT served as the editorial staff. In addition, twelve specialists were occasionally invited as consultants and the UNESCO consultants from various countries gave recommendations in the development of the biology curriculum materials. There were many mini-trials of chapters and topics to make sure that they were practical.
The first drafts of the M.S. 4 textbook and teachers' guide were tried out in the academic year 1973 in ten schools and the follow-up program was carried out. At the same time, the M.S. 5 materials were prepared for trial in the academic year 1974. Consequently, in the 1974 academic year, the M.S. 5 materials were tested in ten schools and the second edition of the M.S. 4 materials were tested in twenty schools. A follow-up program similar to that of the 1973 trial year was carried out in both M.S. 4 and M.S. 5 trial schools also. Again the information from the school trials and the follow-up study became the basis for revision and improvement (41, 99).

The revised edition of the M.S. 4 and 5 biology curriculum materials was finished in 1975 and 1976, respectively. The student textbook was divided into two separate books to be used for the first and second semester of M.S. 4, but the teacher's guide was in a single book. The same procedure was followed with the M.S. 5 textbooks and teachers' guide. The academic year 1975-1976 was devoted to the rewriting and preparation of the manuscripts for the commercial editions. All of these materials became available for use in the upper secondary schools all over the country in June, 1976 (99).

Teacher Training in the IPST Biology Program

The IPST planners realized that for the success of the new curriculum in the school system, the new books, teachers'
guide, and equipment were not enough. The teacher is the key person in the implementation of a new curriculum. To conduct the new curriculum, the teacher must know how to use it effectively. To further this aim, the IPST biology curriculum development program offered in-service training workshops before the trial program. These workshops provided the teachers who participated in the trial opportunities to study the textbook and the teachers' guide in terms of both materials and approaches. The objectives of these workshops were aimed at

1. The participants' study and understanding of biology curriculum development.

2. The participants' understanding of various materials and equipment produced by the Biology Design Team.

3. The participants' discussing the utilization of materials and equipment as well as the presentation of lessons using the materials and the equipment.

4. The opportunity of micro-teaching and with the other experiences designed to increase the awareness of how to teach the new course.

5. The promotion of cooperation that should lead to mutual benefits in developing materials and equipment for the improvement of the teaching of biology and for the efficient pre-service and in-service training (41, p. 7).

During the academic year 1973-1975, workshops were held for the teachers in the trial program. The in-service training programs including three-week workshops, two-week workshops, two Saturday meetings, and one-week workshops were offered to the IPST biology teachers. These trial teachers
served as master teachers for the in-service training program held later, too. During the trial programs, the workshops were conducted by the members of the BDT, guest specialists from other institutes, and UNESCO consultants. The IPST provided spaces, laboratory facilities, and the financial support. Also, the teacher training program included the philosophy and rationale of the IPST biology programs (99).

In November 1975, IPST began the first active pre-service teacher training program. The pre-service program was based on the objectives that (1) provide information concerning the development of the IPST curriculum materials, (2) exchange ideas on pre-service teacher training program in various colleges, and (3) aid in the implementation of the new curriculum materials all over the country (99). Today, the IPST offers both pre-service and in-service programs to prospective teachers and current teachers respectively.

Research Studies Related to the IPST Biology Program

Research studies have been conducted which evaluate the effectiveness and suitability of the new biology curriculum and the IPST teacher-training program. After the new M.S. 4 biology curriculum was tested in the academic year 1973, a subsequent evaluation of the materials was conducted. The data were collected from: (1) feedback from the trained
teachers' opinions on each chapter, (2) teaching observations by six observers who visited trial schools once every two weeks, (3) two Saturday meetings where participants discussed gathering information on teaching problems and made suggestions concerning the uses of curriculum during the two-week trial period.

The results from ten teachers and 712 students in ten trial schools were first determined by means of student achievement test in which the full score was 100 while the average score obtained from the mid-year test was 70.80 with a standard deviation (S.D.) of 8.66. The range of scores was between 36-90, and only eight students obtained scores lower than fifty per cent of the full score. The average score obtained from the final exam was 71.76, while the S.D. was 9.85; the range of scores was between 37-99; and only eleven students obtained scores lower than fifty per cent of the full score.

Data were also obtained from a student questionnaire in which it was found that seventy-six per cent of the students thought that the new curriculum was good; the rest either did not express any opinion or did not think that it was good. Finally, data were gathered from a trial teacher's questionnaire about the students' interests. It was found that 99.2% of the trial teachers thought that the students were interested in both the content and the laboratory experience of the new curriculum. Also, surveys showed that
most teachers could not use the new curriculum to the greatest advantage since they did not have a clear understanding of its content and lacked the skills to teach effectively the new materials (41).

In the IPST Progress Report During the Period of July 1-December 31, 1973, which summarized the results from these ten trial schools, it was stated that: (1) the students' interest and understanding were quite high and satisfactory, (2) the teachers' guide was very useful to teachers, (3) the equipment used was satisfactory, and (4) teachers were able to use new approaches as indicated in the new curriculum. Some problems appeared in the use of the new materials; they were (1) most teachers felt that the estimated time for some chapters was not enough, (2) many students did not become familiar with the type of questions used in the IPST tests, and (3) laboratory equipment was not sufficient (49).

From the IPST Report on the Final Examination Results of the Academic Year 1974, the following conclusions were reported: (1) teachers felt very satisfied with the new texts that permit more student activities, (2) the teachers' guides were reasonably helpful; however, teachers requested more supplementary knowledge, (3) the equipment was very satisfactory except in a class consisting of 45 students or more, and (4) the tests were very helpful for both teachers and students in evaluating their teaching and learning processes. The M.S. 4 (grade 11) final exam results showed
that 1364 out of 1456 students passed (a score of 50 or above) the biology examination with scores ranging from 28 to 99. The M.S. 5 (grade 12) final exam results showed an average score of 66.8 with an S.D of 11.1. The range of scores was between 33 - 91. Only 46 M.S. 5 students out of the 672 received scores lower than fifty per cent of the full score (48).

From the IPST Progress Report of the Biology Design Team During the Period of August 1 - September 30, 1974, the participants' opinions from the workshop of M.S. 4 and 5 programs were summarized as follows: (1) the M.S. 5 group preferred emphasis on subject matter of the chapters that would give them confidence in answering the student's advanced questions; (2) the M.S. 4 group, on the other hand, preferred emphasis on teaching demonstrations; (3) the team should produce more videotapes of model teaching and should also provide experts to demonstrate teachings in the real classes; and (4) the IPST should provide the service of lending audio-visual equipment for schools (49).

In May, 1975, a summer workshop was held for the in-service training of 360 biology teachers. At the completion of the workshop, participating teachers were given questionnaires which dealt with advantages gained from participation in the workshop. The results showed that forty-nine per cent of the teachers indicated that they gained much benefit from the workshop; forty-one per cent indicated a somewhat
moderate gain; and approximately ten per cent thought that they gained only a small amount from the workshop (77).

Tunkajiwangkoon (110) conducted a subsequent analysis of the content of the M.S. 4 biology materials of the IPST. She reported that approximately seventy-one per cent of the subject matter was concerned with knowledge, nine per cent with comprehension, two per cent with application, and eighteen per cent with the processes of science. She also suggested that some drawings would improve the materials and a glossary should be added at the end of the student text.

Soydhurum (99) evaluated the effectiveness of the new Thai biology curriculum, concentrating on the following: (1) activities in the classroom conducted by one group of teachers who had taught the new curriculum materials for several years, and another group of teachers who were teaching for the first time; (2) affective behaviors expressed by the student, and (3) attitudes of the teachers toward the new curriculum program. The results from the study were that (1) teachers using the new materials were able to carry out classroom practices that were in a high degree of conformity with those advocated by the program's developers; (2) students using the new materials demonstrated affective behaviors in harmony with the program philosophy; (3) teachers accepted the program philosophy; (4) the affective behaviors expressed by students were related to classroom practices conducted by their teachers; (5) the attitudes of
teachers toward the program were affected by their experience in teaching the program materials; (6) the experience in teaching the program materials did not substantially affect the classroom practices conducted by the teachers; (7) the attitudes of the teachers toward the program were not related to their classroom practices; (8) classroom practices conducted by the teacher appear to be influenced by a combination of their attitudes toward the program and their experience in teaching the program materials; and (9) affective behaviors expressed by students appear to be influenced by a combination of the classroom practice conducted by their teachers and the teacher's attitudes toward the program. He also recommended that a similar study should be conducted with the whole curriculum program used in a large number of schools. This study should emphasize effects of other factors that influenced the variables under investigation.

In her study, Suchareekul (109) developed an instrument to measure the Thai science teacher's preference for using inquiry teaching behaviors. She also measured the influence of the new science curricula and training on the inquiry teacher behaviors of three samples of teachers. The samples were (1) IPST trained teachers using the IPST science curricula, (2) teachers using the IPST curricula who had not received IPST training, and (3) teachers who were neither trained nor using the IPST curricula. She found that teachers who were IPST trained or used the IPST science
curricula used more inquiry behaviors than teachers who were not trained and were not using the new curricula. Also, the IPST training and the IPST curricula were significantly influencing teacher behavior in the desired direction, a fact which suggests the need for intensifying the emphasis upon developing inquiry teaching skills among all teachers, assuming inquiry teaching is a goal.

Several studies have been done with regard to the IPST biology materials. Most of the studies are concerned with student achievement in biology, student attitudes toward biology, and teacher judgments of the new biology materials. There are only a few studies (previously discussed in this chapter) concerned with the implementation of curriculum objectives and analyses of textbooks and laboratory manuals.


27. ———, How We Think, Boston, D. C. Heath and Company, 1933.


76. "On the Place of Science in Education," A Report Presented to the Council of the American Association for the Advancement of Science at the Second Nashville Meeting, December, 1927, by the Special Committee on the Place of Science in Education, School Science and Mathematics, XXIII (June, 1928), 640-664.


CHAPTER III

PROCEDURES

This chapter describes the procedures followed in the study. It includes (1) the criteria applied in the selection of textbooks, (2) descriptions of the instruments that were used to gather data, and (3) the procedures as they relate to the research questions.

Selection of Textbooks

The Texas textbooks used in the study are those adopted under the provisions of the Textbook Law. According to these provisions the State Board of Education selects fifteen persons from a list recommended by the State Commissioner of Education to serve as members of the State Textbook Committee. This committee studies the textbooks offered for adoption by the interested publishers and recommends to the Commissioner of Education a complete list of textbooks which it approves for adoption at various grade levels and in the various subjects. Consequently, textbook selection is influenced as much by the content of the text as the way the textbook is written (8).

The Proclamation issued by the Texas State Board of Education calling for the adoption of textbooks in biology states:
Textbooks for Biology I shall present an inquiry approach to basic concepts in biology including hypotheses, theories, and modern research. The basic concepts shall incorporate inquiry student learning activities that are appropriate at the high school level (9, p. 27).

The textbooks adopted by the Texas Textbook Law present

important scientific discoveries of the past and the relationship of these activities to modern biological advancements

interdependence of organisms as related to their environment

individual and/or small group of student laboratory and outdoor activities to support the concepts being presented

the exclusive and correct usage of the metric system of measurement as applied to content and laboratory activities (9, p. 27).

There was no selection of the Thai biology textbooks because only one set of textbooks, created by the Institute for the Promotion of Teaching Science and Technology, Bangkok, Thailand is used in all Thai high schools.

In this study, the investigator analyzed the following five Texas biology textbooks and the grades eleven and twelve Thai biology textbooks.

Texas Biology Textbooks:


Thai Biology Textbooks:

Title: *Biology Book I and II for the Eleventh Grade*


Title: *Biology Book III and IV for the Twelfth Grade*


Because biology programs generally included laboratory activities, the investigator also analyzed the laboratory manuals that accompanied each textbook. For Thai biology textbooks and the Cunningham text, the laboratory activities included in each chapter of the texts were analyzed. Only the following four manuals adopted by the Texas state textbook committee had separate laboratory manuals. They were:


The Instrument

The Rationale for Using the Instrument

Klopfer (4) constructed a Table of Specifications with the goal of providing a framework to aid in evaluating student outcomes from secondary science programs. In a content analysis study of the stated aims of science education literature, Fraser (2,3) found Klopfer's Table of Specifications to be sufficiently comprehensive for classifying the aims of science education. Klopfer's instrument includes categories from Bloom's (1) and Krathwohl's (5) taxonomy of educational objectives.

The instrument for this study was the Table of Specifications for Science Education (Appendix A) developed by Klopfer:

The categories and subcategories of student behavior and content described in the table of specifications can be used to characterize any science program or unit... Besides characterizing a science program or unit, the table of specifications reveals its structures. With respect to each included content area, the grid shows where expected knowledge objectives lead to comprehension or application behaviors, and it shows where knowledge objectives exist largely in isolation. The specifications grid identifies those content areas where development of the student's skills in different processes of scientific inquiry is aimed for. It shows where there are objectives in the attitude, manual skills, and orientation categories, and their relation, if any, to objectives in other categories (4, p. 583).

The vertical dimensions of the Table of Specifications (Appendix A) presents the science content areas. The
content subcategories are further divided into content areas, and each of these has several component topics and ideas. The following content areas covered all the content found in Texas and Thai biology textbooks.

**Biological Sciences (1.0)**

1.1 **Biology of the cell**

1.11 **Cell Structure and function**
Organisms are made of cells; the cell as the unit of structure and function.

1.12 **Transport of cellular material**
Diffusion and osmosis; osmoregulation, permeability, membrane phenomena.

1.13 **Cell metabolism**
Basic ideas of metabolism and respiration; intracellular metabolism.

1.14 **Photosynthesis**
Organismic, cellular, and biochemical aspects of photosynthesis.

1.15 **Cell responses**
Regulation of cell response and cell behavior.

1.16 **Concept of the gene**
The idea of an inheritable unit: gene and gene action; deoxyribonucleic acid (DNA).

1.2 **Biology of the organism**

1.21 **Diversity of life**
Variety of life; classification of plants and animals; taxonomic relationships between plant and animals; the diversity of plant and animal forms and its implications.

1.22 **Metabolism in organisms**
Ideas of breathing, digestion, etc., plant and animal physiology; metabolism in organisms and the structural adaptations involved.

1.23 **Regulation in organisms**
Regulation of temperature and water balance; homeostasis at the level of the multicellular organism.
1.24 Coordination and behavior
Plant and animal reactions to external stimuli; plant and animal coordination and responses, behavior; nervous and hormonal regulation.

1.25 Reproduction and development
Ideas of reproduction, life histories; animal reproduction and development, metamorphosis; plant reproduction and development.

1.26 Human biology
Man as a living organism; man in his physical and social environment.

1.3 Biology of populations

1.31 Natural environment
Interrelationships between plants and animals in their environment; energy relationships in and ecosystem.

1.32 Cycle in nature
Food chains and food relationships; predators and scavengers; food cycles, pyramid of numbers.

1.33 Natural groups and their segregation
Concept of natural groups; speciation, modern taxonomy.

1.34 Population genetics

1.35 Evolution
Basic ideas of evolution, variation, competition, adaptation, natural selection (4, pp. 580-581).

Physical Sciences (2.0)

2.1 Chemistry

2.17 Atomic and molecular structure
Elements and compounds, atoms, molecules; chemical bonding and chemical structure, modern atomic theories.

2.19 Chemistry of life processes
Chemistry of respiration and nutrition; biochemical reactions, enzymes.
2.110 **Nuclear chemistry**
Nuclear reactions, radioactivity, isotopes.

2.2 **Physics**

2.23 **Energy and its conservation**
Forms of energy, work, transformations of energy; mechanical energy, potential energy, kinetic energy; conservation of energy.

2.29 **Light and spectra**
Mirror and lenses; geometrical optics, optical instruments, photometry; color; spectra; electromagnetic spectrum.

2.3 **Earth and space sciences**

2.31 **Solar system**
Earth and moon in relation to the sun, direction, seasons; the solar system, explanation of apparent solar motions; planetary motion, Kepler's laws, Newton's explanation.

2.33 **Meteorology**
Weather phenomena; weather maps and their interpretation, forecasting; climate.

2.34 **Physical geology**
Earth's crust, stratigraphy; rocks and minerals, material resources, soil studies, petrology; earth forms, deposition, erosion, weathering.

2.35 **Historical geology**
Long-term processes, uniformitarianism; fossils and fossilization; palaeontology; geological time scale and major periods.

2.36 **Oceanography** (4, pp. 581-582).

General (3.0)

3.1 **Historical development**
Consideration of the historical background and development through time of observations, concepts, theories, and methods in science; the relevance of new data and new instruments to scientific progress; the interrelationships between scientific development and the general state and advance of society.
3.2 Nature and structure of science
The relationship between empiricism and rationalism; the difference between observation and interpretation and between data and conceptualization; the philosophical status of statements of scientific observation, law, and theory; the tentative quality of scientific data, concepts, and theories.

3.3 Nature and scientific inquiry
Multiplicity of approaches in formulating a question, proposing hypotheses, deciding on appropriate procedure, gathering and interpreting relevant data, formulating laws and principles, interpolating, extrapolating, theorizing, validating, predicting.

3.4 Biographies of scientists
Presentations of scientists as human beings who engage in scientific work as a profession; recognition that scientists are people with diverse educational backgrounds, families, personal problems, and interests in fields of human endeavor outside the sciences.

3.5 Measurement
Basic forms of measurement encountered in science, such as number, length, mass, and time; simple combinations of the basic measurements, such as volume, density, speed, growth rate; the practical and theoretical aspects of units, standards, scaling, and errors of measurement (4, pp. 582-583).

On the horizontal line of the Table of Specifications (Appendix A), there are nine categories of student behaviors. Each category is composed of several subcategories as shown in Appendix A and B. It should be noticed that some of the following explanations of subcategories give an explanation of the topic as well as giving appropriate examples. When subcategories could be clearly understood from the heading topic, examples only were given. In some subcategories explanations of the heading topic were given, but examples were deemed unnecessary.
Knowledge and Comprehension (A.0)

This category consists of all the knowledges that the student has received from the textbook. At this level of understanding, the student demonstrates the degree of his comprehension by identifying and translating the knowledge into new situations that differed in some way from those studied in the textbook. This category is divided further into eleven subcategories. They are,

A.1 Knowledge of specific facts. -- Klopfer does not explain this subcategory clearly. Consequently, the investigator defined this subcategory by adapting Bloom's definition of it. Bloom maintains that the student must absorb:

Knowledge of dates, events, persons, places, etc. This may include very precise and specific information such as the specific date or exact magnitude of a phenomenon. It may also include approximate or relative information such as an approximate time period or the general order of magnitude of a phenomenon (1, p. 65).

The examples of this subcategory are found in statements about the structures and functions of plants and animals. Examples are, the hydra has nematocysts in its tentacles; the reproductive organ of an angiosperm is a flower; or, the thyroid gland secretes thyroxin.

A.2 Knowledge of scientific terminology. -- This level involves a student's learning those definitions and terms that are peculiar to the scientific vocabulary. Examples are, tree trunks increase in diameter as cambium cells divide; the process by which energy is released from food
is called respiration; or, the area in which animals live and reproduce is called their home range.

A.3 Knowledge of concepts of science. — This level also is concerned with definition, but deals with the broader concepts of science, i.e. "those abstractions of observed phenomena or relationships which scientists have found to be continually useful in investigating the natural world and for which they have agreed upon exact definitions" (4, pp. 566-567). Examples of these concepts are photosynthesis, respiration, evolution, homeostasis, and nerve impulse.

A.4 Knowledge of conventions. — This category centers on the student's ability to properly use and interpret signs, symbols, abbreviations, and practices which are an integral part of any specific scientific discipline and which are representative of significant entities or relationships that have been adopted in a science discipline (4, p. 567). For example, Ca, Na, and Cl are the symbols of Calcium, Sodium, and Chlorine, respectively. In genetics, T is used for the tall trait, t stands for short trait. Capital letters designate dominate traits, small letters recessive ones.

A.5 Knowledge of trends and sequences. — This category addresses the need for the student to be capable of the "ordering of phenomena in the correct sequence of their occurrence in nature or under experimental manipulation"
(4, p. 567). Examples include: the Krebs cycle in respiration, the nitrogen cycle, and the menstruation cycle.

A. 6 Knowledge of classification, categories, and criteria. -- This area deals with student's ordering of objects and phenomena according to one or another of the structures established for this purpose by scientists in a given discipline. It also involves having the student recognize the peculiar traits or characteristics that cause such an object or phenomenon to be classed in a particular category. The examples include the classification of the opossum as marsupial because it nurtures its young in a pouch; the classification of Euglena in the class flagellates because it moves by mean of flagella; and, the classification of the pine as a gymnosperm because of the nature of its reproductive organ.

A.7 Knowledge of scientific techniques and procedures. -- This category involves a student's acquiring knowledge of the procedures that specific scientists have followed in conducting their inquiries, for example: how Redi demonstrated that life comes from life; how Hans Spemann performed experiments about embryonic induction; how Karl von Frisch experiments to test whether bees can communicate.

A.8 Knowledge of scientific principles and laws. -- This are involves the student's memorization of particular scientific principles or laws, which are those generalizations derived and established by scientists on the basis
of numerous observations of phenomena. Examples of these laws might include the law of independent assortment, the law of dominance, or the law of segregation.

A.9 Knowledge of theories or major conceptual schemes. -- This subcategory develops the student's recall in specific theories such as the theory of natural selection, the germ theory, and the theory of spontaneous generation.

A.10 Identification of a fact, concept, procedure, classification scheme, or theory in a new content. -- This category requires a student to learn, for example, the criteria for classifying plants in the Phylum Tracheophyta. When studying ferns, the student may be required to identify the criteria gymnosperms and decide that they are also classified as tracheophytes.

A.11 Translation of a fact, term, concept, trend, principle, or theory presented in one symbolic form to another symbolic form. -- This area suggests for example, that given a growth curve of paramecium, the student translates it into a verbal statement about the growth of paramecium; or given the genotype such as TtRR, that the student translates it into a phenotype, tall and round (Tt stands for tall, hybrid, and RR stands for round, purebred).

Processes of Scientific Inquiry

This includes the processes found mostly in the student laboratory manual. These activities were concerned with student inquiry in each subject category. Klopfer states:
"The ordering of these four categories is not arbitrary, but represents successively greater involvement in the processes scientists employ to investigate the natural world and to construct new ideas" (4, p. 568).

**Processes of Scientific Inquiry I; Observing and Measuring (B.0)**

**B.1 Observation of objects and phenomena.** -- The student observes the situations, objects, and phenomena that are outlined in the laboratory manual. For example, he observes the movement of a paramecium, or observes the cross-section of a leaf.

**B.2 Description of observations using appropriate language.** -- After observing something in the activity, the student should be able to describe what he saw to another person by oral or written communication.

**B.3 Measurement of objects and changes.**

**B.4 Selection of appropriate measuring instruments.**

**B.5 Estimation of measurements and recognition of limits in accuracy of measurements.**

In the subcategories B.3, B.4, and B.5, the student learns about what should be measured and what instrument should be used to measure. While measuring an object, the student should recognize the limitation of the instrument and measure with accuracy..
C.1 Recognition of a Problem. — From everyday life situations or from observation of laboratory experiments, the student may find a problem that he would like to solve. The student will be able to state in writing what the problem is.

C.2 Formulation of a working hypothesis

C.3 Selection of suitable tests of a hypothesis

In the last two categories (C.2, and C.3), the student is required to develop hypotheses concerning the problem. Then he chooses the one that is appropriate and carries through the experimentations "that logically ... verify the hypothesis if it is correct" (f, p. 570).

C.4 Design of appropriate procedures for performing experimental tests. -- The student plans the procedures in the experiments, such as, the selection of subjects, determination of experimental and control groups, and the identification of appropriate instruments and equipment to be used in the study.

D.1 Processing of experimental data. -- This requires the student to manipulate, adjust, and organize his observations and measurements. The student is also required to display the computations he has made and to reduce the data to a form suitable for interpretation and analyze the errors in measurements and observations which may be present in the experimental procedure.
D.2 Presentation of data in the form of functional relationships. -- The student is required to arrange data from the experimentation in the table or to plot the data points on a sheet of graph paper.

D.3 Interpretation of experimental data and observation. -- The student develops a discrete concept of what the experimental results signify, and interprets experimental findings obtained in inquiries of other persons.

D.4 Extrapolation, when warranted, of functional relationships beyond actual observations, and interpolation between observed points.

D.5 Evaluation of a hypothesis under test in the light of the experimental data obtained. -- The student finds out if the findings from the experiments verify or reject the hypothesis.

D.6 Formulation of appropriate generalizations (empirical laws or principles) that are warranted by the relationships found. -- The student compares the results from his experiments to the other results derived from evidence covering a range of related phenomena. The outcome of the student's thinking, the generalization that he formulates, provides a synthesis.

Processes of Scientific Inquiry IV: Building, Testing and Revising
A Theoretical Model (E.O)

Klopfer states,

the investigator goes no further than the accumulation of knowledge or the formulation of
principles. The investigator is engaging in "stable enquiry," ...and it is then that an investigator can engage in "fluid enquiry." In this type of inquiry, the aim of research is not only to ascertain facts and to formulate principles, but to build a theoretical model that will satisfactorily interrelate and accommodate them (4, p. 572).

The following subcategories concern the student's higher mental processes used in the scientific inquiry method.

E.1 Recognition of the need for a theoretical model. -- This subcategory addresses the need of the student to understand and accept theory building as part of scientific inquiry. By recognizing the correlative, explanatory, and heuristic function of a theoretical model, the student can go beyond observations and empirical generalizations to the level of formulating and testing a theoretical model.

E.2 Formulation of a theoretical model to accommodate known phenomena and principles. -- This involves the student's synthesizing his knowledge in order to perceive an abstract relationship. In this subcategory, the student forms a general statement consisting of a small set of postulates about certain behaviors of nature.

E.3 Specification of phenomena and principles that are satisfied or explained by a theoretical model. -- The student analyzes the relationship between a theoretical model and generalized evidence, expressed as both empirical laws and principles and discrete observation.

E.4 Deduction of new hypotheses from a theoretical model to direct observations and experiments for testing it.
-- In this subcategory, the student deduces a hypothesis from a theoretical model and plans to experiment and observe in order to test the hypothesis.

E.5 Interpretation and evaluation of the results of the experiments to test a theoretical model. -- In this subcategory, the student seeks to analyze the relationship between the empirical evidence and the theoretical model from which the hypothesis was deduced.

E.5 Formulation, when warranted by new observations or interpretations, of a revised, refined, or extended theoretical model. -- Whenever there is the accumulation of new observations and reinterpretation of the results from the experiments, the student faces a new phase of modification in that he finds it necessary to reformulate his theoretical model.

Application of Scientific Knowledge and Methods (F.O)

In this category, the student applies his knowledge and scientific processes to solve a problem from everyday life that he has never faced before.

F.1 Application to new problems in the same field of Science. -- This is the most common situation for which students must organize in a school contest, what they have learned in any given field of science. It gives rise to questions like, why do we water the roots of a plant rather than other organs?, or why should a fish tank be aerated by stirring up the water or pumping air through it?
F.2 Application to new problems in a different field of science.-- This subcategory concerns the student's use of a fact, concept, principle, theory, or method that has been learned in one science field in the solving of a problem faced in another field. For example, why do plants wilt in dry weather?, or why is the sun called the source of energy for all life?

F.3 Application of scientific knowledge and inquiry skills to problems outside of science. -- Examples of this category include, why does bread not continue to rise after it is baked?, how is vegetative reproduction useful to man?, how is it harmful?

Manual Skills (G.O)

This category concerns the student's manipulative skills in performing activity in the laboratory or in the field.

G.1 Development of skills in using common laboratory equipment. -- This subcategory emphasizes the manual and coordinating skills in manipulating the balance, microscope, ruler, and chemical glassware.

G.2 Performance of common laboratory techniques with care and safety.-- This subcategory involves the student's execution of a specific sequence of manipulations toward an already defined end.

Attitudes and Interests (H.O)

This category surveys and asks the student's opinion about the subject of science, whether it interests the
student, whether he enjoys it, and whether it helps him to adapt his thought processes to the use of inquiry skills in his everyday life. This category utilizes

1. several different formats for using likert-type items to measure attitudes and interests.

2. an attitude scale using the method of equal-appearing intervals.

3. the semantic differential technique.

4. two formats for using a forced-choice questionnaire.

5. an activities inventory (4, p. 618).

All these formats are used to measure the following subcategories:

H.1 Manifestation of favorable attitudes toward science and scientists.

H.2 Acceptance of scientific inquiry as a way of thought.

H.3 Adoption of habits of thought which ideally characterize scientists where engaged in inquiry ("Scientific attitude").

H.4 Enjoyment of science learning experiences.

H.5 Development of interests in science and science-related activities.

H.6 Development of interest (for some students) in pursuing a career in science or in science-related work.

(4, pp. 576-578).

Orientation (1.0)

This category emphasizes the means by which the student can employ his knowledge and comprehension, thereby relating
science to other disciplines. It also focuses the student's orientation, allowing him to see science in a more meaningful light. This category emphasizes:

I.1 Distinction between various types of statement in science (e.g., observation, interpretation, law, theory) and their relationship to one another.

I.2 Recognition of the limitations of scientific explanation and of the influence of scientific inquiry on general philosophy.

I.3 Historical perspective: Recognition that the past, present, and future development of science is a product of its own history and a reflection of the general culture of its time.

I.4 Realization of the relationships existing among scientific progress, technical achievements, and economic development.

I.5 Awareness of the social and moral implication of scientific inquiry and its results for the individual, community, nation, and the world (4, pp. 578-580).
Collection of Data

Phase I

The first phase in the collection of data was concerned with examining the content of the textbooks at three levels of biological organization -- the cellular level, the organism level, and the population level (Table I). Each level was divided further into a number of content areas. These content areas served as reference points for the structures of the science programs. The content that did not fall into any specified level was considered in the Physical sciences and General categories. The chapter and page numbers are presented in Appendix 0.

Phase II

Phase II of the collection of data was concerned with the provisions for the cognitive, affective, manual skill, processes of scientific inquiry, and orientation objectives contained in each Texas and Thai biology program. Research questions 1-6 are restated below and the instrumentation used is indicated.

Research Question Number

1. How many cognitive, affective, manual skill, processes of scientific inquiry, and orientation objectives are contained in each textbook?

2. How are the cognitive objectives distributed among the levels of the cognitive domain in each textbook?

3. How are the affective objectives distributed among the levels of the affective domain in each textbook?
4. How are the manual skills distributed within the manual skill domain in each textbook?

5. How are the inquiry objectives distributed among the processes of scientific inquiry in each textbook?

6. How are the orientation objectives distributed in each textbook?

The objectives appearing in each Texas and Thai biology textbook and laboratory manual were analyzed. Any content which could be identified as meeting the student behavior objectives was classified as Knowledge and Comprehension (A.0), Processes of Scientific Inquiry (B.0, C.0, D.0, and E.0), Application of Scientific Knowledge and Methods (F.0), Manual Skill (G.0), Attitudes and Interests (H.0), or Orientation (I.0) by using the Klopfer's Table of Specification for Science Education (Appendix B). All the tallied scores for each behavior area in each text were combined and presented as a frequency. This frequency was converted to a percentage of the total objectives for each program.

**Analysis of Data**

This step in the study was concerned with comparing frequencies to determine whether the distributions between each Texas program and Thai program reflected the same cognitive, affective, manual skill, processes of scientific inquiry, and orientation emphasis. Each distribution included the frequency of cognitive, affective, manual skill, processes of scientific inquiry, and orientation tasks. For example, the number of cognitive, affective, manual skill,
processes of scientific inquiry, and orientation objectives was the distributions of objectives for each program. An overview of the comparisons of objective distributions is presented below:

<table>
<thead>
<tr>
<th>Research question number</th>
<th>Comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Do the frequencies of cognitive objectives in each Texas textbook differ significantly from the frequencies of cognitive objectives in the Thai textbooks?</td>
<td>For each Texas biology program, the distribution of cognitive objectives was compared to the distribution of cognitive objectives in Thai biology program.</td>
</tr>
<tr>
<td>Source of Data: Research question 2.</td>
<td>Number of Comparisons: 10</td>
</tr>
<tr>
<td>8. Do the frequencies of affective objectives in each Texas textbook differ significantly from the frequencies of affective objectives in the Thai textbooks?</td>
<td>For each Texas biology program, the distribution of affective objectives was compared to the distribution of affective objectives in Thai biology program.</td>
</tr>
<tr>
<td>Source of Data: Research question 3.</td>
<td>Number of Comparisons: 5</td>
</tr>
<tr>
<td>9. Do the frequencies of manual skill objectives in each Texas textbook differ significantly from the frequencies of manual skill objectives in Thai textbooks?</td>
<td>For each Texas biology program, the distribution of manual skill objectives was compared to the distribution of manual skill objectives in Thai biology program.</td>
</tr>
<tr>
<td>Source of Data: Research question 4.</td>
<td>Number of Comparisons: 5</td>
</tr>
</tbody>
</table>
10. Do the frequencies of processes of scientific inquiry objectives in each Texas textbook differ significantly from the frequencies of processes of scientific inquiry objectives in the Thai textbooks?

11. Do the frequencies of the orientation objectives in each Texas textbook differ significantly from the frequencies of orientation objectives in the Thai textbooks?

For each Texas biology program, the distribution of processes of scientific inquiry objectives was compared to the distribution of processes of scientific inquiry objectives in Thai biology program.

Source of Data: Research question 5.

Number of Comparisons: 20

For each Texas Biology program, the distribution of orientation objectives was compared to the distribution of orientation objectives in Thai biology program.

Source of Data: Research question 6.

Number of Comparisons: 5

The Chi Square Test of Significance of Differences of Proportions from K Independent Samples (7) was used in all comparisons of frequency distributions in analysis of data. If the compared distributions were found not to differ significantly, the distributions reflected the same relative cognitive, affective, manual skill, processes of scientific inquiry, and orientation emphases. However, if a significant difference was found, the distributions did not reflect the same relative cognitive, affective, manual skill, processes of scientific inquiry, and orientation emphases. The procedures for analysis of data were the following:

1. The frequency of cognitive, affective, manual skill, processes of scientific inquiry, and orientation objectives
from each Texas and Thai biology program became the observed frequencies in the chi-square tables.

2. For the expected frequencies, the distribution of objectives from each Texas and Thai biology program were computed from the following table:

<table>
<thead>
<tr>
<th>OUTCOME</th>
<th>SAMPLES</th>
<th>TOTAL FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A.0</td>
<td>B.0</td>
</tr>
<tr>
<td>TEXAS TEXTBOOK</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>THAI TEXTBOOK</td>
<td>A'</td>
<td>0</td>
</tr>
<tr>
<td>FREQUENCY</td>
<td>n_1</td>
<td>n_2</td>
</tr>
</tbody>
</table>

\[0, 0, 0 \ldots 0, 0\] represent the frequency of occurrence of a given outcome for a given category. 

0 was the total frequency for outcome A (Texas biology textbooks). 

0 was the total frequency for outcome A' (Thai biology textbooks). 

\[n_1, n_2, \ldots, n_9\] was the total number in each category.
N was the total number in the study.

A Chi-square was calculated using the following formula:

$$\chi^2 = \sum_{j=1}^{k} \sum_{i=j}^{2} \frac{(O_{ij} - E_{ij})^2}{(E_{ij})}$$

The degree of freedom, $V = (k-1)$ where $k$ was the number of samples. $(E_{ij})$ was the expected value for a cell and was calculated in the usual manner of a $\chi^2$. For example, $E_{11} = (n_1)(O_1)/N$; $E_{23} = (n_3)(O_2)/N$; etc. Thus $E_{ij} = (n_j)(O_i)/N$. The calculated value was compared to the Table value for $\chi^2$ with $V = (k-1)$. If the calculated value was greater, the null hypothesis was rejected.

If the investigator found that there were significant differences between the objectives utilized in biology textbooks used in Texas and those used in Thailand, Post Hoc Procedures for the K-Sample Problem with Independent Proportions (6, pp. 380-382) were used to determine if there was significant difference in a pair of group scores at any level of significance.

The procedure used in analysis of the difference between two proportions was to:

Solve for $\chi^2$ by:

$$\chi^2 = \frac{(p_1-p_2)^2}{\frac{p_1q_1}{n_1} + \frac{p_2q_2}{n_2}}$$
Where:

\[ p_1 = \frac{\text{the number in one sample with a given response divided by the total number in that sample.}}{1} \]

\[ q_1 = 1 - p_1 \]

\[ p_2 = \frac{\text{the number in a second sample with a given response divided by the total number in that sample.}}{1} \]

\[ q_2 = 1 - p_2 \]

\[ n_1 = \text{the total number in the } p_1 \text{ sample.} \]

\[ n_2 = \text{the total number in the } p_2 \text{ sample.} \]

The following table is representative of the tables that were used in presenting the findings of the study:

<table>
<thead>
<tr>
<th>OUTCOME</th>
<th>SAMPLES</th>
<th>TOTAL FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A.O</td>
<td>NOT A.O</td>
</tr>
<tr>
<td>TEXAS TEXTBOOK A</td>
<td>( p_1 )</td>
<td>( q_1 )</td>
</tr>
<tr>
<td>THAI TEXTBOOK A'</td>
<td>( p_2 )</td>
<td>( q_2 )</td>
</tr>
</tbody>
</table>

Summary

This chapter presented the procedures for the study. The criteria for selection of textbooks were described. Descriptions of the instruments, the analysis of data, and the procedures used in analysis were explained.
CHAPTER BIBLIOGRAPHY


CHAPTER IV

FINDINGS AND ANALYSIS OF THE DATA

This chapter presents an analysis and summary of the data gathered in the study. Phase I examines the biological content of each textbook. Phase II examines the provisions made in each text for cognitive, affective, manual skill, processes of scientific inquiry, and orientation objectives and also determines whether differences exist in the selected texts in the distribution of these objectives. In Phase III the chi-square values are used to determine the presence or absence of significant differences in the objectives derived from comparisons between (1) the IPST and Cunningham programs, (2) the IPST and Oram programs, (3) the IPST and Otto programs, (4) the IPST and Smallwood programs, and (5) the IPST and Weinberg programs.

Phase I

Content Emphasis of Textbooks

Table I and Appendix C to O present the biological content which is emphasized in each program selected for this study. All of the texts approached the subject matter differently and, indeed, none of them conformed precisely to the scheme outlined in Table I.
Each content area presented in Table I was found in different chapters of different textbooks. For example, Chapter I of Oram's text included content in Natural Environment (1.31), and Cycles in Nature (1.32). Consequently, Chapter I, with its appropriate page numbers, was included in the content topic section of Appendix 0. It should be noted that each of the textbooks included all of the content areas listed in Table I. However, since some of these topics were scattered or barely mentioned in some texts, only the major topic and/or section involved in the book's table of contents was considered. For example, the section on Population Genetics (1.34) was found in all textbooks, but this section was listed only in the heading section in Oram's, Otto's, and Weinberg's texts. As a result, only the mark "x" were put in Table I, and the chapters and their page numbers were put in Appendix 0.

In the section on Biology of the Cell (1.1), every textbook discussed Cell Structure and Function (1.11) and the Transportation of Cellular Material (1.12), while studies in Cell Metabolism (1.13), Photosynthesis (1.14), and Concept of the Gene (1.16) were contained in every text except Cunningham's. Information about Cell Responses (1.15) was included only in the IPST, Oram, and Otto textbooks.

In the section of Biology of the Organism (1.2), the content area on Diversity of Life (1.21), Metabolism in Organisms (1.22), Regulation in Organism (1.23), Coordination and
<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
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<th>1.1 Biology of the Cell</th>
<th>1.2 Biology of Organism</th>
<th>1.3 Biology of Population</th>
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<td>Cell Structure and Function</td>
<td>1.12 Transport of Cellular Materials</td>
<td>1.15 Photosynthesis</td>
<td>1.21 Diversity of Life</td>
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<td></td>
<td>1.13 Cell Metabolism</td>
<td></td>
<td>1.16 Concept of the Gene</td>
<td>1.22 Metabolism in Organism</td>
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<td>1.23 Regulation in Organism</td>
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<td>1.24 Coordination and Behavior</td>
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<td>1.25 Reproduction and Development</td>
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<td>1.26 Human Biology</td>
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<td>1.32 Cycles in Nature,</td>
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<td>1.35 Evolution</td>
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<p>| IPST      | X X X X X X X X X X X X X X X X X X X X X X |
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| Oram      | X X X X X X X X X X X X X X X X X X X X X |
| Otto      | X X X X X X X X X X X X X X X X X X X X X |
| Smallwood | X X X X X X X X X X X X X X X X X X X X X |
| Weinberg  | X X X X X X X X X X X X X X X X X X X X X |</p>
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<tr>
<th>2.17 Atomic and Molecular Structure</th>
<th>2.19 Chemistry of Life Processes</th>
<th>2.23 Energy and its Conservation</th>
<th>2.29 Light and Spectra</th>
<th>2.31 Solar System</th>
<th>2.33 Meteorology</th>
<th>2.34 Physical Geology</th>
<th>2.35 Historical Geology</th>
<th>2.37 Oceanography</th>
<th>3.1 Historical Development</th>
<th>3.2 Nature and Structure of Science</th>
<th>3.3 Nature of Scientific Inquiry</th>
<th>3.4 Biographies of Scientists</th>
<th>3.5 Measurement</th>
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TABLE I continued
Behavior (1.24), Reproduction and Development (1.25), and Human Biology-(1.26) were included in all textbooks.

In the section on Biology of Populations (1.3), the content area on Natural Environment (1.31). Cycles in Nature (1.32), Natural Groups and Their Segregation (1.33), and Evolution (1.35) were contained in all textbooks. Information about Population Genetics (1.34) was included only in the Oram, Otto, and Weinberg textbooks.

In the section of Chemistry (2.1), it was found that all textbooks included information on Atomic and Molecular Structure (2.17) and Chemistry of Life Processes (2.19), but only Cunningham's and Weinberg's textbooks included Nuclear Chemistry (2.110).

Some data on Physics (2.2) were found in all textbooks. The IPST, Oram, and Weinberg textbooks included information on Energy and Its Conservation (2.23) while only the Oram and Weinberg textbooks had anything on Light and Spectra (2.29).

Sections on Earth and Space Sciences (2.3) were found scattered throughout all textbooks, except the Smallwood text which did not cover this content area at all. Only Weinberg's textbook included a discussion of the Solar System (2.31) while discussions of Meteorology (2.33) and Oceanography (2.37) were found only in Cunningham's text. Cunningham's text also included a discussion of Physical Geology (2.34), as did Weinberg's and Otto's. Historical Geology (2.35) was found in all textbooks, except Smallwood's.
In the General Areas (3.0), all textbooks included sections on the Historical Development of Science (3.1) and Measurement (3.5). Discussions of the Nature and Structure of Science (3.2) were found in the Cunningham, Oram, Otto, and Weinberg textbooks. The Nature of Scientific Inquiry (3.3) was covered in the IPST, Oram, and Otto textbooks, and the Biographies of Scientists (3.4) were found in all textbooks, except the Cunningham and the IPST textbooks.

**Summary**

A listing of the chapters and their page numbers is presented in Appendix 0 while the content areas that appear in each textbook are shown in Table I. The difference among textbooks lay in how much each content area was emphasized. For example, a few of the texts mentioned some areas but only in a cursory manner. This would suggest that any textbook which was used would show the instructional planning that emphasized the content the student should know in the biological sciences, physical sciences, and general areas.

**Phase II**

**Analysis of Textbooks**

All textbook objectives were classified to provide the data for this phase. Tables II through XLIII compare each Texas and Thai biology program to determine the differences in the distribution of cognitive, affective, manual skill, processes of scientific inquiry, and orientation objectives.
Research questions 1 - 6 are restated and each is followed by a presentation and analysis of the data found in this study.

Research question 1. -- How many cognitive, affective, manual skill, processes of scientific inquiry, and orientation objectives are contained in each textbook?

Comparisons in total objectives were made on the following: (1) the IPST and Cunningham programs, (2) the IPST and Oram programs, (3) the IPST and Otto programs, (4) the IPST and Smallwood programs, and (5) the IPST and Weinberg programs. These data are shown in Tables II through VI.

Table II shows that the IPST program contains a greater number of total objectives (N=3167) than the Cunningham program (N=2618). As shown, the IPST program has the highest percentage of Knowledge and Comprehension objectives (A.O = 85.54%), and the lowest percentage of Orientation objectives (I.O = 0.50%). Cunningham's program has the highest percentage of objectives in Knowledge and Comprehension (A.O = 69.79%), and the lowest percentage of objectives in Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It (C.O = 0.31%). Even though the two programs have a high percentage of Knowledge and Comprehension objectives (A.O), they differ in their emphasis on this objectives. The IPST program is comprised of approximately 87% cognitive objectives (A.O = 85.54%, and F.O = 1.80%), 9.76% of processes of scientific inquiry objectives (B.O = 4.55%, C.O = 0.79%, D.O = 4.42%, and E.O = 0%), 2.40% of manual skill objectives, and 0.50% of orientation objectives; the program does not


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<td>76</td>
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<tr>
<td></td>
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<td>Cunningham</td>
<td>f</td>
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<td></td>
<td>%</td>
<td>69.79</td>
<td>10.35</td>
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<td>4.62</td>
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</table>

$$\chi^2 = 232.697 \quad P \leq .001 \quad df = 6$$
include affective objectives. Cunningham's program is comprised of approximately 74% cognitives (A.O = 69.79%, and F.O = 4.51%), 20.13% processes of scientific inquiry objectives (B.O = 10.35%, C.O = 0.31%, D.O = 9.47%, and E.O = 0%), 4.62% manual skill objectives, and 0.95% orientation objectives. Moreover, this program does not include affective objectives.

In summary, the IPST program emphasizes cognitive objectives while the Cunningham program shifts away from this objective and devotes approximately one fourth of the program to non-cognitive objectives. Cunningham's program contains a greater percentage of processes of scientific inquiry, manual skill, and orientation objectives than the IPST program.

Table III shows that the IPST program contains a smaller number of total objectives (N=3167) than Oram's program (N=3890). Oram's program contains approximately 76% cognitive objectives (A.O = 74.42%, and F.O = 2.06%), 20.13% processes of scientific inquiry objectives (B.O = 9.74%, C.O = 0.23%, D.O = 7.63%, and E.O = 0%), 5.22% manual skill objectives, 0.7% orientation objectives, and 0.0% affective objectives. Both the IPST and Oram programs have a higher percentage of Knowledge and Comprehension objectives (A.O) than any of the other objectives. About 13% and 25% of the IPST and Oram programs, respectively, contain all the objectives in processes of scientific inquiry, manual skill, and orientation. Also, Oram's program has a higher percentage of objectives than does the IPST program in Processes of Scientific Inquiry.
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<td>16</td>
<td>3167</td>
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<tr>
<td></td>
<td>% 85.54</td>
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<td>0.79</td>
<td>4.42</td>
<td>0</td>
<td>1.80</td>
<td>2.40</td>
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<td>Oram</td>
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<td>297</td>
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<td>27</td>
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<td>% 74.42</td>
<td>9.74</td>
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\[ \chi^2 = 167.876 \quad P \leq .001 \quad df = 6 \]

Table IV shows that Otto's program contains a greater number of total objectives (N=4985) than the IPST program (N=3167). Otto's program contains approximately 87% cognitive objectives (A.O = 87.10%, and F.O = 0.44%), 9.03% processes of scientific inquiry objectives (B.O = 5.94%, C.O = 0.20%, D.O = 2.89%, and E.O = 0%), 2.97% manual skill objectives, 0.46% orientation objectives, and 0.0% affective objectives. A comparison of these two programs show that they have closely related percentages of objectives in Knowledge and Comprehension (A.O), Processes of Scientific Inquiry I: Observing and Measuring (B.O), Manual Skill (G.O), and Orientation (I.O). Cognitive objectives play an equally important roles in the IPST (87.34%) and the Otto (87.54%) programs. Moreover, these two programs do not differ significantly in their emphasis on the other objectives.

Table V shows that both the IPST and the Smallwood programs have almost the same number of total objectives. The IPST program contains 3167 total objectives while Smallwood's program contains 3190. Smallwood's program has approximately 85.55% cognitive objectives (A.O = 84.17%, and F.O = 1.38%), 10.03% processes of scientific inquiry objectives (B.O = 7.18%, C.O = 0.06%, D.O = 2.79%, and E.O = 0%), 3.89% manual
## TABLE IV

COMPARISON OF FREQUENCIES AND PERCENTAGE OF TOTAL OBJECTIVES FOR THE IPST AND OTTO PROGRAMS

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<td>144</td>
<td>25</td>
<td>144</td>
<td>0</td>
<td>57</td>
<td>76</td>
<td>0</td>
<td>16</td>
<td>3167</td>
</tr>
<tr>
<td></td>
<td>% 85.54</td>
<td>4.55</td>
<td>0.79</td>
<td>4.42</td>
<td>0</td>
<td>1.80</td>
<td>2.40</td>
<td>0</td>
<td>0.50</td>
<td>100</td>
</tr>
<tr>
<td>Otto</td>
<td>f 4342</td>
<td>296</td>
<td>10</td>
<td>144</td>
<td>0</td>
<td>22</td>
<td>148</td>
<td>0</td>
<td>23</td>
<td>4985</td>
</tr>
<tr>
<td></td>
<td>% 87.10</td>
<td>5.94</td>
<td>0.20</td>
<td>2.89</td>
<td>0</td>
<td>0.44</td>
<td>2.97</td>
<td>0</td>
<td>0.46</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 75.413 \quad \text{P} \leq .001 \quad df = 6 \]
### TABLE V

Comparison of Frequencies and Percentages of Total Objectives for the IPST and Smallwood Programs

<table>
<thead>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td><strong>f</strong> 2709</td>
<td>144</td>
<td>25</td>
<td>140</td>
<td>0</td>
<td>57</td>
<td>76</td>
<td>0</td>
<td>16</td>
<td>3167</td>
</tr>
<tr>
<td></td>
<td><strong>%</strong> 85.54</td>
<td>4.55</td>
<td>0.79</td>
<td>4.42</td>
<td>0</td>
<td>1.80</td>
<td>2.40</td>
<td>0</td>
<td>0.50</td>
<td>100</td>
</tr>
<tr>
<td>Smallwood</td>
<td><strong>f</strong> 2685</td>
<td>229</td>
<td>2</td>
<td>89</td>
<td>0</td>
<td>44</td>
<td>124</td>
<td>0</td>
<td>17</td>
<td>3190</td>
</tr>
<tr>
<td></td>
<td><strong>%</strong> 84.17</td>
<td>7.18</td>
<td>0.06</td>
<td>2.79</td>
<td>0</td>
<td>1.38</td>
<td>3.89</td>
<td>0</td>
<td>0.53</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 63.568 \quad p \leq .001 \quad df = 6 \]
skill objectives, 0.53% of the orientation objectives, and 0.0% affective objectives. Both the IPST and Smallwood programs contain a higher percentage in Knowledge and Comprehension objectives (A.O) than any of the other objectives. Moreover, these two programs have closely related percentages of objectives in Knowledge and Comprehension (A.O), Application of Scientific Knowledge and Method (F.O), and Orientation (I.O). Percentage difference can be found, however, in the objectives of processes of scientific inquiry (B.O, C.O, and D.O), and manual skill.

Table VI shows that the IPST program contains a slightly greater number of total objectives (N=3167) than does Weinberg's program (N=3126). As shown, the Weinberg program contains approximately 82% cognitive objectives (A.O = 81.25%, and F.O = 1.18%), 12.86% processes of scientific inquiry objectives (B.O = 6.39%, C.O = 0.58%, D.O = 5.89%, and E.O = 0%), 3.68% manual skill objectives, 1.02% of the orientation objectives, and 0.0% affective objectives. Both the IPST and Weinberg programs contain a higher percentage in Knowledge and Comprehension Objectives (A.O) than any of the other objectives. Moreover, the Weinberg program has a higher percentage in the objectives of Processes of Scientific Inquiry I: Observing and Measuring (B.O), Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalization (D.O), Manual Skills (G.O), and Orientation (I.O), than does the IPST program.
TABLE VI
COMPARISON OF FREQUENCIES AND PERCENTAGES OF TOTAL OBJECTIVES FOR THE IPST AND WEINBERG PROGRAMS

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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>2709</td>
<td>144</td>
<td>25</td>
<td>140</td>
<td>0</td>
<td>57</td>
<td>76</td>
<td>0</td>
<td>16</td>
<td>3167</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>85.54</td>
<td>4.55</td>
<td>0.79</td>
<td>4.42</td>
<td>0</td>
<td>1.80</td>
<td>2.40</td>
<td>0.50</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Weinberg</td>
<td>f</td>
<td>2540</td>
<td>200</td>
<td>18</td>
<td>184</td>
<td>0</td>
<td>37</td>
<td>115</td>
<td>0</td>
<td>32</td>
<td>3126</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>81.25</td>
<td>6.39</td>
<td>0.58</td>
<td>5.89</td>
<td>0</td>
<td>1.18</td>
<td>3.68</td>
<td>0.10</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 38.957 \quad P \leq .001 \quad df = 6 \]
Summary

In summary, it was found that any textbook having a greater emphasis on cognitive objectives would of necessity have a lesser number of objectives in the other categories. In other words, the greater the number of objectives found in one category, the smaller the remaining ones which in fact accounts for the inverse relationship between cognitive objectives and other objectives. Yet, all textbooks emphasized cognitive instruction as their major objective. Some textbooks emphasized the processes of scientific inquiry and the other domains. However, as was observed in Chapter III, it was not possible to measure the affective objectives because the textbooks did not include a means for evaluating the student's attitudes and interests.

Research question 2. -- How are the cognitive objectives distributed among the levels of the cognitive domain in each textbook?

The cognitive objectives include the objectives in the categories of Knowledge and Comprehension (A.O), and Application of Scientific Knowledge and Method (F.O). To obtain the data for this question, five comparisons in Knowledge and Comprehension objectives (A.O), were made and five other comparisons in Application of Scientific Knowledge and Method (F.O). A comparison made between (1) the IPST and Cunningham programs, (2) the IPST and Oram programs, (3) the IPST and Otto programs, (4) the IPST and Smallwood programs, and
(5) the IPST and Weinberg programs. The data are shown in the
Tables VII through XVI.

Table VII shows that the IPST program contains a greater
number of Knowledge and Comprehension objectives \((A.O = 2709)\)
than does the Cunningham program \((A.O = 1827)\). The IPST pro-
gram has the highest percentage of objectives in Knowledge
of Specific Fact \((A.1 = 47.88\%)\), the second in Knowledge of
Scientific Terminology \((A.2 = 32.85\%)\), and the third in Know-
ledge of Concepts of Science \((A.3 = 8.31\%)\). Cunningham's
program has the highest percentage of objectives in A.1
\((41.54\%)\), the second in A.2 objectives \((34.81\%)\), and the
third in A.3 \((11.33\%)\). Also both programs have closely re-
lated percentages of objectives in Knowledge of Trends and
Sequences \((A.5 \text{ in the IPST program }= 0.92\%, \text{ in Cunningham's}
\text{ program, } 0.93\%)\), Knowledge of Scientific Principles and Laws
\((A.8 \text{ in the IPST program }= 4.69\%, \text{ in Cunningham's program,
} 4.49\%)\), and Knowledge of Theories or Major Conceptual Schemes
\((A.9 \text{ in the IPST program }= 0.18\%, \text{ in Cunningham's program,
} 0.33\%)\). Both programs have different percentages in the ob-
jectives of Knowledge of Conventions \((A.4 \text{ in the IPST program
} = 0.85\%, \text{ in Cunningham's program, } 0.27\%)\), Knowledge of Class-
ifications, Categories, and Criteria \((A.6 \text{ in the IPST program
} = 1.14\%, \text{ in Cunningham's program, } 0.16\%)\), Knowledge of Sci-
entific Techniques and Procedures \((A.7 \text{ in the IPST program =}
1.99\%, \text{ in Cunningham's program } 3.23\%)\), Identification Know-
ledge in a New Context \((A.10 \text{ in IPST program } = 0.11\%, \text{ in
}}
### TABLE VII

**COMPARISON OF FREQUENCIES AND PERCENTAGES OF KNOWLEDGE AND COMPREHENSION OBJECTIVES (A.O) FOR THE IPST AND CUNNINGHAM PROGRAMS**

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IPST</strong></td>
<td>£ 1297</td>
<td>890</td>
<td>225</td>
<td>23</td>
<td>25</td>
<td>31</td>
<td>54</td>
<td>127</td>
<td>5</td>
<td>3</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>% 47.88</td>
<td>32.85</td>
<td>8.31</td>
<td>0.85</td>
<td>0.92</td>
<td>1.14</td>
<td>1.99</td>
<td>4.69</td>
<td>0.18</td>
<td>0.11</td>
<td>1.07</td>
</tr>
<tr>
<td><strong>Cunningham</strong></td>
<td>£ 759</td>
<td>636</td>
<td>207</td>
<td>5</td>
<td>17</td>
<td>3</td>
<td>59</td>
<td>82</td>
<td>6</td>
<td>16</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>% 41.54</td>
<td>34.81</td>
<td>11.33</td>
<td>0.27</td>
<td>0.93</td>
<td>0.16</td>
<td>3.23</td>
<td>4.49</td>
<td>0.33</td>
<td>0.88</td>
<td>2.03</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 207.472 \quad p \leq 0.001 \quad df = 10 \]
Cunningham's program, 0.88%), and Translation Knowledge from one Symbolic Form to Another (A.11 in the IPST program = 1.07%, in Cunningham's program, 2.03%). In short, both programs, have a higher emphasis on the same three subcategory objectives (A.1, A.2, and A.3) than any of the other objectives, and have varied emphasis on the other subcategory objectives (A.4 to A.11).

Table VIII shows the comparison between the IPST's and Oram's Knowledge and Comprehension objectives (A.0). The IPST program contains 2709 Knowledge and Comprehension objectives while Oram's program has 2895 of these objectives. In the Oram program, the highest percentage of objectives in Knowledge of Scientific Terminology (A.2 = 41.45%), second is Knowledge of Specific Facts (A.1 = 38.31%), and third is Knowledge of Concepts of Science (A.3 = 12.47%). It is interesting to note that Oram's first two highest objectives (A.1 and A.2) are in reverse emphasis from those of the IPST program (A.1 = 47.88%, and A.2 = 32.85%). It is also found that these two programs have closely related percentages of objectives in Knowledge of Classifications, Categories, and Criteria (A.6 in the IPST program = 1.14%, in Oram's program A.6 = 1.31%), Knowledge of Theories or Major Conceptual Schemes (A.9 in IPST program = 0.18%, in Oram's program A.9 = 0.31%), and Identification Knowledge in a New Context (A.10 in IPST program = 0.11%, in Oram's program, 0.10%). Different percentage of objectives are found in Knowledge of
### TABLE VIII

**Comparison of Frequencies and Percentages of Knowledge and Comprehension Objectives (A.0) for the IPST and Oram Programs**

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>IPST</th>
<th>Oram</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A.1 Knowledge of Specific Facts</td>
<td>1297</td>
<td>1109</td>
</tr>
<tr>
<td></td>
<td>A.2 Knowledge of Scientific Terminology</td>
<td>890</td>
<td>1200</td>
</tr>
<tr>
<td></td>
<td>A.3 Knowledge of Concepts of Science</td>
<td>225</td>
<td>361</td>
</tr>
<tr>
<td></td>
<td>A.4 Knowledge of Conventions</td>
<td>23</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>A.5 Knowledge of Trends and Sequences</td>
<td>25</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>A.6 Knowledge of Classifications, Categories</td>
<td>31</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>A.7 Knowledge of Scientific Techniques and</td>
<td>54</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>A.8 Knowledge of Scientific Principles and</td>
<td>127</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>A.9 Knowledge of Theories or Major Conceptual</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Schemes</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>A.10 Identification Knowledge in a New Context</td>
<td>29</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>All Translation Knowledge from One Symbolic</td>
<td>2709</td>
<td>2895</td>
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<tr>
<td></td>
<td>Form to Another</td>
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\[ \chi^2 = 140.442 \quad P \leq .001 \quad df = 10 \]
Conventions (A.4 in IPST program = 0.85%, in Oram's program, 1.07%), Knowledge of Trends and Sequences (A.5 in IPST program = 0.92%, in Oram's program, 2.14%), Knowledge of Scientific Techniques and Procedures (A.7 in IPST program = 1.99%, in Oram's program = 1.28%), Knowledge of Scientific Principles and Laws (A.8 in IPST program = 4.69%, in Oram's program = 0.90%), and Translation Knowledge from one Symbolic Form to Another (A.11 in the IPST program = 1.07%, in Oram's program, 0.66%). As shown, the IPST program emphasizes more objectives in the subcategories of A.1, A.7, A.8, A.10 and A.11, than does Oram's program. Oram's program emphasizes more objectives in the subcategories of A.2, A.3, A.4, A.5, A.6, and A.9, than does the IPST's. In summary both programs have a higher emphasis on the same three subcategory objectives (A.1, A.2, and A.3) than any of the other objectives, and have the varied emphasis on the other subcategory objectives (A.4 to A.11).

Table IX shows that the IPST program contains 2709 Knowledge and Comprehension objectives (A.0) while Otto's program contains 4342 of these same objectives. Otto's program has the highest percentage of objectives in Knowledge of Specific Facts (A.1 = 40.33%), second in Knowledge of Scientific Terminology objectives (A.2 = 37.24%), and third in Knowledge of Concepts of Science objectives (A.3 = 8.16%). This program has the same order of the three highest percentage objectives (A.1, A.2, and A.3) as does the IPST program. As shown,
TABLE IX

COMPARISON OF FREQUENCIES AND PERCENTAGES OF KNOWLEDGE AND COMPREHENSION OBJECTIVES (A.O) FOR THE IPST AND OTTO PROGRAMS

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</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>1297</td>
<td>890</td>
<td>225</td>
<td>23</td>
<td>25</td>
<td>31</td>
<td>54</td>
<td>127</td>
<td>5</td>
<td>3</td>
<td>29</td>
<td>2709</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>47.88</td>
<td>32.85</td>
<td>8.31</td>
<td>0.85</td>
<td>0.92</td>
<td>1.14</td>
<td>1.99</td>
<td>4.69</td>
<td>0.18</td>
<td>0.11</td>
<td>1.07</td>
<td>100</td>
</tr>
<tr>
<td>Otto</td>
<td>f</td>
<td>1751</td>
<td>1617</td>
<td>363</td>
<td>19</td>
<td>86</td>
<td>55</td>
<td>58</td>
<td>345</td>
<td>9</td>
<td>29</td>
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<tr>
<td></td>
<td>%</td>
<td>40.33</td>
<td>37.24</td>
<td>8.16</td>
<td>0.44</td>
<td>1.98</td>
<td>1.27</td>
<td>1.34</td>
<td>7.95</td>
<td>0.21</td>
<td>0.67</td>
<td>0.23</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 3.965 \quad P \geq 0.05 \quad df = 10 \]
Otto's program emphasizes more objectives in the subcategories of Knowledge of Scientific Terminology (A.2 in Otto's program = 37.24%, in the IPST program, 32.85%), Knowledge of Trends and Sequences (A.5 in Otto's program = 1.98%, in the IPST program, 0.92%), Knowledge of Classifications, Categories, and Criteria (A.6 in Otto's program = 1.27%, in the IPST program, 1.14%), Knowledge of Scientific Principles and Laws (A.8 in Otto's program = 7.95%, in the IPST program A.7 = 4.69%), Knowledge of Theories or Major Conceptual Schemes (A.9 in Otto's program = 0.21%, in the IPST program, 0.18%), and Identification Knowledge in a New Context (A.10 in Otto's program = 0.67%, in the IPST program, 0.11%). Conversely, the IPST program emphasizes more objectives in the subcategories of Knowledge of Specific Facts (A.1 in the IPST program = 47.88%, in Otto's program, 40.33%), Knowledge of Concepts of Science (A.3 in the IPST program = 8.31%, in Otto's program, 8.16%), Knowledge of Conventions (A.4 in the IPST program = 0.85%, in Otto's program, 0.44%), Knowledge of Scientific Techniques and Procedures (A.7 in the IPST program = 1.99%, in Otto's program, 1.34%), and Translation Knowledge from one Symbolic Form to Another (A.11 in the IPST program = 1.07%, in Otto's program, 0.23%). It is concluded that both programs have a higher emphasis on the same three subcategory objectives (A.1, A.2, and A.3) than any of the other objectives, and have varied emphasis on the other subcategory objectives (A.4 to A.11).
Table X shows that the IPST program contains 2709 Knowledge and Comprehension objectives (A.0) while Smallwood's program contains 2683 of the same objectives. Smallwood's program has the highest percentage of objectives in Knowledge of Specific Facts (A.1 = 41.97%), the second in Knowledge of Scientific Terminology (A.2 = 37.09%), and the third in Knowledge of Concepts of Science (A.3 = 10.39%). This program has the same order of three highest percentage objectives (A.1, A.2, and A.3) as the IPST program. As shown, Smallwood's program emphasizes more objectives in the subcategories of Knowledge of Scientific Terminology (A.2 in Smallwood's program = 37.09%, in the IPST program A.2 = 32.85%), Knowledge of Concepts of Science (A.3 in Smallwood's program = 10.39%, in the IPST program, 8.31%), Knowledge of Trends and Sequences (A.5 in Smallwood's program = 1.27%, in the IPST program, 0.92%), Knowledge of Scientific Techniques and Procedures (A.7 in Smallwood = 2.01%, in the IPST program, 1.99%), Knowledge of Theories or Major Conceptual Schemes (A.9 in Smallwood's program = 0.22%, in IPST program, 0.18%, and Identification Knowledge in a New Context (A.10 in Smallwood's program = 0.78%, in the IPST program, 0.11%). Conversely, the IPST program emphasizes more objectives in the subcategories of Knowledge of Specific Facts (A.1 in the IPST program = 47.88%, in Smallwood's program, 41.97%), Knowledge of Conventions (A.4 in the IPST program = 0.85%, in Smallwood's program, 0.52%), Knowledge of Classification, Categories, and
### TABLE X

**COMPARISON OF FREQUENCIES AND PERCENTAGES OF KNOWLEDGE AND COMPREHENSION OBJECTIVES (A.0) FOR THE IPST AND SMALLWOOD PROGRAMS**

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</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>1297</td>
<td>890</td>
<td>225</td>
<td>23</td>
<td>25</td>
<td>31</td>
<td>54</td>
<td>127</td>
<td>5</td>
<td>3</td>
<td>29</td>
<td>2709</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>47.88</td>
<td>32.85</td>
<td>8.31</td>
<td>0.85</td>
<td>0.92</td>
<td>1.14</td>
<td>1.99</td>
<td>4.69</td>
<td>0.18</td>
<td>0.11</td>
<td>1.07</td>
<td>100</td>
</tr>
<tr>
<td>Smallwood</td>
<td>f</td>
<td>1127</td>
<td>996</td>
<td>279</td>
<td>14</td>
<td>34</td>
<td>23</td>
<td>54</td>
<td>120</td>
<td>6</td>
<td>21</td>
<td>11</td>
<td>2685</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>41.97</td>
<td>37.09</td>
<td>10.39</td>
<td>0.52</td>
<td>1.27</td>
<td>0.86</td>
<td>2.01</td>
<td>4.47</td>
<td>0.22</td>
<td>0.78</td>
<td>0.41</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 2.318 \quad P \geq .05 \quad df = 10 \]
Criteria (A.6 in the IPST program = 1.14%, in Smallwood's program, 0.86%), Knowledge of Scientific Principles and Laws (A.8 in the IPST program = 4.69%, in Smallwood's program, 4.47%), and Translation of Knowledge from one Symbolic Form to Another (A.11 in the IPST program = 1.07%, in Smallwood's program, 0.41%). It is concluded that both programs have a higher emphasis on the same three subcategory objectives (A.1, A.2, and A.3) than any of the other objectives, and have varied emphasis on the other subcategory objectives (A.4 to A.11).

Table XI shows that the IPST program contains 2709 Knowledge and Comprehension objectives (A.0) while Weinberg's program contains 2540 of these objectives. Weinberg's program has the highest percentage of objectives in Knowledge of Specific Facts (A.1=41.85%), the second in Knowledge of Scientific Terminology (A.2 = 36.42%), and the third in Knowledge of Concepts of Science (A.3 = 15.51%). Thus, this program has the same order of three highest percentage objectives (A.1, A.2, and A.3) as the IPST program. As shown, Weinberg's program emphasizes more objectives in the subcategories of Knowledge of Scientific Terminology (A.2 in Weinberg program = 36.42%, in IPST program, 32.85%), Knowledge of Concepts of Science (A.3 in Weinberg program = 15.51%, in the IPST program, 8.31%), Knowledge of Trends and Sequences (A.5 in Weinberg program = 1.26%, in the IPST program, 0.92%, Knowledge of Scientific Techniques and Procedures (A.7 in
TABLE XI
COMPARISON OF FREQUENCIES AND PERCENTAGES OF KNOWLEDGE AND COMPREHENSION OBJECTIVES (A.O) FOR THE IPST AND WEINBERG PROGRAMS

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>1297</td>
<td>890</td>
<td>225</td>
<td>23</td>
<td>25</td>
<td>31</td>
<td>54</td>
<td>127</td>
<td>5</td>
<td>3</td>
<td>29</td>
<td>2709</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>47.88</td>
<td>32.85</td>
<td>8.31</td>
<td>0.85</td>
<td>0.92</td>
<td>1.14</td>
<td>1.99</td>
<td>4.69</td>
<td>0.18</td>
<td>0.11</td>
<td>1.07</td>
<td>100</td>
</tr>
<tr>
<td>Weinberg</td>
<td>f</td>
<td>1063</td>
<td>925</td>
<td>394</td>
<td>8</td>
<td>32</td>
<td>28</td>
<td>59</td>
<td>9</td>
<td>14</td>
<td>2</td>
<td>6</td>
<td>2540</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>41.85</td>
<td>36.42</td>
<td>15.51</td>
<td>0.31</td>
<td>1.26</td>
<td>1.10</td>
<td>2.32</td>
<td>0.35</td>
<td>0.55</td>
<td>0.08</td>
<td>0.24</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 20.909 \quad p \leq 0.05 \quad df = 10 \]
Weinberg program = 2.32%, in the IPST program, 1.99%), and Knowledge of Theories or Major Conceptual Schemes (A.9 in Weinberg's program = 0.55%, in the IPST program, 0.18%). Conversely, the IPST program emphasizes more objectives in the subcategories of Knowledge of Specific Facts (A.1 in the IPST program = 47.88%, in Weinberg's program, 41.85%), Knowledge of Conventions (A.4 in the IPST program = 0.85%, in Weinberg's program, 0.31%), Knowledge of Classifications, Categories, and Criteria (A.6 in the IPST program = 1.14%, in Weinberg's program, 1.10%), Knowledge of Scientific Principles and Laws (A.8 in the IPST program = 4.69%, in Weinberg's program, 0.35%), Identification Knowledge in a New Context (A.10 in the IPST program = 0.11%, in Weinberg's program, 0.08%), and Translation Knowledge from one Symbolic Form to Another (A.11 in the IPST program = 1.07%, in Weinberg's program 0.24%). It is concluded that both programs have a higher emphasis on the same three subcategory objectives (A.1, A.2, and A.3) than any of the other objectives, and have varied emphasis on the other subcategory objectives (A.4 to A.11).

Summary

Each program emphasized different Knowledge and Comprehension objectives (A.0). When the frequency of each of the subcategories was examined, it was found that objectives related to Knowledge of Specific Facts (A.1) occurred most often, Knowledge of Scientific Terminology (A.2) second, and
Knowledge of Concepts of Science (A.3) third. Remaining frequencies varied among the other subcategories of each program.

Table XII shows the comparison of Application of Scientific Knowledge and Method objectives (F.O) between the IPST program and Cunningham's program. The IPST program contains 57 objectives while Cunningham's program contains 118. The IPST program has 54.39% while Cunningham's program has 44.92% objectives related to Application to New Problems in the Same Field of Science (F.1). In addition, 29.82% of the IPST program and 3.39% of the Cunningham program relate to Application to New Problems in Different Fields of Science (F.2); 15.79% of the IPST and 51.69% of Cunningham's are concerned with the Application to Problems Outside of Science objectives (F.3). The IPST program ranks first in the F.1 objective, second in the F.2 objective, and third in the F.3 objective. Cunningham's program has a different approach. This program emphasizes first the F.3 objective, second the F.1 objective, and third the F.2 objective.

Table XIII shows that the IPST program contains a smaller number of Application of Scientific Knowledge and Method objectives (F.O = 57) than Oram's program (F.O = 80). Oram's program is comprised of 73.75% Application to New Problems in the Same Field of Science objectives (F.1), 17.50% Application to the New Problem in a Different Field of Science objectives (F.2), and 8.75% Application to New Problems Outside of Science Objectives (F.3). As shown, the IPST program
TABLE XII

COMPARISON OF FREQUENCIES AND PERCENTAGES OF APPLICATION OF SCIENTIFIC KNOWLEDGE AND METHOD OBJECTIVES (F.O) FOR THE IPST AND CUNNINGHAM PROGRAMS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>F.1 Application to New Problems in the Same Field of Science</th>
<th>F.2 Application to New Problems in the Different Fields of Science</th>
<th>F.3 Application to Problems Outside of Science (Including Technology)</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>31</td>
<td>17</td>
<td>9</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>54.39</td>
<td>29.82</td>
<td>15.79</td>
<td>100</td>
</tr>
<tr>
<td>Cunningham</td>
<td>f</td>
<td>53</td>
<td>4</td>
<td>61</td>
<td>118</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>44.92</td>
<td>3.39</td>
<td>51.69</td>
<td>100</td>
</tr>
</tbody>
</table>

χ² = 33.287  \( P \leq 0.001 \)  df = 2
**TABLE XIII**

COMPARISON OF FREQUENCIES AND PERCENTAGES OF APPLICATION OF SCIENTIFIC KNOWLEDGE AND METHOD OBJECTIVES (F.O) FOR THE IPST AND ORAM PROGRAMS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>F.1 Application to New Problems in the Same Field of Science</th>
<th>F.2 Application to Problems in the Different Fields of Science</th>
<th>F.3 Application to Problems Outside of Science (Including Technology)</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>31</td>
<td>17</td>
<td>9</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>54.39</td>
<td>29.82</td>
<td>15.79</td>
<td>100</td>
</tr>
<tr>
<td>Oram</td>
<td>f</td>
<td>59</td>
<td>14</td>
<td>7</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>73.75</td>
<td>17.50</td>
<td>8.75</td>
<td>100</td>
</tr>
</tbody>
</table>

$\chi^2 = 0.612 \quad P \geq 0.05 \quad df = 2$
emphasizes more objectives in the subcategories of F.2 (in the IPST program = 29.82%, in Oram's program, 17.50%), and F.3 (in the IPST program = 15.79%, in Oram's program, 8.75%), than does Oram's. Oram's program emphasizes more objectives in the subcategory of F.1 (in Oram's program = 73.75%, in the IPST program, 54.39%). It is concluded that both programs have a higher emphasis on F.1 objectives than any of the other objectives, and vary in emphasis on F.2 and F.3 objectives.

Table XIV shows that the IPST program contains a greater number of Application of Scientific Knowledge and Method objectives (F.0 = 57) than does Otto's program (F.0 = 22). In Otto's program, 95.45% is related to Application to New Problems in the Same Field of Science objectives (F.1), 4.55% to Application to New Problems Outside of Science objectives (F.3), and none to the objectives of Application to New Problems in a Different Field of Science (F.2 = 0%). As shown, the IPST program emphasizes more objectives in the subcategories F.2 (in the IPST program = 29.82%, in Otto's program, 0%), and F.3 (in the IPST program = 15.79%, in Otto's program, 4.55%), than Otto's. Otto's program emphasizes more objectives in the subcategory of F.1 (in Otto's program = 95.45%, in the IPST program = 54.39%), than the IPST's. Thus, both programs have a higher emphasis on F.1 objectives than any of the other objectives, and vary in emphasis on F.2 and F.3 objectives.

Table XV shows that the IPST program contains a greater number of Application of Scientific Knowledge and Method
TABLE XIV

COMPARISON OF FREQUENCIES AND PERCENTAGES OF APPLICATION
OF SCIENTIFIC KNOWLEDGE AND METHOD OBJECTIVES (F.O)
FOR THE IPST AND OTTO PROGRAMS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>F.1 Application to New Problems in the Same Field of Science</th>
<th>F.2 Application to New Problems in the Different Fields of Science</th>
<th>F.3 Application to Problems Outside Science (Including Technology)</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>f</td>
<td>31</td>
<td>17</td>
<td>9</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>54.39</td>
<td>29.82</td>
<td>15.79</td>
<td>100</td>
</tr>
<tr>
<td>IPST</td>
<td>f</td>
<td>21</td>
<td>0</td>
<td>1</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>95.45</td>
<td>0</td>
<td>4.55</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 28.558 \quad P \leq .001 \quad df = 2 \]
TABLE XV

COMPARISON OF FREQUENCIES AND PERCENTAGES OF APPLICATION OF SCIENTIFIC KNOWLEDGE AND METHOD OBJECTIVES (F.O) FOR THE IPST AND SMALLWOOD PROGRAMS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>F.1 Application to New Problems in the Same Field of Science</th>
<th>F.2 Application to New Problems in the Different Fields of Science</th>
<th>F.3 Application to Problems Outside of Science (Including Technology)</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f 31</td>
<td>17</td>
<td>9</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>% 54.39</td>
<td>29.82</td>
<td>15.79</td>
<td>100</td>
</tr>
<tr>
<td>Smallwood</td>
<td>f 36</td>
<td>6</td>
<td>2</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>% 81.82</td>
<td>13.64</td>
<td>4.55</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 1.796 \quad P \geq .05 \quad df = 2 \]
objectives (F.O = 57) than Smallwood's program (F.O = 44).
In Smallwood's program 81.82% is related to Application to New Problems in the Same Field of Science objectives (F.1), 13.64% to Application to New Problems in a Different Field of Science objectives (F.2), and 4.55% to Application to New Problems Outside of Science objectives (F.3). As shown, the IPST program emphasizes more objectives in the subcategories of F.2 (in the IPST program = 29.82%, in Smallwood's program = 13.64%), and F.3 (in the IPST program = 15.79%, in Smallwood's program = 4.55%), than Smallwood's. Smallwood's program emphasizes more objectives in the subcategory of F.1 (in the Smallwood program = 81.82%, in the IPST program, 54.39%) than does the program developed by the IPST. Hence both programs have a higher emphasis on F.1 objectives than any of the other objectives, and vary in emphasis on F.2 and F.3 objectives.

Table XVI shows that the IPST program contains a greater number of Application of Scientific Knowledge and Method objectives (F.O = 57) than does the Weinberg program (F.O = 37). Weinberg's program is comprised of 59.46% Application to New Problems in the Same Field of Science objectives (F.1), 13.51% Application to New Problems in a Different Field of Science objectives (F.2), and 27.03% Application to New Problems Outside of Science objectives (F.3). As shown, the IPST program emphasizes more objectives in the subcategory of F.2 (in the IPST program = 29.82%, in Weinberg's program, 13.51%)
TABLE XVI
COMPARISON OF FREQUENCIES AND PERCENTAGES OF APPLICATION OF SCIENTIFIC KNOWLEDGE AND METHOD OBJECTIVES (F.O) FOR THE IPST AND WEINBERG PROGRAMS

<table>
<thead>
<tr>
<th>BEHAVIORS</th>
<th>IPST</th>
<th>Weinberg</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>F.1 Application to New Problems in the Same Field of Science</td>
<td>31</td>
<td>22</td>
<td>57</td>
</tr>
<tr>
<td>%</td>
<td>54.39</td>
<td>59.46</td>
<td>100</td>
</tr>
<tr>
<td>F.2 Application to New Problems in the Different Fields of Science</td>
<td>17</td>
<td>5</td>
<td>22</td>
</tr>
<tr>
<td>%</td>
<td>29.82</td>
<td>13.51</td>
<td></td>
</tr>
<tr>
<td>F.3 Application to Problems Outside of Science (Including Technology)</td>
<td>9</td>
<td>10</td>
<td>19</td>
</tr>
<tr>
<td>%</td>
<td>15.79</td>
<td>27.03</td>
<td></td>
</tr>
</tbody>
</table>

\[ \chi^2 = 4.072 \quad p > .05 \quad df = 2 \]
than Weinberg's. The Weinberg program emphasizes more objectives than the IPST program in the subcategories of F.1 (in Weinberg's program = 59.46%, in the IPST program = 54.39%), and F.3 (in Weinberg's program = 27.03%, in the IPST program, 15.79%). Thus both programs have a higher emphasis on F.1 objectives than any of the other objectives, and vary in emphasis on F.2 and F.3 objectives.

**Summary**

All programs contained the objectives related to Application of Scientific Knowledge and Method (F.O). Some programs had a higher percentage of objectives in the subcategory of Application of New Problems to the Same Field of Science (F.1) while other programs had a high percentage of objectives in Application of New Problems to Different Fields of Science (F.2), or Application to Problems Outside of Science (F.3).

**Research question 3.** -- How are the affective objectives distributed among the levels of the affective domain in each textbook?

Table XVII summarizes the frequency and percentages of objectives related to Attitude and Interest (H.O) in the six programs examined. No textbook contained the subcategory objectives in the attitudes and interest of students.

**Research question 4.** -- How are the manual skills distributed within the manual skill domain in each textbook?

Comparisons in manual skill objectives were made on the following: (1) the IPST and Cunningham programs, (2)
TABLE XVII
FREQUENCIES AND PERCENTAGES OF ATTITUDES AND INTEREST OBJECTIVES (H.O) IN TEXAS AND THAI BIOLOGY TEXTBOOKS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>H.1 Manifestation of Favorable Attitudes Towards Science and Scientists</th>
<th>H.2 Acceptance of Scientific Inquiry as a Way of Thought</th>
<th>H.3 Adoption of &quot;Scientific Attitudes&quot;</th>
<th>H.4 Enjoyment of Science Learning Experiences</th>
<th>H.5 Development of Science and Science-related Activities</th>
<th>H.6 Development of Pursuing a Career in Science</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cunningham</td>
<td>f</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Oram</td>
<td>f</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>%</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Otto</td>
<td>f</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Smallwood</td>
<td>f</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Weinberg</td>
<td>f</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
the IPST and Oram programs, (3) the IPST and Otto programs, (4) the IPST and Smallwood programs, and (5) the IPST and Weinberg programs. The data are shown in the Tables XVIII through XXII.

Table XVIII shows that the IPST program contains a smaller number of Manual Skill objectives \( G.O = 76 \) than Cunningham's program \( G.O = 121 \). In IPST program, 25% related to the objectives of Development of Skills in Using Common Laboratory Equipment \( G.1 \), and 75% to objectives of Performance of Common Laboratory Exercises with Care and Safety \( G.2 \). Cunningham's program is comprised of 16.53% \( G.1 \) objectives, and 83.47% \( G.2 \) objectives. As shown, both programs have a high percentage in the objectives of \( G.2 \) and a low percentage of \( G.1 \) objectives.

Table XIX shows that the IPST program contains a smaller number of Manual Skill objectives \( G.O = 76 \) than Oram's program \( G.O = 203 \). Oram's program contains 33.99% of objectives related to Development of Skills in Using Common Laboratory Equipment \( G.1 \), and 66.01% of objectives related to Performance of Common Laboratory Exercises with Care and Safety \( G.2 \). As shown, both programs have a high percentage in \( G.2 \) objectives, and a low percentage in \( G.1 \) objectives. It is also found that the frequency percentage of the \( G.1 \) objective in the IPST program is one third that of the \( G.2 \) objective while in Oram's program the frequency percentage of the \( G.1 \) objective is one half that of the \( G.2 \) objective.
TABLE XVIII

COMPARISON OF FREQUENCIES AND PERCENTAGES OF MANUAL SKILL OBJECTIVES (G.O) FOR THE IPST AND CUNNINGHAM PROGRAMS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>G.1 Development of Skills in Using Common Laboratory Equipment</th>
<th>G.2 Performance of Common Laboratory Exercises with Care and Safety</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>19</td>
<td>57</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>25</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>Cunningham</td>
<td>f</td>
<td>20</td>
<td>101</td>
<td>121</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>16.53</td>
<td>83.47</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 20.375 \quad P < .001 \quad df = 1 \]
### TABLE XIX

**COMPARISON OF FREQUENCIES AND PERCENTAGES OF MANUAL SKILL OBJECTIVES (G.O) FOR THE IPST AND ORAM PROGRAMS**

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>G.1 Development of Skills in Using Common Laboratory Equipment</th>
<th>G.2 Performance of Common Laboratory Exercise with Care and Safety</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>19</td>
<td>57</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>25</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>Oram</td>
<td>f</td>
<td>69</td>
<td>134</td>
<td>203</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>33.99</td>
<td>66.01</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 39.508 \quad P \leq .001 \quad df = 1 \]
Table XX shows that the IPST program contains a smaller number of Manual Skill objectives (G.O = 76) than Otto's program (G.O = 148). In Otto's program 28.38% of objectives are related to Development of Skills in Using Common Laboratory Equipment (G.1) while 71.62% of the objectives are related to Performance of Common Laboratory Exercises with Care and Safety (G.2). As shown, both programs have a high percentage in G.2 objectives, and a low percentage in G.1 objectives. It is also shown that the frequency percentage of the G.2 objective in the IPST program is three times that of the G.1 objective while in Otto's program the frequency percentage of the G.2 objective is two and one third times that of G.1 objective.

Table XXI shows that the IPST program contains a smaller number of Manual Skill objectives (G.O = 76) than does Smallwood's program (G.O = 124). In Smallwood's program 25.81% of objectives relate to Development of Skills in Using Common Laboratory Equipment (G.1) and 74.19% to Performance of Common Laboratory Exercises with Care and Safety (G.2). As shown, both programs have a high percentage in G.2 objectives, and a low percentage in the G.1 objectives. It is also shown that both programs have closely related percentages of these two subcategory objectives (G.1 in the IPST program = 25%, in Smallwood's program, 25.81%; G.2 in the IPST program = 75%, in Smallwood's program, 74.19%).
### Table XX

**Comparison of Frequencies and Percentages of Manual Skill Objectives (G.O) for the IPST and Otto Programs**

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>G.1 Development of Skills in Using Common Laboratory Equipment</th>
<th>G.2 Performance of Common Laboratory Exercises with Care and Safety</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>f</td>
<td>19</td>
<td>57</td>
<td>76</td>
</tr>
<tr>
<td>IPST</td>
<td>%</td>
<td>25</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>Otto</td>
<td>f</td>
<td>42</td>
<td>106</td>
<td>148</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>28.38</td>
<td>71.62</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 2.458 \quad P \geq .05 \quad df = 1 \]
TABLE XXI

COMPARISON OF FREQUENCIES AND PERCENTAGES OF MANUAL SKILL OBJECTIVES (G.O) FOR THE IPST AND SMALLWOOD PROGRAMS

| TEXTBOOKS | BEHAVIORS | G.1 Development of Skills in using Common Laboratory Equipment | G.2 Performance in Common Laboratory Exercises with Care and Safety | TOTAL |
|-----------|-----------|---------------------------------------------------------------|-----------------------------------------------------------------.|-------|
|           | f         | 19                                                            | 57                                                                | 76    |
| IPST      | %         | 25                                                            | 75                                                                | 100   |
|           | f         | 32                                                            | 92                                                                | 124   |
| Smallwood | %         | 25.81                                                         | 74.19                                                             | 100   |

\[ \chi^2 = 11.578 \quad \text{P} \leq 0.01 \quad \text{df} = 1 \]
Table XXII shows that the IPST program contains a smaller number of Manual Skill objectives (G.O = 76) than does Weinberg's program (G.O = 115). Weinberg's program contains 32.17% of the objectives related to Development of Skills in Using Common Laboratory Equipment (G.1), and 67.83% of the objectives related to Performance of Common Laboratory Exercises with Care and Safety (G.2). As shown, both programs have a high percentage in the G.2 objectives, and a low percentage in the G.1 objectives. It is also shown that the frequency percentage of the G.1 objective in the IPST program is one third that of G.2 objective while in Weinberg's program the frequency percentage of the G.1 objective is one half that of the G.2 objective.

Summary

All programs included the objectives related to Manual Skills (G.O). They all contained a high percentage of objectives related to Performance of Common Laboratory Exercises with Care and Safety (G.2), and a low percentage of objectives related to Development of Skills in Using Common Laboratory Equipment (G.1).

Research question 5. -- How are the inquiry objectives distributed among the processes of scientific inquiry in each textbook?

The inquiry objectives include the objectives in the categories of Processes of Scientific Inquiry I: Observing and Measuring (B.O), Processes of Scientific Inquiry II:
<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>G.1 Development of Skills in Using Common Laboratory Equipment</th>
<th>G.2 Performance of Common Laboratory Exercises with Care and Safety</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>19</td>
<td>57</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>25</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>Weinberg</td>
<td>f</td>
<td>37</td>
<td>78</td>
<td>115</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>32.17</td>
<td>67.83</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 8.734 \quad p < .01 \quad df = 1 \]
Seeing a Problem and Seeking to Solve It (C.O), Processes of Scientific Inquiry III: Interpreting data and Formulating Generalizations (D.O), and Processes of Scientific Inquiry IV: Building, Testing, and Revising a Theoretical Model (E.O). There are five comparisons for each category. These comparisons are made between (1) the IPST and Cunningham programs, (2) the IPST and Oram programs, (3) the IPST and Otto programs, (4) the IPST and Smallwood programs, and (5) the IPST and Weinberg programs. The data are shown in Tables XXIII through XXXVIII.

Table XXIII shows that the IPST program contains a smaller number of Processes of Scientific Inquiry I: Observing and Measuring (B.0 = 144) than does Cunningham's program (B.0 = 271). In the IPST program, 45.83% of the objectives relate to Observing of Objects and Phenomena (B.1), 44.44% to Description of Observation Using Appropriate Language (B.2), 4.86% to each subcategory objective in Measurement of Objects and Changes (B.3), and Estimation of Measurement and Recognition of Limits to Accuracy (B.5); the program does not mention the objectives of Selection of Appropriate Measuring Instruments (B.4 = 0%). The Cunningham program contains 36.53% of the B.1 objective, 37.64% of the B.2 objective, and 12.92% in each subcategory of the B.3 objectives. However, this program was not mentioned at all in the B.4 objective. As shown, the IPST program is most heavily weighted toward the B.1 objective,
TABLE XXIII

COMPARISON OF FREQUENCIES AND PERCENTAGES OF PROCESSES OF SCIENTIFIC INQUIRY I: OBSERVING AND MEASURING OBJECTIVES (B.O) FOR THE IPST AND CUNNINGHAM PROGRAMS

<table>
<thead>
<tr>
<th>BEHAVIORS</th>
<th>IPST</th>
<th>Cunningham</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.1 Observing of Objects and Phenomena</td>
<td>f: 66</td>
<td>f: 99</td>
<td>144</td>
</tr>
<tr>
<td></td>
<td>%: 45.83</td>
<td>%: 36.53</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>B.2 Description of Observation Using Appropriate Language</td>
<td>64</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td>%: 44.44</td>
<td>%: 37.64</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B.3 Measurement of Objects and Changes</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>%: 4.86</td>
<td>%: 12.92</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B.4 Selection of Appropriate Measuring Instruments</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>%: 0</td>
<td>%: 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B.5 Estimation Measurement of Limits in Accuracy</td>
<td>7</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>%: 4.86</td>
<td>%: 12.92</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \chi^2 = 68.549 \quad p \leq .001 \quad df = 4 \]
and has more emphasis on the B.1 and B.2 objectives than Cunningham's. The Cunningham program is most greatly concentrated in the B.2 objective, and has more emphasis on the B.3 and B.5 objectives than the IPST program. Neither program contains the B.4 objective.

Table XXIV shows that the IPST program contains a smaller number of Processes of Scientific Inquiry I: Observing and Measuring objectives (B.0 = 144) than the Oram program (B.0 = 379). As shown, the IPST program contains its highest percentage in the objective related to Observing of Objects and Phenomena (B.1 = 45.83%), and has more emphasis on the B.1 objective (in the IPST program = 45.83%, in the Oram program, 39.58%) and the objective related to Description of Observation Using Appropriate Language (B.2 in the IPST program = 44.44%, in the Oram program, 31.04%), than Oram's. The Oram program contains its highest percentage in the B.1 objective (39.58%), and has more emphasis on the objectives related to Measurement of Objects and Changes (B.3 in the Oram program = 15.04%, in the IPST program, 4.86%), Selection of Appropriate Measuring Instruments (B.4 in Oram's program = 0.53%, in the IPST program, 0%), and Estimation of Measurement and Recognition of Limits in Accuracy (B.5 in Oram's program = 13.46%, in the IPST program, 4.86%), than the IPST's. It is significant that both programs contain a higher percentage of the same subcategory
TABLE XXIV
COMPARISON OF FREQUENCES AND PERCENTAGES OF PROCESSES OF SCIENTIFIC INQUIRY I: OBSERVING AND MEASURING OBJECTIVES (B.O) FOR THE IPST AND ORAM PROGRAMS

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>66</td>
<td>64</td>
<td>7</td>
<td>0</td>
<td>7</td>
<td>144</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>45.83</td>
<td>44.44</td>
<td>4.86</td>
<td>0</td>
<td>4.86</td>
<td>100</td>
</tr>
<tr>
<td>Oram</td>
<td>f</td>
<td>150</td>
<td>119</td>
<td>57</td>
<td>2</td>
<td>51</td>
<td>379</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>39.58</td>
<td>31.40</td>
<td>15.04</td>
<td>0.53</td>
<td>13.46</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 74.356 \quad p \leq .001 \quad \text{df} = 4 \]
objectives (B.1) than any of the other objectives, and variously emphasize the other subcategory objectives.

Table XXV shows that the IPST program contains a smaller number of Processes of Scientific Inquiry I: Observing and Measuring objectives \((B.O = 144)\) than the Otto program \((B.O = 296)\). As shown, both programs are closely related in their highest percentage in the objective of Observing of Objects and Phenomena \((B.1 \text{ in the IPST program} = 45.83\%, \text{ in the Otto program,} 45.95\%)\). The IPST program has placed more emphasis on the objectives related to Measurement of Objects and Changes \((B.3 \text{ in the IPST program} = 4.86\%, \text{ in the Otto program,} 3.04\%)\), and Estimation of Measurement and Recognition of Limits in Accuracy \((B.5 \text{ in the IPST program} = 4.86\%, \text{ in the Otto program,} 3.04\%)\), than Otto's. The Otto program has emphasized the objectives of Description Observation Using Appropriate Language \((B.2 \text{ in the Otto program} = 47.97\%, \text{ in the IPST program,} 44.44\%)\) more than the IPST's. Neither program contains the objective related to Selection of Appropriate Measuring Instruments \((B.4)\).

Table XXVI shows that the IPST program contains a smaller number of Processes of Scientific Inquiry I: Observing and Measuring objectives \((B.O = 144)\) than the Smallwood program \((B.O = 229)\). As shown, the IPST program contains its highest percentage in the objective related to Observing of Objects and Phenomena \((B.1 = 45.83\%)\), and has more emphasis on the B.1 objective \((\text{in the IPST program} = 45.83\%, \text{ in the})\)
**TABLE XXV**

**COMPARISON OF FREQUENCIES AND PERCENTAGES OF PROCESSES OF SCIENTIFIC INQUIRY I: OBSERVING AND MEASURING OBJECTIVES (B.O) FOR THE IPST AND OTTO PROGRAMS**

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>66</td>
<td>64</td>
<td>7</td>
<td>0</td>
<td>7</td>
<td>144</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>45.83</td>
<td>44.44</td>
<td>4.86</td>
<td>0</td>
<td>4.86</td>
<td>100</td>
</tr>
<tr>
<td>Otto</td>
<td>f</td>
<td>136</td>
<td>142</td>
<td>9</td>
<td>0</td>
<td>9</td>
<td>296</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>45.95</td>
<td>47.97</td>
<td>3.04</td>
<td>9</td>
<td>3.04</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 7.767 \quad p \geq .05 \quad df = 4 \]
TABLE XXVI

COMPARISON OF FREQUENCIES AND PERCENTAGES OF PROCESSES OF SCIENTIFIC INQUIRY I: OBSERVING AND MEASURING OBJECTIVES (B.O) FOR THE IPST AND SMALLWOOD PROGRAMS

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>66</td>
<td>64</td>
<td>7</td>
<td>0</td>
<td>7</td>
<td>144</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>45.83</td>
<td>44.44</td>
<td>4.86</td>
<td>0</td>
<td>4.86</td>
<td>100</td>
</tr>
<tr>
<td>Smallwood</td>
<td>f</td>
<td>93</td>
<td>77</td>
<td>29</td>
<td>1</td>
<td>29</td>
<td>229</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>40.61</td>
<td>33.62</td>
<td>12.66</td>
<td>0.44</td>
<td>12.66</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 20.022 \quad P \leq .001 \quad df = 4 \]
Smallwood program, 40.61%), and objective related to Description of Observation Using Appropriate Language (B.2 in the IPST program = 44.44%, in the Smallwood program, 33.62%), than Smallwood's. The Smallwood program contains its highest percentage in the B.1 objective (40.61%), and has more emphasis on the objectives related to Measurement of Objects and Phenomena (B.3 in the Smallwood program = 12.66%, in the IPST program, 4.86%), Selection of Appropriate Measuring Instruments (B.4 in the Smallwood program = 0.44%, in the IPST program, 0%), and Estimate of Measurement and Recognition of Limits in Accuracy (B.5 in the Smallwood program = 12.66%, in the IPST program, 4.86%), than the IPST's. Both programs contain a higher percentage of the same subcategory objective (B.1) than any of the other objectives, and variously emphasize the other subcategory objectives.

Table XXVII shows that the IPST program contains a smaller number of Processes of Scientific Inquiry I: Observing and Measuring objectives (B.0 = 144) than the Weinberg program (B.0 = 200). As shown, the IPST program contains its highest percentage in the objective related to Observing of Objects and Phenomena (B.1 = 45.83%), and has placed more emphasis on the B.1 objective (in the IPST program = 45.83%, in the Weinberg program, 41.50%), and objectives related to Description of Observation Using Appropriate Language (B.2 in the IPST program = 44.44%, in the Weinberg program, 39.50%) than Weinberg's. The Weinberg
TABLE XXVII
COMPARISON OF FREQUENCIES AND PERCENTAGES OF PROCESSES OF SCIENTIFIC INQUIRY I: OBSERVING AND MEASURING OBJECTIVES (B.O) FOR THE IPST AND WEINBERG PROGRAMS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>( f )</th>
<th>%</th>
<th>( f )</th>
<th>%</th>
<th>( f )</th>
<th>%</th>
<th>( f )</th>
<th>%</th>
<th>( f )</th>
<th>%</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>B.1 Observing of Objects and Phenomena</td>
<td>66</td>
<td>45.83</td>
<td>64</td>
<td>44.44</td>
<td>7</td>
<td>4.86</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>4.86</td>
<td>144</td>
</tr>
<tr>
<td>Weinberg</td>
<td>B.2 Description of Observation Using Appropriate Language</td>
<td>83</td>
<td>41.50</td>
<td>79</td>
<td>39.50</td>
<td>21</td>
<td>10.50</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>8.50</td>
<td>200</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 10.426 \quad P \leq 0.05 \quad df = 4 \]
program contains its highest percentage in the B.1 objective (41.50%), and has emphasized the objectives related to Measurement of Objects and Phenomena (B.3 in the Weinberg program = 10.50%, in the IPST program, 4.86%), and Estimation of Measurement and Recognition of Limits in Accuracy (B.5 in the Weinberg program = 8.50%, in the IPST program, 4.86%) more than the IPST's. Neither program contains the objective of Selection of Appropriate Measuring Instruments (B.4).

Summary

In summary, of the objectives examined, all laboratory manuals had a higher frequency and percentage in the subcategories of Observing of Objects and Phenomena (B.1), and Description of Observation Using Appropriate Language (B.2) more than any of the other objectives. The subcategories in Measurement of Objects and Changes (B.3) and Estimation of Measurement and Recognition of Limits in Accuracy (B.5) had varied frequency and quantity in the manuals. Surprisingly, all the laboratory manuals examined in the study scarcely mentioned the Selection of Appropriate Measuring Instruments (B.4).

Table XXVIII shows that the IPST program contains a greater number of objectives related to Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It (C.O = 25) than the Cunningham program (C.O = 8).
TABLE XXVIII
COMPARISON OF FREQUENCIES AND PERCENTAGES OF PROCESSES
OF SCIENTIFIC INQUIRY II: SEEING A PROBLEM AND
SEEKING WAYS TO SOLVE IT OBJECTIVES
(C.O) FOR THE IPST AND
CUNNINGHAM PROGRAMS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>C.1 Recognition of a Problem</th>
<th>C.2 Formulation of a Working Hypothesis</th>
<th>C.3 Selection of Suitable Tests of a Hypothesis</th>
<th>C.4 Design of Appropriate Procedure for Performing Tests</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>16</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>8</td>
<td>20</td>
<td>8</td>
<td>64</td>
<td>100</td>
</tr>
<tr>
<td>Cunningham</td>
<td>f</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 6.436 \quad \text{P} \geq .05 \quad \text{df} = 3 \]
The IPST program contains 8% Recognition of a Problem objectives (C.1), 20% Formulation of a Working Hypothesis objective (C.2), 8% Selection of Suitable Tests of a Hypothesis objective (C.3), and 64% Design of Appropriate Procedure for Performing Experimental Tests objective (C.4). The Cunningham program does not contain the objectives of C.1, C.2, and C.3. This program contains only the C.4 objectives (100%). It is interesting to note that the IPST program contains all the subcategory objectives (C.1, C.2, C.3, and C.4), and has its highest percentage in the C.4 objective while the Cunningham program only emphasizes the C.4 objective.

Table XXIX shows that the IPST program contains a greater number of objectives related to Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It (C.0 = 25) than the Oram program (C.0 = 9). As shown, the IPST program contains its highest percentage in the objective related Design of Appropriate Procedure for Performing Experimental Tests (C.4 = 64%), and has more emphasis on the C.4 objective (in the IPST program = 64%, in the Oram program, 33.33%), and the objective related to Selection of Suitable Tests of a Hypothesis (C.3 in the IPST program = 8%, in the Oram program, 0%), than Oram's. The Oram program contains its highest percentage in the objective related to Formulating of a Working Hypothesis (C.2 = 55.56%), and has more emphasis on the C.2 objective.


<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>C.1 Recognition of a Problem</th>
<th>C.2 Formulation of a Working Hypothesis</th>
<th>C.3 Selection of Suitable Tests of a Hypothesis</th>
<th>C.4 Design of Appropriate Procedure for Performing Experimental Tests</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>16</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>8</td>
<td>20</td>
<td>8</td>
<td>64</td>
<td>100</td>
</tr>
<tr>
<td>Oram</td>
<td>f</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>11.11</td>
<td>55.56</td>
<td>0</td>
<td>33.33</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 10.155 \quad P \leq .05 \quad df = 3 \]
and the objective related to Recognition of a Problem (C.1 in the Oram program = 11.11%, in the IPST program, 8%). The IPST program contains all the subcategory objectives (C.1, C.2, C.3, and C.4), and has its highest percentages in C.4 objective, the Oram program does not contain the C.3 objective, and has its highest percentage in the C.2 objective.

Table XXX shows that the IPST program contains a greater number of objectives related to Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It (C.0 = 25) than the Otto program (C.0 = 10). As shown, the Otto program does not contain the objectives related to Recognition of a Problem (C.1 = 0%), Formulation of a Working Hypothesis (C.2 = 0%), and Selection of Suitable Tests of a Hypothesis (C.3 = 0%). This program contains only the objective of Design of Appropriate Procedure for Performing Experimental Tests (C.4 = 100%). The IPST program contains all the subcategory objectives (C.1 = 8%, C.2 = 20%, C.3 = 8%, and C.4 = 64%), and has its highest percentage in the C.4 objective, the Otto program contains only the C.4 objective.

Table XXXI shows that the IPST program contains a greater number of objectives related to Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It (C.0 = 25) than the Smallwood program (C.0 = 2). As shown, the Smallwood program does not contain the objectives
TABLE XXX

COMPARISON OF FREQUENCIES AND PERCENTAGES OF PROCESSES OF SCIENTIFIC INQUIRY II: SEEING A PROBLEM AND SEEKING WAYS TO SOLVE IT OBJECTIVES (C.O) FOR THE IPST AND OTTO PROGRAMS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>C.1 Recognition of a Problem</th>
<th>C.2 Formulation of a Working Hypothesis</th>
<th>C.3 Selection of Suitable Tests of a Hypothesis</th>
<th>C.4 Design of Appropriate Procedure for Performing Experimental Tests</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>16</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>8</td>
<td>20</td>
<td>8</td>
<td>64</td>
<td>100</td>
</tr>
<tr>
<td>Otto</td>
<td>f</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 12.060 \quad p \leq 0.01 \quad df = 3 \]
### TABLE XXXI

**COMPARISON OF FREQUENCIES AND PERCENTAGES OF PROCESSES OF SCIENTIFIC INQUIRY II: SEEING A PROBLEM AND SEEKING WAYS TO SOLVE IT OBJECTIVES (C.O) FOR THE IPST AND SMALLWOOD PROGRAMS**

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>IPST</th>
<th>SMALLWOOD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C.1 Recognition of a Problem</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>C.2 Formulation of a Working</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Hypothesis</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C.3 Selection of Suitable Tests</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>of a Hypothesis</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C.4 Design of Appropriate</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Procedure for Performing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Experimental Tests</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>25</td>
<td>2</td>
</tr>
</tbody>
</table>

\[
\chi^2 = 19.783 \quad P \leq .001 \quad df = 3
\]
related to Recognition of a Problem (C.1 = 0%), and Selection of Suitable Tests of a Hypothesis (C.3 = 0%). This program contains the objectives of Formulation of a Working Hypothesis (C.2 = 50%), and Design of Appropriate Procedure for Performing Experimental Tests (C.4 = 50%). The IPST program contains all the subcategory objectives (C.1 = 8%, C.2 = 20%, C.3 = 8%, and C.4 = 64%), and has its highest percentage in C.4 objective, while the Smallwood program contains only the C.2 (50%) and C.4 (50%) objectives.

Table XXXII shows that the IPST program contains a greater number of objectives related to Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It (C.0 = 25) than Weinberg's program (C.0 = 18). As shown, Weinberg's program contains its highest percentage in the objective related to Designing of Appropriate Procedure for Performing Experimental Tests (C.4 = 66.67%), and has more emphasis on the objective of Recognition of a Problem (C.1 in Weinberg program = 27.78%, in the IPST program, 8%), than IPST's program. This program does not mention at all in the objective of Selection of Suitable Tests of a Hypothesis (C.3 = 0%). The IPST program has a more emphasis on the objective of Formulation of a Working Hypothesis (C.2 in the IPST program = 20%, in Weinberg's program, 5.56%), and C.3 objective (in the IPST program = 8%, in Weinberg's program, 0%), than does Weinberg's. Thus while the IPST program contains all the subcategory
TABLE XXXII

COMPARISON OF FREQUENCIES AND PERCENTAGES OF PROCESSES OF SCIENTIFIC INQUIRY II: SEEING A PROBLEM AND SEEKING WAYS TO SOLVE IT OBJECTIVES (C.O) FOR THE IPST AND WEINBERG PROGRAMS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>C.1 Recognition of a Problem</th>
<th>C.2 Formulation of a Working Hypothesis</th>
<th>C.3 Selection of Suitable Tests of a Hypothesis</th>
<th>C.4 Design of Appropriate Procedure for Performing Experimental Tests</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>16</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>8</td>
<td>20</td>
<td>8</td>
<td>64</td>
<td>100</td>
</tr>
<tr>
<td>Weinberg</td>
<td>f</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>27.78</td>
<td>5.56</td>
<td>0</td>
<td>66.67</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 1.059 \quad p \gg .05 \quad df = 3 \]
objectives (C.1, C.2, C.3, and C.4), and has its highest percentage in C.4 objective, Weinberg's program does not contain the C.3 objective, and has its highest percentage in the C.4 objective.

**Summary**

All program except Oram's contained their higher frequencies and percentage ratings in the area of Discussions of Appropriate Procedure for Performing Experimental Tests (C.4), than any of the others. The frequency and percentage rating in the subcategories of Recognition of a Problem (C.1), Formulation of a Working Hypothesis (C.2), and Selection of Suitable Tests of a Hypothesis (C.3) varied. Some programs did not mention them at all.

Table XXXIII shows that the IPST program contains a smaller number of objectives related to Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalizations (D.O = 140) than does the Cunningham program (D.O = 248). As shown, the IPST program contains 10% of its objectives Processing of Experimental Data (D.1), as 17.86% of its objectives Presentation of Data in the Form of Functional Relationships (D.2), as 24.29% of its objectives Interpretation of Experimental Data and Observations (D.3), as 9.29% of its objectives Extrapolation and Interpolation (D.4), and 38.57% of its objectives Formulating of Generalization Warranted by Relationships Found (D.6). This
### TABLE XXXIII
COMPARISON OF FREQUENCIES AND PERCENTAGES OF PROCESSES
OF SCIENTIFIC INQUIRY III: INTERPRETING DATA AND
FORMULATING GENERALIZATION OBJECTIVES (D.0)
FOR IPST AND CUNNINGHAM PROGRAMS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>D.1 Processing of Experimental Data</th>
<th>D.2 Presentation of Data in the Form of Functional Relationships</th>
<th>D.3 Interpretation of Experimental Data and Observations</th>
<th>D.4 Extrapolation and Interpolation</th>
<th>D.5 Evaluation of a Hypothesis Under Test in Light of Data Obtained</th>
<th>D.6 Formulating of Generalizations Warranted by Relationships Found</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>f</td>
<td>14</td>
<td>25</td>
<td>34</td>
<td>13</td>
<td>0</td>
<td>54</td>
<td>140</td>
</tr>
<tr>
<td>IPST</td>
<td>%</td>
<td>10</td>
<td>17.86</td>
<td>24.29</td>
<td>9.29</td>
<td>0</td>
<td>38.57</td>
<td>100</td>
</tr>
<tr>
<td>Cunningham</td>
<td>f</td>
<td>25</td>
<td>40</td>
<td>70</td>
<td>20</td>
<td>0</td>
<td>93</td>
<td>248</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>10.08</td>
<td>16.13</td>
<td>28.23</td>
<td>8.06</td>
<td>0</td>
<td>37.5</td>
<td>100</td>
</tr>
</tbody>
</table>

\[
\chi^2 = 55.373 \quad P \leq .001 \quad df = 5
\]
program does not mention at all in the objective of Evaluation of Hypothesis Under Test in the Light of Data Obtained (D.5). The Cunningham program contains as its objectives 10.08% of D.1, 16.13% of D.2, 28.23% of D.3, 8.06% of D.4, and 37.5% of D.6. This program also makes no mention at all of any D.5 objectives. Thus the IPST program has its highest percentage in the D.6 objective, and has more emphasis on the objective of D.2 and D.4 than does Cunningham's. Cunningham's program has its highest percentage in the D.6 objective and has more emphasis on the objectives of D.1 and D.3 than does the IPST's. Neither program contains D.5 objectives.

Table XXXIV shows that the IPST program contains a smaller number of objectives in Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalization (D.0 = 140) than does the Oram program (D.0 = 297). As shown, Oram's program contains its highest percentage in the objectives related to Presentation of Data in the Form of Functional Relationships (D.2 = 37.04%) and has more emphasis on the objectives related to Processing of Experimental Data (D.1 in Oram's program = 22.22%, in the IPST program = 10%), and D.2 objectives (in Oram's program = 37.04 in the IPST program = 17.86%) than the IPST's. The IPST program contains its highest percentage in the objectives related to Formulating of Generalization Warranted by Relationships Found (D.6 = 38.57%), and has more emphasis on the objectives
TABLE XXXIV

COMPARISON OF FREQUENCIES AND PERCENTAGES OF PROCESSES OF SCIENTIFIC INQUIRY III: INTERPRETING DATA AND FORMULATING GENERALIZATION OBJECTIVES (D.O) FOR THE IPST AND ORAM PROGRAMS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>D.1 Processing of Experimental Data</th>
<th>D.2 Presentation of Data in the Form of Functional Relationships</th>
<th>D.3 Interpretation of Experimental Data and Observations</th>
<th>D.4 Extrapolation and Interpolation</th>
<th>D.5 Evaluation of a Hypothesis Under Test in Light of Data Obtained</th>
<th>D.6 Formulations of Generalizations Warranted by Relationships Found</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>¥</td>
<td>14</td>
<td>25</td>
<td>34</td>
<td>13</td>
<td>0</td>
<td>54</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>10</td>
<td>17.86</td>
<td>24.29</td>
<td>9.29</td>
<td>0</td>
<td>38.57</td>
<td>100</td>
</tr>
<tr>
<td>Oram</td>
<td>¥</td>
<td>66</td>
<td>110</td>
<td>44</td>
<td>4</td>
<td>0</td>
<td>73</td>
<td>297</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>22.22</td>
<td>37.04</td>
<td>14.81</td>
<td>1.35</td>
<td>0</td>
<td>24.58</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 32.832 \quad p \leq .001 \quad df = 5 \]
related to Interpretation of Experimental Data and Observations (D.3 in the IPST program = 24.29%, in Oram's program = 14.81%), Extrapolation and Interpolation (D.4 in the IPST program = 9.29%, in Oram's program = 1.35%) and the D.6 objectives (in the IPST program = 38.57%, in Oram's program = 24.58%) than Oram's. Both programs do not contain the objectives related to Evaluation of a Hypothesis Under Test in the Light of Data Obtained (D.5).

Table XXXV shows that the IPST program and the Otto program contain a similar number of objectives related to Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalization (D.0 in the IPST program = 140, in Otto's program = 144). As shown, Otto's program contains its highest percentage in objective related to Formulating of Generalization Warranted by Relationships Found (D.6 = 43.06%) and has more emphasis on the objectives related to Presentation of Data in the Form of Functional Relationships (D.2 in Otto's program = 33.33%, in the IPST program = 17.86%) than the IPST's. This program is closely related to the IPST program in the percentage of objectives related to Processing of Experimental Data (D.1 in Otto program = 11.11%, in the IPST program = 10%). The IPST program contains its highest percentages in the D.6 objective (38.57%), and has more emphasis in the objectives of Interpretation of Experimental Data and Observations (D.3 in the IPST program = 24.29%, in Otto's program = 11.81%) and Extrapolation and Interpolation (D.4 in the IPST
TABLE XXXV

COMPARISON OF FREQUENCIES AND PERCENTAGES OF PROCESSES
OF SCIENTIFIC INQUIRY III: INTERPRETING DATA AND
FORMULATING GENERALIZATION OBJECTIVES (D.0)
FOR THE IPST AND OTTO PROGRAMS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>D.1 Processing of Experimental Data</th>
<th>D.2 Presentation of Data in the Form of Functional Relationships</th>
<th>D.3 Interpretation of Experimental Data and Observations</th>
<th>D.4 Extrapolation and Interpolation</th>
<th>D.5 Evaluation of a Hypothesis Under Test in Light of Data Obtained</th>
<th>D.6 Formulating of Generalizations Wanted by Relationships Found</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>14</td>
<td>25</td>
<td>34</td>
<td>13</td>
<td>0</td>
<td>54</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>10</td>
<td>17.86</td>
<td>24.29</td>
<td>9.29</td>
<td>0</td>
<td>38.57</td>
<td>100</td>
</tr>
<tr>
<td>Otto</td>
<td>f</td>
<td>16</td>
<td>48</td>
<td>17</td>
<td>1</td>
<td>0</td>
<td>62</td>
<td>144</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>11.11</td>
<td>33.33</td>
<td>11.81</td>
<td>0.69</td>
<td>0</td>
<td>43.06</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 12.372 \quad p \leq 0.05 \quad df = 5 \]
Neither contains the objective of Evaluation of a Hypothesis under Test in the Light of Data Obtained (D.5). Hence both programs have their higher percentages in the D.6 objective than any of the other objectives, and variously emphasize the other subcategory objectives.

Table XXXVI shows that the IPST program contains a greater number of objectives related to Processes of Scientific Inquiry III: Interpreting Data and Formulating generalization (D.0 = 140) than does the Smallwood program (D.0 = 89). As shown, the Smallwood program contains its highest percentage in the objective of Formulating of Generalization Warranted by Relationships Found (D.6 = 48.31%), and has more emphasis in the objectives of Processing of Experimental Data (D.1 in Smallwood's program = 16.85%, in the IPST program = 10%), and the D.6 objective (in the Smallwood program = 48.31%, in the IPST program = 38.57%) than the IPST's. The IPST program contains its highest percentage in the D.6 objective (38.57%), and has more emphasis on the objectives of Presentation of Data in the Form of Functional Relationships (D.2 in the IPST program = 17.86%, in the Smallwood program = 12.36%), Interpretation of Experimental Data and Observations (D.3 in the IPST = 24.29%, in Smallwood's program = 21.35%), and Extrapolation and Interpolation (D.4 in the IPST program = 9.29%, in Smallwood's program = 1.12%) than Smallwood's. Both
### Table XXXVI

**Comparison of Frequencies and Percentages of Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalization Objectives (D.0) for the IPST and Smallwood Programs**

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>D.1 Processing of Experimental Data</th>
<th>D.2 Presentation of Data in the Form of Functional Relationships</th>
<th>D.3 Interpretation of Experimental Data and Observations</th>
<th>D.4 Extrapolation and Interpolation</th>
<th>D.5 Evaluation of a Hypothesis Under Test in Light of Data Obtained</th>
<th>D.6 Formulating of Generalizations Warranted by Relationships</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>14</td>
<td>25</td>
<td>34</td>
<td>13</td>
<td>0</td>
<td>54</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>10</td>
<td>17.86</td>
<td>24.29</td>
<td>9.29</td>
<td>0</td>
<td>38.57</td>
<td>100</td>
</tr>
<tr>
<td>Smallwood</td>
<td>f</td>
<td>1.5</td>
<td>11</td>
<td>19</td>
<td>1</td>
<td>0</td>
<td>43</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>16.85</td>
<td>12.36</td>
<td>21.35</td>
<td>1.12</td>
<td>0</td>
<td>48.31</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 12.172 \quad P \leq .05 \quad df = 5 \]
programs do not contain the objective related to Evaluation of a Hypothesis Under Test in the Light of Data Obtained (D.5). Thus both programs have a higher percentage in the D.6 objective than any of the other objectives, and variously emphasized the other subcategory objectives.

Table XXXVII shows that the IPST program contains a smaller number of objectives related to Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalization (D.0 = 140) than the Weinberg program (D.0 = 184). As shown, both programs have closely related their highest percentage in the objectives related to Formulating of Generalization Warranted by Relationships Found (D.6 in the IPST program = 38.57%, in Weinberg program = 38.59%). The IPST program has more emphasis on objectives related to Processing of Experimental Data (D.1 in the IPST program = 10%, in Weinberg's program = 7.07%), Interpretation of Experimental Data and Observations (D.3 in the IPST program = 24.29%, in Weinberg's program = 19.57%), and Extrapolation and Interpolation (D.4 in the IPST program = 9.29%, in Weinberg's program = 1.63%) than does Weinberg's. Weinberg's program has more emphasis on the objective related to Presentation of Data in the Form of Functional Relationships (D.2 in Weinberg's program = 33.15%, in the IPST program = 17.86%) than the IPST's. Also both programs do not contain the objectives related to Evaluation of a Hypothesis Under Test in the Light of Data Obtained (D.5).
TABLE XXXVII

COMPARISON OF FREQUENCIES AND PERCENTAGES OF PROCESSES OF SCIENTIFIC INQUIRY III: INTERPRETING DATA AND FORMULATING GENERALIZATION OBJECTIVES (D.O) FOR THE IPST AND WEINBERG PROGRAMS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>D.1 Processing of Experimental Data</th>
<th>D.2 Presentation of Data in the Form of Functional Relationships</th>
<th>D.3 Interpretation of Experimental Data and Observations</th>
<th>D.4 Extrapolation and Interpolation</th>
<th>D.5 Evaluation of Hypothesis Under Test in Light of Data Obtained</th>
<th>D.6 Formulating of Generalizations Warranted by Relationships Found</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>14</td>
<td>25</td>
<td>34</td>
<td>13</td>
<td>0</td>
<td>54</td>
<td>140</td>
</tr>
<tr>
<td>IPST</td>
<td>%</td>
<td>10</td>
<td>17.86</td>
<td>24.29</td>
<td>9.29</td>
<td>0</td>
<td>38.57</td>
<td>100</td>
</tr>
<tr>
<td>Weinberg</td>
<td>f</td>
<td>13</td>
<td>61</td>
<td>36</td>
<td>3</td>
<td>0</td>
<td>71</td>
<td>184</td>
</tr>
<tr>
<td>Weinberg</td>
<td>%</td>
<td>7.07</td>
<td>33.15</td>
<td>19.57</td>
<td>1.63</td>
<td>0</td>
<td>38.59</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 6.914 \quad p \gg .05 \quad df = 5 \]
Summary

All programs, except Oram's contained a high frequency and percentage of objectives concerning the Formulating of Generalizations Warranted by Relationships Found (D.6). The other subcategory objectives varied in frequency and percentage of occurrence. It was observed that not all programs contained objectives related to Evaluation of a Hypothesis Under Test in the Light of Data Obtained (D.5).

Table XXXVIII summarizes the frequency and percentage objectives relative to the Processes of Scientific Inquiry IV: Building, Testing, and Revising a Theoretical Model (E.O). As Table XXXVIII shows, none of the programs contain discussion or experiments in this area.

Research question 6. -- How are the orientation objectives distributed in each testbook?

Comparisons in Orientation objectives were made in the following: (1) the IPST and Cunningham programs, (2) the IPST and Oram programs, (3) the IPST and Otto programs, (4) the IPST and Smallwood programs, and (5) the IPST and Weinberg programs. The data shown in Tables XXXIX through XLIII.

Table XXXIX shows that the IPST program contains a smaller number of objectives related to Orientation (I.0 = 16) than Cunningham's program (I.0 = 25). As shown, the IPST program contains 12.5% of its objectives related to Relationships Among Various Types of Statements in Science.
TABLE XXXVIII

FREQUENCIES AND PERCENTAGES OF PROCESSES OF SCIENTIFIC INQUIRY IV: BUILDING, TESTING, AND REVISING A THEORETICAL MODEL OBJECTIVES (E.O) IN TEXAS AND THAI BIOLOGY TEXTBOOKS AND LABORATORY MANUALS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>E.1 Recognition of the Used for a Theoretical Model</th>
<th>E.2 Formulation of a Theoretical Model to Accommodate Knowledge</th>
<th>E.3 Specification of Relationships Satisfied by a Model</th>
<th>E.4 Deduction of New Hypothesis from a Theoretical Model</th>
<th>E.5 Interpretation and Evaluation of Tests of a Model</th>
<th>E.6 Formulation of a Revised, Refined, or Extended Model</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cunningham</td>
<td>f</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>%</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Oram</td>
<td>f</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Otto</td>
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</tr>
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<td>0</td>
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<td>0</td>
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</tr>
<tr>
<td>Smallwood</td>
<td>f</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>%</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Weinberg</td>
<td>f</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
(I.1), 18.75% of the objectives related to Recognition of the Philosophical Limitations and Influence of Scientific Inquiry (I.2), 12.5% of the objectives related to Historical Perspective: Recognition of Background of Science (I.3), 37.5% of the objectives related to Realization of the Relationships Among Science, Technology, and Economics (I.4), and 18.75% of the objectives related to Awareness of the Social and Moral Implication of Scientific Inquiry and Its Results (I.5). Cunningham's program contains 8% in the I.1 objective, 24% in the I.4 objective, and 68% in the I.5 objective. This program does not contain I.2 and I.3 objectives. Thus while the IPST program contains all the subcategory objectives and has its highest percentage in I.4 objectives, the Cunningham program contains only I.1, I.4, and I.5 objectives, having its highest percentage in I.5 objective, too.

Table XL shows that the IPST program contains a smaller number of objectives related to Orientation (I.0 = 16) than does the Oram program (I.0 = 27). As shown, Oram's program contains its highest percentage of objectives related to Relationships Among Various Types of Statements in Science (I.1 = 29.63%), and has more emphasis on the objectives related to Historical Perspective: Recognition of the Background of Science (I.3 in Oram's program = 18.52%, in the IPST program = 12.5%), and Awareness of the Social and Moral Implication of Scientific Inquiry and Its Results
TABLE XXXIX

COMPARISON OF FREQUENCIES AND PERCENTAGES OF ORIENTATION OBJECTIVES (O.O) FOR THE IPST AND CUNNINGHAM PROGRAMS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>1.1 Relationships Among Various Types of Statements in Science</th>
<th>1.2 Recognition of the Philosophical Limitations and Influence of Scientific Inquiry</th>
<th>1.3 Historical Perspective: Recognition of the Background of Science</th>
<th>1.4 Realization of the Relationships Among Science, Technology, and Economics</th>
<th>1.5 Awareness of the Social and Moral Implication of Scientific Inquiry and Its Results</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>12.5</td>
<td>18.75</td>
<td>12.5</td>
<td>37.5</td>
<td>18.75</td>
<td>100</td>
</tr>
<tr>
<td>Cunningham</td>
<td>f</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>17</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>68</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 3.889 \quad P \geq 0.05 \quad df = 4 \]
## TABLE XL

COMPARISON OF FREQUENCIES AND PERCENTAGES OF ORIENTATION OBJECTIVES (I.O) FOR THE IPST AND ORAM PROGRAMS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>IPST</th>
<th>Oram</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I.1 Relationships Among Various Types of Statements in Science</td>
<td>f = 2</td>
<td>f = 8</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>I.2 Recognition of the Philosophical Limitations and Influence of Scientific Inquiry</td>
<td>% = 12.5</td>
<td>% = 29.63</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>I.3 Historical Perspective: Recognition of the Background of Science</td>
<td>% = 18.75</td>
<td>% = 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I.4 Realization of the Relationships Among Science, Technology, and Economics</td>
<td>% = 12.5</td>
<td>% = 18.52</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I.5 Awareness of the Social and Moral Implication of Scientific Inquiry and Its Results</td>
<td>% = 6</td>
<td>% = 7</td>
<td></td>
</tr>
<tr>
<td>IPST</td>
<td></td>
<td>37.5</td>
<td>25.93</td>
<td></td>
</tr>
<tr>
<td>Oram</td>
<td></td>
<td>18.75</td>
<td>25.93</td>
<td></td>
</tr>
</tbody>
</table>

\[ \chi^2 = 1.062 \quad \text{P} \geq .05 \quad \text{df} = 4 \]
(I.5 in Oram's program = 25.93%, in the IPST program = 18.75%) than the IPST's. This program does not contain objectives related to Recognition of the Philosophical Limitations and Influence of Scientific Inquiry (I.2). The IPST program contains its highest percentage in the objective related to Realization of the Relationships Among Science, Technology, and Economics (I.4 = 37.50%), and has more emphasis on I.2 objective (in the IPST's program = 18.75%, in Oram's program = 0%), and I.4 objective (in the IPST program = 37.50%, in Oram program = 25.93%) than does Oram's. Hence while the IPST program contains all the sub-category objectives, and has its highest percentage in I.4 objective, Oram's program contains only I.1, I.3, and I.4, and I.5 objectives, and has its highest percentage in the I.1 objective.

Table XLI shows that the IPST program contains a smaller number of objectives related to Orientation (I.0 = 16) than does Otto's program (I.0 = 23). Both programs have their highest percentage in the objectives related to Realization of the Relationships Among Science, Technology, and Economics (I.4 in the IPST program = 37.5%, in Otto's program = 47.83%). The IPST program has more emphasis on the objectives related to Recognition of the Philosophical Limitations and Influence of Scientific Inquiry (I.2 in the IPST program = 18.75%, in Otto's program = 17.39%), Historical Perspective: Recognition of Background of Science(I.3)
TABLE XLI

COMPARISON OF FREQUENCIES AND PERCENTAGES OF ORIENTATION OBJECTIVES (I.O) FOR THE IPST AND OTTO PROGRAMS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>IPST</th>
<th>Otto</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I.1 Relationships Among Various Types of Statements in Science</td>
<td>f: 2</td>
<td>f: 3</td>
<td>f: 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>%: 12.5</td>
<td>%: 13.04</td>
<td>%: 13.04</td>
</tr>
<tr>
<td></td>
<td>I.2 Recognition of the Philosophical Limitations and Influence of Scientific Inquiry</td>
<td>f: 3</td>
<td>f: 4</td>
<td>f: 7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>%: 18.75</td>
<td>%: 17.39</td>
<td>%: 17.39</td>
</tr>
<tr>
<td></td>
<td>I.3 Historical Perspective: Recognition of the Background of Science</td>
<td>f: 2</td>
<td>f: 2</td>
<td>f: 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>%: 12.5</td>
<td>%: 8.7</td>
<td>%: 8.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>%: 37.5</td>
<td>%: 47.83</td>
<td>%: 47.83</td>
</tr>
<tr>
<td></td>
<td>I.5 Awareness of the Social and Moral Implication of Scientific Results</td>
<td>f: 3</td>
<td>f: 3</td>
<td>f: 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>%: 18.75</td>
<td>%: 13.04</td>
<td>%: 13.04</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>f: 16</td>
<td>f: 23</td>
<td>f: 39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>%: 100</td>
<td>%: 100</td>
<td>%: 100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 7.656 \quad p \gg 0.05 \quad df = 4 \]
in IPST program = 12.5%\text{,} in Otto's program = 8.7\%\text{), and}
Awareness of the Social and Moral Implication of Scientific
Inquiry and its Results (I.5 in the IPST program = 18.75\%,
in Otto's program = 13.04\%) than Otto's. Otto's program
has more emphasis on the objective related to Relationships
Among Various Types of Statements in Science (I.1 in Otto's
program = 13.04\%, in the IPST program = 12.5\%) than the
IPST's. Thus both programs contain their higher percentages
in the I.4 objective than any of the other objectives, and
variously emphasize the other subcategory objectives.

Table XLII shows that the IPST and the Smallwood pro-
gram contain a similar number of objectives related to
Orientation (I.0 in the IPST program = 16, in the Smallwood
program = 17). As shown, Smallwood's program contains its
highest percentage in the objectives related to Recognition
of the Philosophical Limitations and Influence of Scientific
Inquiry (I.2 = 35.29\%), and has more emphasis on the I.2 ob-
jective (in Smallwood's program = 35.29\%, in the IPST pro-
gram = 18.75\%), and the objectives related to Historical
Perspective: Recognition of the Backgrounds of Science (I.3
in the Smallwood program = 29.41\%, in the IPST program =
12.5\%) than the IPST's. This program does not contain the
objectives related to Relationships Among Various Types of
Statements in Science (I.1). The IPST program contains its
highest percentage in the objectives related to Realization
of the Relationships Among Science, Technology, and
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>12.5</td>
<td>18.75</td>
<td>12.5</td>
<td>37.5</td>
<td>18.75</td>
<td>100</td>
</tr>
<tr>
<td>Smallwood</td>
<td>f</td>
<td>0</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>0</td>
<td>35.29</td>
<td>29.41</td>
<td>29.41</td>
<td>5.88</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 2.362 \quad P > .05 \quad df = 4 \]
Economics (I.4 = 37.5%), and has more emphasis on the I.1 objective (in the IPST program = 12.5%, in Smallwood's program = 0%), the I.4 objective (in the IPST program = 37.5%, in the Smallwood program = 29.41%) and the objectives related to Awareness of the Social and Moral Implication of Scientific Inquiry and its Results (I.5 in the IPST program = 18.75%, in Smallwood's program = 5.88%) than does Smallwood's program. Consequently, while the IPST program contains all the subcategory objectives, and has its higher percentage in the I.4 objective, Smallwood's program does not contain the I.1 objective, and has its highest percentage in the I.2 objective.

Table XLIII shows that the IPST program contains smaller number of objectives related to Orientation (I.0 = 16) than Weinberg's program (I.0 = 32). As shown, both programs have the same highest percentage in the objectives related to Realization of the Relationship Among Science, Technology, and Economics (I.4 = 37.5%). The IPST program has more emphasis on the objectives related to Relationships Among Various Types of Statements in Science (I.1 in the IPST program = 12.5% in Weinberg's program = 3.13%), and Recognition of the Philosophical Limitations and Influence of Scientific Inquiry (I.2 in the IPST program = 18.75%, in Weinberg's program = 6.25%) than Weinberg's. Weinberg's program has more emphasis on the objectives related to Historical Perspective: Recognition of Background
TABLE XLIII

COMPARISON OF FREQUENCIES AND PERCENTAGES OF ORIENTATION OBJECTIVES (I.O) FOR THE IPST AND WEINBERG PROGRAMS

<table>
<thead>
<tr>
<th>TEXTBOOKS</th>
<th>BEHAVIORS</th>
<th>1.1 Relationship Among Various Types of Statements in Science</th>
<th>1.2 Recognition of the Philosophical Limitations and Influence of Scientific Inquiry</th>
<th>1.3 Historical Perspective: Recognition of the Background of Science</th>
<th>1.4 Realization of the Relationships Among Science, Technology, and Economics</th>
<th>1.5 Awareness of the Social and Moral Implication of Scientific Inquiry and Its Results</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPST</td>
<td>f</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>12.5</td>
<td>18.75</td>
<td>12.5</td>
<td>37.5</td>
<td>18.75</td>
<td>100</td>
</tr>
<tr>
<td>Weinberg</td>
<td>f</td>
<td>1</td>
<td>2</td>
<td>7</td>
<td>12</td>
<td>10</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>3.13</td>
<td>6.25</td>
<td>21.88</td>
<td>37.5</td>
<td>31.25</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 5.567 \quad P \geq 0.05 \quad df = 4 \]
of Science (1.3 in Weinberg's program = 21.88%, in the IPST program = 12.5%), and Awareness of the Social and Moral Implication of Scientific Inquiry and Its Results (1.5 in Weinberg's program = 31.25%, in the IPST program = 18.75%) than the IPST's. Thus both programs contain their higher percentage in the 1.4 objective than any of the other objectives, and various emphasis on the other subcategory objectives.

Summary

Each of the programs examined contained objectives related to the Orientation (1.0). However, differences in the frequency and percentage of objectives were found among the subcategories of the six programs.

Phase III

Comparison of Cognitive, Affective, Manual Skill, Processes of Scientific Inquiry, and Orientation Distributions

Phase III of the study consisted of a comparison of the distributions of cognitive, affective, manual skill, processes of scientific inquiry, and orientation objectives in textbooks and laboratory manuals. The Chi Square Test of Significance of Differences of Proportions from K Independent Samples and Post Hoc Procedures for the K Samples Problem with Independent Proportions were used to determine the presence or absence of significant differences in the
objectives derived from Texas and Thai biology programs. Table XLIV contains the statistical information pertinent to a discussion of research questions 7 through 11. The chi-square values found under the column heading marked "total" are those obtained from a comparison of total objectives distributions for each Texas and Thai biology program.

Asterisks were used to identify the presence of statistically significant differences. One asterisk after a chi-square value denotes significance at the 0.05 level. This significance level indicates the probability that there is less than five chances in one hundred that there are no differences in the two distributions of frequencies across each category objective. Two asterisks after a chi-square value denotes the presence of differences at the 0.01 level. This significant level indicates the probability that there is less than one chance in one hundred that there is no difference in the two distributions of frequencies across each category objective. Three asterisks after a chi-square value denotes significance at the 0.001 level. This significance level indicates the probability that there is less than one chance in one thousand that there is no difference in the two distributions of frequencies across each category objective. The absence of an asterisk is an indication that the distributions in objective are statistically consistent.
TABLE XLIV

CHI SQUARE VALUES OF OBJECTIVES FOR COMPARISONS OF TEXAS AND THAI BIOLOGY PROGRAMS

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>A.O</th>
<th>B.O</th>
<th>C.O</th>
<th>D.O</th>
<th>F.O</th>
<th>G.O</th>
<th>I.O</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pairwise Contrast</td>
<td>$\chi^2$</td>
<td>$\chi^2$</td>
<td>$\chi^2$</td>
<td>$\chi^2$</td>
<td>$\chi^2$</td>
<td>$\chi^2$</td>
<td>$\chi^2$</td>
<td>$\chi^2$</td>
</tr>
<tr>
<td>IPST/Cunningham</td>
<td>207.472***</td>
<td>68.549***</td>
<td>6.436</td>
<td>53.373***</td>
<td>33.287***</td>
<td>20.375***</td>
<td>3.889</td>
<td>232.697***</td>
</tr>
<tr>
<td>IPST/Oram</td>
<td>140.442***</td>
<td>74.356***</td>
<td>10.155*</td>
<td>32.832***</td>
<td>0.612</td>
<td>39.508***</td>
<td>1.062</td>
<td>167.876***</td>
</tr>
<tr>
<td>IPST/Smallwood</td>
<td>2.318</td>
<td>20.022***</td>
<td>19.783***</td>
<td>12.172*</td>
<td>1.796</td>
<td>11.578**</td>
<td>2.362</td>
<td>63.568***</td>
</tr>
</tbody>
</table>

*(P ≤ .05)  
**(P ≤ .01)  
****(P ≤ .001)
The Chi Square Test of Significance of Difference of Proportions from K Independent Samples was used to determine the significant differences in total objectives derived from each Texas and Thai biology program. The null hypothesis was stated as follows: there were no significant differences in total objectives between each Texas and Thai biology program.

In total category of Table XLIV, the results of the Chi Square Test demonstrate the presence of statistically significantly differences in total objective (P < 0.001) derived from each Texas and Thai biology program. The presence of statistically significant differences in total objectives resulted in a failure to accept the null statement. Therefore, the comparison of the distributions of total objectives from these programs established the presence of actual differences.

The Post Hoc Procedure for the K Sample Problem with Independent Proportions was used to answer the Research questions 7 - 11.

Research question 7. -- Do the frequencies of cognitive objectives in each Texas textbook differ significantly from the frequencies of cognitive objectives in the Thai textbooks?

The cognitive objectives relate to the objectives of Knowledge and Comprehension (A.O), and Application of Scientific Knowledge and Methods (F.O). In order to test this question statistically, the null hypothesis was stated as follows: there were no significant differences in the
objectives related to Knowledge and Comprehension (A.O), and Application of Scientific Knowledge and Method (F.O) between each Texas and Thai biology program.

The chi-square values for the A.O category in Table XLIV demonstrate the presence of statistically significant differences in Knowledge and Comprehension objectives (A.O) between (1) the IPST and Cunningham programs ($P \leq 0.001$), (2) the IPST and Oram programs ($P \leq 0.001$), and (3) the IPST and Weinberg programs ($P \leq 0.05$). The presence of statistically significant differences in Knowledge and Comprehension objectives resulted in a failure to accept the null statement. Therefore, the comparisons of Knowledge and Comprehension distributions from these programs established the presence of actual differences. Conversely, (1) the IPST and Otto programs, and (2) the IPST and Smallwood programs were statistically consistent for Knowledge and Comprehension objective.

The chi-square values for the F.O category in Table XLIV, demonstrated the presence of statistically significant differences in the objectives related to Application of Scientific Knowledge and Methods (F.O) between (1) the IPST and Cunningham programs ($P \leq 0.001$), and (2) the IPST and Otto programs ($P \leq 0.001$). The presence of statistically significant differences in this distribution resulted in a failure to accept the null statement. Therefore, the comparisons of objectives in Application of Scientific
Knowledge and Methods (F.O) from these programs established the presence of actual differences. Conversely, (1) the IPST and Oram programs, (2) the IPST and Smallwood programs, and (3) the IPST and Weinberg programs, were statistically consistent for the distributions of this objective.

Research question 8. -- Do the frequencies of affective objectives in each Texas textbook differ significantly from the frequencies of affective objectives in the Thai textbooks?

There is no frequency and percentage for objectives related to affective domain found in the six programs examined. Therefore, there are no significant differences in the distributions of affective objectives between each Texas program and the Thai biology program.

Research question 9. -- Do the frequencies of manual skill objectives in each Texas textbook differ significantly from the frequencies of manual skill objectives in Thai textbooks?

In order to test this question statistically, the null hypothesis was stated as follows: there were no significant differences in the objective related to Manual Skills (G.O) between each Texas program and the Thai biology program.

The chi-square values for the G.O category in Table XLIV demonstrate the presence of statistically significant differences in Manual Skill objectives (G.O) between (1) the IPST and Cunningham programs ($P \leq 0.001$), (2) the IPST and Oram programs ($P \leq 0.001$), (3) the IPST and Smallwood programs ($P \leq 0.01$), and (4) the IPST and Weinberg programs ($P \leq 0.01$). The presence of statistically significant
differences in Manual Skill objectives (G.O) resulted in a failure to accept the null statement. Therefore, the comparisons of manual skill distributions from these programs established the presence of actual differences. Only the IPST and Otto programs were statistically consistent for Manual Skill objectives (G.O).

Research question 10. — Do the frequencies of processes of scientific inquiry objectives in each Texas textbook differ significantly from the frequencies of processes of scientific inquiry objectives in the Thai textbooks?

The inquiry objectives include the objectives related to (1) Processes of Scientific Inquiry I: Observing and Measuring (B.O), (2) Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It (C.O), (3) Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalizations (D.O), and (4) Processes of Scientific Inquiry IV: Building, Testing, and Revising a Theoretical Model (E.O). In order to test this question statistically, the null hypothesis was stated as follows: there were no significant differences in B.O, C.O, D.O, and E.O objectives between each Texas biology program and the Thai biology program.

The chi-square values for the B.O category in Table XLIV demonstrate the presence of statistically significant differences in the B.O objectives between (1) the IPST and Cunningham programs ($P \leq 0.001$), (2) the IPST and Oram programs ($P \leq 0.001$), (3) the IPST and Smallwood programs
The presence of statistically significant differences in the B.O objectives resulted in a failure to accept the null statement. Therefore, the comparisons of the B.O distributions from these programs established the presence of actual differences. Only the IPST's and Otto's program were statistically consistent for the B.O objectives.

The chi-square values for the C.O category in Table XLIV demonstrate the presence of statistically significant differences in C.O objectives between (1) the IPST and Oram programs ($P \leq 0.05$), (2) the IPST and Otto programs ($P \leq 0.01$), and (3) the IPST and Smallwood programs ($P \leq 0.001$). The presence of statistically significant differences in the C.O objectives resulted in a failure to accept the null statement. Therefore, the comparison of the C.O distributions from these programs established the presence of actual differences. Conversely, (1) the IPST and Cunningham programs, and (2) the IPST and Weinberg programs, were statistically consistent for the C.O objectives.

The chi-square values for D.O category in Table XLIV demonstrate the presence of statistically significant differences in the D.O objectives between (1) the IPST and Cunningham programs ($P \leq 0.001$), (2) the IPST and Oram programs ($P \leq 0.001$), (3) the IPST and Otto programs ($P \leq 0.05$), and (4) the IPST and Smallwood programs ($P \leq 0.05$). The presence of statistically significant differences in the D.O
objectives resulted in a failure to accept the null statement. Therefore, the comparisons of the D.O distributions from these programs established in the presence of actual differences. Only the IPST and Weinberg programs were statistically consistent for the D.O objectives.

There is no frequency and percentage of E.O objectives found in the six programs examined. Therefore, there are no significant differences in the distributions of E.O objectives between each Texas and Thai biology program.

Research question 11. -- Do the frequencies of the orientation objectives in each Texas textbook differ significantly from the frequencies of orientation objectives in the Thai textbooks?

In order to test this question statistically, the null hypothesis was stated as follows: there were no significant differences in the objectives related to Orientation (I.O) between each Texas program and the Thai biology program.

I.O category of Table XLIV, all six programs were statistically consistent for Orientation objectives (I.O).

Summary

The statistical comparisons of total objectives established the presence of statistically significant differences between each Texas and Thai biology program (P<0.001). The results can be summarized as follows:

1. The IPST's and Cunningham's programs differed significantly in the objectives related to (A.O) Knowledge and Comprehension (P<0.001), (B.O) Processes of Scientific
Inquiry I: Observing and Measuring ($P \leq 0.001$), (D.O) Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalizations ($P \leq 0.001$), (F.O) Application of Scientific Knowledge and Methods ($P \leq 0.001$), and (G.O) Manual Skills ($P \leq 0.001$). Both programs were statistically consistent in the objectives related to (C.O) Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It, and (I.O) Orientation.

2. The IPST's and Oram's programs differed significantly in the objectives related to (A.O) Knowledge and Comprehension ($P \leq 0.001$), (B.O) Processes of Scientific Inquiry I: Observing and Measuring ($P \leq 0.001$), (C.O) Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It ($P \leq 0.05$), (D.O) Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalizations ($P \leq 0.001$), and (G.O) Manual Skills ($P \leq 0.001$). Both programs were statistically consistent in the objectives related to (F.O) Application of Scientific Knowledge and Methods, and (I.O) Orientation.

3. The IPST's and Otto's programs differed significantly in the objectives related to (C.O) Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It ($P \leq 0.01$), (D.O) Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalizations ($P \leq 0.05$), and (F.O) Application of Scientific Knowledge and Methods ($P \leq 0.001$). Both programs were statistically consistent in

4. The IPST's and Smallwood's programs differed significantly in the objectives related to (B.O) Processes of Scientific Inquiry I: Observing and Measuring ($P \leq 0.001$), (C.O) Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It ($P \leq 0.001$), (D.O) Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalizations ($P \leq 0.05$), and (G.O) Manual Skills ($P \leq 0.01$). Both programs were statistically consistent in the objectives related to (A.O) Knowledge and Comprehension, (F.O) Application of Scientific Knowledge and Methods, and (I.O) Orientation.

5. The IPST's and Weinberg's programs differed significantly in the objectives related to (A.O) Knowledge and Comprehension ($P \leq 0.05$), (B.O) Processes of Scientific Inquiry I: Observing and Measuring ($P \leq 0.05$), and (G.O) Manual Skills ($P \leq 0.01$). Both programs were statistically consistent in the objectives related to (C.O) Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It, (D.O) Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalizations, (F.O) Application of Scientific Knowledge and Methods, and (I.O) Orientation.
CHAPTER V

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

This chapter summarizes the problem, procedures, and conclusions of this study. In addition, implications and recommendations for further research are presented.

SUMMARY

Because of the concern in Thailand for the development of a new high school biology program, science educators have been concerned about the selection of appropriate objectives. This study has attempted to examine and compare the objectives of a secondary school science programs in Texas and Thai high schools in the hope that such a study might aid the development of a better Thai program. Studies of criteria for the selection of course content in biology textbooks, scientific inquiry, affective development in biological science, and the importance of psychomotor domain were also reviewed.

There were two foci of this study. The first was that of determining, through an analysis of Texas and Thai biology programs, which objectives -- cognitive, affective, manual skill, processes of scientific inquiry, and orientation objectives -- were emphasized in three major and twenty-seven minor fields of biology. The second purpose was to determine
if significant differences existed in the frequency distribution of these objectives in Texas and Thai programs.

Statement of the Problem

This study was designed to determine if the biology programs used in Texas differed from those used in Thailand. The study examined the provisions for cognitive, affective, manual skill, processes of scientific inquiry, and orientation objectives in Texas and Thai biology programs. In addition, frequencies were compared between each Texas program and the Thai biology program to determine if differences existed in the number of objectives related to cognitive, affective, manual skill, processes of scientific inquiry, and scientific orientation.

The study focused on the following research questions:

1. How many cognitive, affective, manual skill, processes of scientific inquiry, and orientation objectives are contained in each textbook?

2. How are the cognitive objectives distributed among the levels of the cognitive domain in each textbook?

3. How are the affective objectives distributed among the levels of the affective domain in each textbook?

4. How are the manual skills distributed within the manual skill domain in each textbook?

5. How are the inquiry objectives distributed among the processes of scientific inquiry in each textbook?
6. How are the orientation objectives distributed in each textbook?

7. Do the frequencies of cognitive objectives in each Texas textbook differ significantly from the frequencies of cognitive objectives in the Thai textbooks?

8. Do the frequencies of affective objectives in each Texas textbook differ significantly from the frequencies of affective objectives in the Thai textbooks?

9. Do the frequencies of manual skill objectives in each Texas textbook differ significantly from the frequencies of manual skill objectives in the Thai textbooks?

10. Do the frequencies of processes of scientific inquiry objectives differ significantly from the frequencies of processes of scientific inquiry objectives in the Thai textbooks?

11. Do the frequencies of the orientation objectives in each Texas textbook differ significantly from the frequencies of orientation objectives in the Thai textbooks?

**Procedures**

Only one biology program is used in schools throughout Thailand. This program which was published by the Ministry of Education consists of four textbooks that post a 1977 copyright date.

The five Texas textbooks used in this study were those adopted under the provisions of the Textbook Law. The content of each of the six texts included in the study were
classified by using the criteria of Klopfer's Table of Specifications for Science Education (Appendix A).

Research questions 1 through 6 were discussed with the analysis of textbooks and laboratory manuals. Using the Klopfer's Table of Specifications for Science Education (Appendix B), the content which could be identified as meeting the objectives was classified as: (a) Knowledge and Comprehension (A.0), (b) Processes of Scientific Inquiry (B.0, C.0, D.0, and E.0), (c) Application of Scientific Knowledge and Methods (F.0), (d) Manual Skill (G.0), (e) Attitudes and Interests (H.0), and (f) Orientation (I.0). The frequency for each behavior area was determined and converted to a percentage of the total objectives for each text.

Research questions 7 through 11 were designed to compare frequencies to determine whether the distributions between each of the Texas programs and the Thai program reflected the same emphasis on cognitive, affective, manual skill, processes of scientific inquiry, and orientation objectives. The data obtained in research questions 1 through 6 were used for making the comparisons. The Chi Square Test for Significance of Difference of Proportions from K Independent Sample was used to determine the significant differences in total objectives derived from each Texas and Thai biology program.

The Post Hoc Procedures for the K-Sample Problem with Independent Proportions was used to determine if there was significant difference in the objectives of Texas and Thai
biology programs. A comparison made between (1) the IPST program and the Cunningham program, (2) the IPST program and the Oram program, (3) the IPST program and the Otto program, (4) the IPST program and the Smallwood program, and (5) the IPST program and the Weinberg program. Comparisons were made in the number of objectives related to (1) Knowledge and Comprehension (A.O), (2) Processes of Scientific Inquiry (B.O, C.O, and D.O), (3) Application of Scientific Knowledge and Methods (F.O), (4) Manual Skill (G.O), and (5) Orientation (I.O).

Finding -- Phase I of the Study

Based on the vertical dimensions of the Table of Specifications (Table I), it was found that:

1. Cunningham's biology program did not cover the content of the biological sciences in Cell Metabolism (1.13), Photosynthesis (1.14), Cell Responses (1.15), Concept of the Gene (1.16), and Population Genetics (1.34). Relative to the physical sciences, this program failed to mention the topics of Energy and Its Conservation (2.23), Light and Spectra (2.29), and the Solar System (2.31). Moreover, in the general areas, the program did not include the topics of the Nature of Scientific Inquiry (3.3) and Biographies of Scientists (3.4).

2. Oram's biology program covered all of the content in the Klopf er classification scale in the biological sciences and general areas. However, in physical sciences, the topics of Nuclear Chemistry (2.110), the Solar System (2.31),
Meteorology (2.33), Physical Geology (2.34), and Oceanography (2.37) were not included in the program.

3. Otto's biology program covered all the content areas in the biological sciences and general areas. The program did not mention the topics of Nuclear Chemistry (2.110), Energy and its Conservation (2.23), Light and Spectra (2.29), the Solar System (2.31), Meteorology (2.33), and Oceanography (2.37) in the physical sciences.

4. Smallwood's biology program did not cover the topics of Cell Responses (1.15) and Population Genetics (1.34) in biological sciences. The program also lacked any mention of Nuclear Chemistry (2.110), Energy and Its Conservation (2.23), Light and Spectra (2.29), in the physical sciences as well as any discussion of Earth and Space Sciences (2.3). It also omitted the topics of Nature and Structure of Sciences (3.2), and Nature of Scientific Inquiry (3.3) in general areas.

5. Weinberg's biology program did not cover the topic of Cell Responses (1.15) in biological sciences. In physical sciences, the topics of Meteorology (2.33), and Oceanography (2.37) were not included, as well as the topic of Nature of Scientific Inquiry (3.3) in general areas.

6. The IPST biology program did not cover the topic of Population Genetics (1.34) in biological sciences. The program also lacked mention of the topics of Nuclear Chemistry (2.110), Light and Spectra (2.29), Solar System (2.31),
Meteorology (2.33), physical geology (2.34), and Oceanography (2.37), from the physical sciences, as well as the topics of Nature and Structure of Science (3.2), and Biographies of Scientists (3.4) from general areas.

**Finding -- Phase II of the Study**

All Texas programs differed from the Thai biology program in their distribution of objectives. In addition, all programs (including the Thai program) contained a greater proportion of cognitive objectives than any other objectives. Also, they had the least proportion in orientation objectives. Each program differed in the frequency and percentage of cognitive, affective, manual skill, processes of scientific inquiry, and orientation objectives. The following are summarized from research question 1.

1. The objectives of the IPST biology program were 87.34% cognitive, 9.76% processes of scientific inquiry, 2.04% manual skill, and 0.50% orientation.

2. The objectives of Cunningham's biology program were 74.29% cognitive, 20.13% processes of scientific inquiry, 4.62% manual skill, and 0.95 orientation.

3. The objectives of Oram's biology program were 76.48% cognitive, 17.61% processes of scientific inquiry, 5.22% manual skill, and 0.70% orientation.

4. The objectives of Otto's biology program were 87.54% cognitive, 9.03% processes of scientific inquiry, 2.97% manual skill, and 0.46% orientation.
5. The objectives of Smallwood's biology program were 85.55% cognitive, 10.03% processes of scientific inquiry, 3.89% manual skill, and 0.53% orientation.

6. The objectives of Weinberg's biology program were 82.44% cognitive, 12.86% processes of scientific inquiry, 3.68% manual skill, and 1.02% orientation.

It was noticed that all programs lacked objectives in Processes of Scientific Inquiry IV: Building, Testing, and Revising a Theoretical Model (E.O) and Attitudes and Interests (H.O).

**Finding -- Phase III of the Study**

First, a comparison of objectives made between (1) the IPST program and the Cunningham program, (2) the IPST program and the Oram program, (3) the IPST program and the Otto program, (4) the IPST program and the Smallwood program, and (5) the IPST program and the Weinberg program, differed significantly. Second, a comparison was made in the areas of: (1) Knowledge and Comprehension objectives (A.O), (2) Processes of Scientific Inquiry objectives (B.O, C.O, and D.O), (3) Application of Scientific Knowledge and Method objectives (F.O), (4) Manual Skill objectives (G.O), and (5) Orientation objectives (I.O). It was found that:

1. The IPST's and Cunningham's programs differed significantly in the objectives related to (A.O) Knowledge and Comprehension ($P \leq 0.001$), (B.O) Processes of Scientific Inquiry I: Observing and Measuring ($P \leq 0.001$), (D.O) Processes
of Scientific Inquiry III: Interpreting Data and Formulating Generalizations ($P \leq 0.001$), (F.O) Application of Scientific Knowledge and Methods ($P \leq 0.001$), and (G.O) Manual Skills ($P \leq 0.001$). Both programs were statistically consistent in the objectives related to (C.O) Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It, and (I.O) Orientation.

2. The IPST and Oram programs differed significantly in the objectives related to (A.O) Knowledge and Comprehension ($P \leq 0.001$), (B.O) Processes of Scientific Inquiry I: Observing and Measuring ($P \leq 0.001$), (G.O) Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It ($P \leq 0.05$), (D.O) Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalizations ($P \leq 0.001$), and (G.O) Manual Skills ($P \leq 0.001$). Both programs were statistically consistent in the objectives related to (F.O) Application of Scientific Knowledge and Methods, and (I.O) Orientation.

3. The IPST and Otto programs differed significantly in the objectives related to (C.O) Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It ($P \leq 0.001$), (D.O) Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalizations ($P \leq 0.05$), and (F.O) Application of Scientific Knowledge and Methods ($P \leq 0.001$). Both programs were statistically consistent in the objectives related to (A.O) Knowledge and Comprehension,

4. The IPST and Smallwood programs differed significantly in the objectives related to (B.O) Processes of Scientific Inquiry I: Observing and Measuring ($P \leq 0.001$), (C.O) Processes of Scientific Inquiry II: Seeing a Problem and Seeking Ways to Solve It ($P \leq 0.001$), (D.O) Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalizations ($P \leq 0.05$), and (G.O) Manual Skills ($P \leq 0.01$). Both programs were statistically consistent in the objectives related to (A.O) Knowledge and Comprehension, (F.O) Application of Scientific Knowledge and Methods, and (I.O) Orientation.

5. The IPST and Weinberg programs differed significantly in the objectives and related to (A.O) Knowledge and Comprehension ($P \leq 0.05$), (B.O) Processes of Scientific Inquiry I: Observing and Measuring ($P \leq 0.05$), and (G.O) Manual Skills ($P \leq 0.01$). Both programs were statistically consistent in the objectives related to (C.O) Processes of Scientific Inquiry II: Seeing a Problem and Seeking to Solve It, (D.O) Processes of Scientific Inquiry III: Interpreting Data and Formulating Generalizations, (F.O) Application of Scientific Knowledge and Methods, and (I.O) Orientation.

Conclusions

The following conclusions were drawn from the findings of this study.

1. Objectives in all programs used in this study
emphasize cognitive learning, especially Knowledge and Comprehension (A.0). In this category, the textbooks emphasize first a Knowledge of Specific Facts (A.1), second, a Knowledge of Scientific Terminology (A.2), and third, a Knowledge of Scientific Concepts (A.3). All other subcategories vary from one textbook to another. The category of Application of Scientific Knowledge and Methods (F.0), was emphasized much less often than the Knowledge and Comprehension category. The subcategory of Application of Data to New Problems in the Same Field of Science (F.1) was included more often than any other. This conclusion verifies the anticipated outcome that classroom learning tasks are generally cognitive.

2. Concerning all objectives in all programs used in this study, it was found that more emphasis was placed on cognitive learning and less on any other kind of learning. In addition, the objectives in Processes of Scientific Inquiry (B.0, C.0, D.0, and E.0) that are allegedly the center of all science programs are less emphasized than cognitive objectives. In the analysis of the objectives in the Process of Scientific Inquiry, it was found that all textbooks emphasize Observing and Measuring objectives (B.0), Seeing a Problem and Seeking Ways to Solve It objectives (C.0), and Interpreting Data and Formulating Generalizations objectives (D.0), while the objectives of Building, Testing, and Revising a Theoretical Model (E.0) were not included in any of these programs.
3. The Manual Skill objectives (G.0) in all programs in this study involved a relationship with the processes of scientific inquiry objectives. The more the processes of scientific inquiry objectives were emphasized, the more manual skill objectives were included in the programs. It was found that all programs emphasized the Performance of Common Laboratory Exercises with Care and Safety (G.2) more frequently than the Development of Common Laboratory Equipment objectives (G.1). Obviously, if biology programs are to emphasize student investigations and activities, writers of textbooks will have to pay greater attention to the development of manual skill objectives.

4. As mentioned in Chapter III, the objectives of Attitudes and Interests (H.0) are measured in several different ways. However, none of the programs in this study used any kind of techniques and/or questionnaires to measure the student outcome in the affective domain. To emphasize the student's affective learning experiences, the textbook writers should include in their programs some instruments concerned with the student attitudes and interests to measure the student's responses to the program.

5. Orientation objectives (I.0) received the least emphasis of any of the objectives in the programs in this study. As long as science programs pay more attention to the cognitive objectives than any of the other objectives, they lack the awareness and recognition of how the students see science
in a more meaningful light and relate science to either disciplines, which is, after all, the objective of scientific literacy.

Implications

The conclusions of this study contain several implications for the teaching of biology. Initially, lesson planning by teachers would reflect the emphasis on cognitive learning due to the prevalence of cognitive objectives appearing in the teachers' editions of the textbooks. The relatively lighter emphasis on processes of scientific inquiry, manual skill, affective, and orientation objectives in the program suggests that teachers will spend less time in preparing the experiences in processes of scientific inquiry, manual skill, affective and orientation objectives. The analysis of program objectives supports the aforementioned implication in that objectives were found to be predominantly cognitive in the lessons of teachers using the textbooks and laboratory manuals. If teachers want to include objectives other than cognitive objectives in their lessons, they must make a special effort to do so; since the programs examined in this study fail to include them.

The findings in this study relative to the objectives of each program would appear to be useful to program writers. Textbook authors should consider which objectives they wish to stress. The findings also have shown that biology programs at the high school level contain different proportions
of cognitive, affective, manual skill, processes of scientific inquiry, and orientation objectives. With this information, teachers can select a program which furthers their cognitive, affective, manual skill, processes of scientific inquiry, and orientation goals. Because only one set of high school biology texts is used in Thailand, the Thai high school teachers can and perhaps should select supplementary biology programs that have goals beyond the present books used in the schools.

Recommendation for Further Research

The findings of this study suggest the following research recommendations:

1. For the Thai biology program, additional studies are needed which would compare objectives and questions to determine whether questions in textbooks and teachers’ questions are facilitating the attainment of specific objectives. It is also suggested that categories of questions be included in such studies that concur with the kinds of objectives of the subject matter.

2. To improve the affective domain of the Thai biology program, the program should have its own questionnaires or other instruments to measure student attitudes and interests in the program. These instruments might be employed to assess the students at the beginning and the end of each semester that they take a biology course. Studies should be done to create the categories of questions which would measure the students' attitudes and interests concerning the program.
3. Studies should be conducted to develop, implement, and evaluate a minicourse in laboratory techniques in biology. This minicourse should help the student to improve his manual skill. As a result, some laboratory techniques could be omitted from laboratory investigations and the student would have more time to build, to test, and to revise a theoretical model.

4. Finally, studies involving the development, implementation, and evaluation of a minicourse that emphasizes the means by which the student can employ his knowledge and comprehension by relating science to other disciplines should be conducted. This minicourse should focus the student's orientation and allow him to see science in a more meaningful way. The minicourse might include topics such as: how to use value clarification to solve the problems faced in nutrition, over population, pollution, and the others.
### APPENDIX A

**TWO-DIMENSIONAL CHART OF STUDENT BEHAVIORS AND SCIENCE CONTENTS**  
(Adapted from Klopfer's Table of Specifications, 1971)

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## APPENDIX B

### Table of Specifications

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<td>F.3</td>
<td>G.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### APPENDIX C

**THE TABLE OF CONTENTS OF THE IPST BIOLOGY TEXTBOOKS**

**BOOK I**

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How to Learn Biology</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Ecosystem</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Energy Pathway</td>
<td>33</td>
</tr>
<tr>
<td>4</td>
<td>Nutrition</td>
<td>43</td>
</tr>
<tr>
<td>5</td>
<td>Population</td>
<td>80</td>
</tr>
<tr>
<td>6</td>
<td>Taxonomy</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>Unit of Life</td>
<td>151</td>
</tr>
<tr>
<td>8</td>
<td>Photosynthesis</td>
<td>184</td>
</tr>
<tr>
<td>9</td>
<td>Transportation in Plant</td>
<td>196</td>
</tr>
</tbody>
</table>

**BOOK II**

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Digestion</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>Respiration</td>
<td>19</td>
</tr>
<tr>
<td>12</td>
<td>Transportation in Animals</td>
<td>42</td>
</tr>
<tr>
<td>13</td>
<td>Excretion</td>
<td>65</td>
</tr>
<tr>
<td>14</td>
<td>Reproduction</td>
<td>81</td>
</tr>
<tr>
<td>15</td>
<td>Development</td>
<td>110</td>
</tr>
<tr>
<td>16</td>
<td>Heredity</td>
<td>141</td>
</tr>
</tbody>
</table>

**BOOK III**

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Locomotion and Movement</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>Nervous System</td>
<td>23</td>
</tr>
<tr>
<td>19</td>
<td>Sense Organs</td>
<td>50</td>
</tr>
<tr>
<td>20</td>
<td>Hormones</td>
<td>66</td>
</tr>
<tr>
<td>21</td>
<td>Behavior</td>
<td>90</td>
</tr>
<tr>
<td>22</td>
<td>Body Temperature</td>
<td>112</td>
</tr>
<tr>
<td>23</td>
<td>Cellular Respiration</td>
<td>123</td>
</tr>
<tr>
<td>24</td>
<td>Biochemical Aspects of Photosynthesis</td>
<td>149</td>
</tr>
<tr>
<td>25</td>
<td>Microorganisms</td>
<td>162</td>
</tr>
</tbody>
</table>

**BOOK IV**

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>Human Reproduction</td>
<td>1</td>
</tr>
<tr>
<td>27</td>
<td>Gene and Chromosome</td>
<td>20</td>
</tr>
<tr>
<td>28</td>
<td>Evolution</td>
<td>57</td>
</tr>
<tr>
<td>29</td>
<td>Growth</td>
<td>100</td>
</tr>
<tr>
<td>30</td>
<td>Mineral Cycles</td>
<td>115</td>
</tr>
<tr>
<td>31</td>
<td>Succession</td>
<td>129</td>
</tr>
<tr>
<td>32</td>
<td>Animal and Plant Enemies</td>
<td>140</td>
</tr>
<tr>
<td>33</td>
<td>Environment and Conservation</td>
<td>156</td>
</tr>
</tbody>
</table>
APPENDIX D

THE TABLE OF CONTENTS OF THE IPST
LABORATORY INVESTIGATIONS

2.1 Field Study of a Terrestrial Community
2.2 Simulating Aquatic Ecosystem
2.3 Physical Factors to Plant and Animal Life
2.4 Interdependence between Plants and Animals
2.5 Observation Parasitism

4.1 Digestion of Starches
4.2 Digestion of Sugar
4.3 Digestion of Proteins

5.1 Field Study of a Community
5.2 Digesting Experiment about Area and Population

6.1 Classification and Use of a Dichotomous Key

7.1 Learning to Use Microscope
7.2 Animal and Plant Cells
7.3 Chromosomes in Dividing Cells

8.1 Light in Starch Formation
8.2 Carbon Dioxide in Photosynthesis
8.3 Oxygen Production by Green Plants
8.4 Chlorophyll in Plant Leaves
8.5 Structure of Leaves

9.1 Cell Membrane and Diffusion
9.2 Stem and Root Structures
9.3 Transportation in Plants
9.4 Leaf Structure--Stomata
9.5 Capillary Action

10.1 Chemical Digestion in the Mouth

11.1 Designing Experiment about Respiration
11.2 Measuring the Amount of Oxygen Used
11.3 Structures and Functions of Mammalian Lung
11.4 Breathing Model
11.5 Designing Experiment about Yeast Respiration

12.1 Blood Cells
12.2 Repeating Harvey's Observations
12.3 Circulation
12.4 Structures and Functions of Mammalian Heart
12.5 Measuring Heart Rate
13.1 Excretory System in Earthworm
14.1 Bread Mold
14.2 Budding in Yeast, Hydra, and Duckweed
14.3 Regeneration in Planaria
14.4 Structures and Functions of Flowers
14.5 Plant Sex Organs

15.1 The Development of Seed
15.2 Seed Germination
15.3 Development of Chicken Embryo
15.4 Metamorphosis

16.1 Human Dominant and Recessive Traits
16.2 Continuous Variation
16.3 Discontinuous Variation
16.4 Probability and Mendelian Genetics

17.1 Plant Tropism
17.2 Nutation

19.1 Blind Spot
19.2 Visual Sensation
19.3 Chemicals in Solution
19.4 Effect of Smell on Taste
19.5 Measuring Pain, Temperature, and Pressure Sense

21.1 Behavior of Paramecium

22.1 Surface Area and Temperature Relationships

23.1 Enzymes Affect the Speed of Chemical Reactions
23.2 Enzymes and Temperature

25.1 Isolation Bacteria
25.2 Bacteria and Antibiotic

26.1 Structures of Mammalian Sperm and Ovary

33.1 Effect of DDT on Aquatic Plants
33.2 Effect of Detergents on Fish
33.3 Effect of Water Pollution on Fish
33.4 Measuring Particulate
33.5 Effect of Growing Plants on Land
33.6 Soil Conservation
APPENDIX E

THE TABLE OF CONTENTS OF CUNNINGHAM'S BIOLOGY TEXTBOOK

MODULES I TROUBLES IN THE BIOSPHERE

Minicourse 1-1 Aerial Garbage 5
1-2 Energy in the Air 21
1-3 Aquatic Garbage 33
1-4 More Water Pollution Problems 53
1-5 Land Pollution 77
1-6 The Human Population 89

MODULE II THE WORKINGS OF ORGANISMS

Minicourse 2-1 Studying Life 119
2-2 How Are Organisms Organized? 137
2-3 The Materials of Life 149
2-4 Small Worlds 163
2-5 Environments of Organisms 179
2-6 More Environments of Organisms 199

MODULE III INTERACTIONS WITHIN ORGANISMS

Minicourse 3-1 Homeostasis 237
3-2 The Breathing System 255
3-3 The Circulatory and Excretory Systems 269
3-4 Receiving Information 288
3-5 Coordinating Information 315
3-6 Studying Behavior 339

MODULE IV INTERACTIONS WITH THE ENVIRONMENT

Minicourse 4-1 Producers 361
4-2 Consumers 381
4-3 Consumer Nutrition 401
4-4 Populations 423
4-5 Population Controls 439
4-6 Communities 457

MODULE V ORGANISMS CHANGE IN TIME

Minicourse 5-1 Reproduction, Growth, and Development I 479
5-2 Reproduction, Growth, and Development II 499
5-3 Patterns of Inheritance 521
5-4 Human Genetics 537
5-5 Changing Organisms 549
5-6 The History of Life 569
APPENDIX F

THE TABLE OF CONTENTS OF CUNNINGHAM'S BIOLOGY LABORATORY ACTIVITIES

Minicourse 1-1

1. Observing Burning
2. Measuring Particulate
3. Surveying Opinion about Air Pollution
4. Pocket Air Polluters
5. Effect of Particles on Plants
6. Acids Versus Materials
7. Calculating Automobile Pollutants

Minicourse 1-3

1. Studying BOD
2. Sources of Phosphorus and Nitrogen
3. Effect of Detergents on Aquatic Plants
4. Effect of Detergents on Seeds and Young Plants
5. Effects of Oil on Aquatic Plants
6. Salt Tolerance of Plants

Minicourse 1-4

1. Discovering Sources of Pesticides
2. Biological Effects of Thermal Pollution

Minicourse 1-5

1. Measuring Solid Waste Material
2. Local Solid Waste Disposal
3. Rates of Decomposition
4. Surveying Local Land Use

Minicourse 1-6

1. Growing Families

Minicourse 2-1

1. Keying Insects
2. Functions of Structures
3. Inferring Functions and Environments
4. Measuring Handedness
5. Measuring Eyedness
6. Making Operational Definitions
7. Analyzing Experiments
8. Designing Controlled Experiments
Minicourse 2-2

1. Observing Cells
2. Observing Common Cells

Minicourse 2-3

1. Building a Sensitive Balance
2. Identifying Chemicals in Food
3. Studying Diffusion
4. Observing Diffusion
5. Studying Osmosis
6. Effect of Shape on the Ratio of Surface Area to Volume
7. Surface Area and Volume Relationships

Minicourse 2-4

1. Observing Microorganisms
2. Growing Microorganisms
3. Growing Bread Mold
4. Effects of Chemicals on Molds
5. Mold Reproduction
6. Growing Yeast
7. Making Food for Microorganisms
8. Testing Antiseptics

Minicourse 2-5

1. Counting Local Organisms
2. Adaptive Value of Waxy Leaves
3. Effect of Color on Heat Absorption
4. Mini-grasslands

Minicourse 2-6

1. Collecting Soil Organisms
2. Studying Earthworms
3. Measuring Organic Content of Soil
4. Simulating Aquatic Ecosystems
5. Simulating Land Ecosystems

Minicourse 3-1

1. An Eye for an Eye
2. Got the Beat?
3. Temperature and Breathing in Fish
4. Other Animals and Other Effects

Minicourse 3-2

1. Measuring Breathing Set Point
2. Hyperventilation and Breathing Rates
3. Breathless
4. Breathing Model
5. Measuring Lung Capacities

Minicourse 3-3

1. Measuring Heart Rate
2. Repeating Harvey's Observations
3. Observing Capillaries

Minicourse 3-4

1. Measuring Depth Perception
2. Tunnel Vision
3. Everyone's Blind
4. Chemicals in Solution
5. Measuring Taste Thresholds
6. Mopping Your Tongue
7. Effect of Smell on Taste
8. Measuring Your Pressure Sense
9. Locating Sounds
10. Time Sense
11. Study Telepathy
12. Building Choice Chambers

Minicourse 3-5

1. Studying Simple Reflexes
2. Reaction Time
3. Getting Used to It
4. Nonfood Chemical Use
5. Measuring Illusions

Minicourse 3-6

1. Animal Movements
2. Responses to Stimuli by Nonhuman Organisms
3. Studying Tropisms
4. Studying Other Tropisms

Minicourse 4-1

1. Van Helmont-type Experiment
2. Food-making by Plants
3. Oxygen Production by Green Plants
4. Lack of Light and Photosynthesis
5. Do Plants Need CO₂?
6. Studying Plant Pigments
7. Roots Up Close
8. Water Movements in Stems
9. Where Does All the Water Go?
10. Observing Leaf Surfaces
11. Measuring Transportation
Minicourse 4-2

1. Food-Chain Hunt
2. Local Food Webs
3. Making a Calorimeter
4. Counting Calories
5. Body Temperature
6. Calculating Activity Kilocalories
7. Calculating Liquid Intake
8. Vitamins in Your Diet
9. Minerals in Your Diet
10. Minerals in Bones
11. Food Additives
12. Food Costs

Minicourse 4-3

1. Enzyme Action
2. Chemical Digestion in the Mouth
3. Changing Your Weight

Minicourse 4-4

1. Is Advertising Biased?
2. Sampling Natural Populations
3. Simulating Population Growth
4. Environmental Resistance and Microorganisms

Minicourse 4-5

1. Environmental Microclimates

Minicourse 4-6

1. Parasite Hunt
2. Observing Lichens
3. Studying Legumes

Minicourse 5-1

1. Studying Flower Parts
2. Observing Embryos
3. Seed Hunting
4. Germination and Growth Variables
5. How do Plants Grow?
6. Growing Potatoes Asexually
7. More Asexually Reproduction in Plants
8. Budding in Yeast
9. Biological Graft

Minicourse 5-2

1. Asexual Reproduction in Planarians
2. Changes in Body Proportions
Minicourse 5-3

1. Using Mendel's Theory
2. Flipping Coins
3. DNA

Minicourse 5-4

1. Human Dominant and Recessive Traits
2. Sex Ratios

Minicourse 5-5

1. Changing Gene Numbers
2. Galapagos Iguanas

Minicourse 5-6

1. Thinking Like a Dendrochronologist
# Appendix G

## The Table of Contents in Oram's Textbook

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The World of Living Things</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Biology as a Science</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>Materials of Life</td>
<td>36</td>
</tr>
<tr>
<td>4</td>
<td>Cell Structure and Function</td>
<td>60</td>
</tr>
<tr>
<td>5</td>
<td>Energy for Life</td>
<td>84</td>
</tr>
<tr>
<td>6</td>
<td>The Flow of Energy</td>
<td>106</td>
</tr>
<tr>
<td>7</td>
<td>Reproduction: The Cell</td>
<td>124</td>
</tr>
<tr>
<td>8</td>
<td>Reproduction: Heredity</td>
<td>144</td>
</tr>
<tr>
<td>9</td>
<td>Reproduction: Genes and Chromosomes</td>
<td>160</td>
</tr>
<tr>
<td>10</td>
<td>Reproduction: Chemical Aspects</td>
<td>180</td>
</tr>
<tr>
<td>11</td>
<td>Reproduction: The Organism</td>
<td>202</td>
</tr>
<tr>
<td>12</td>
<td>Development</td>
<td>228</td>
</tr>
<tr>
<td>13</td>
<td>Evolution</td>
<td>258</td>
</tr>
<tr>
<td>14</td>
<td>Adaptation and Speciation</td>
<td>280</td>
</tr>
<tr>
<td>15</td>
<td>Classification</td>
<td>300</td>
</tr>
<tr>
<td>16</td>
<td>The Protists</td>
<td>312</td>
</tr>
<tr>
<td>17</td>
<td>The Plants</td>
<td>340</td>
</tr>
<tr>
<td>18</td>
<td>The Animals</td>
<td>358</td>
</tr>
<tr>
<td>19</td>
<td>Digestion</td>
<td>388</td>
</tr>
<tr>
<td>20</td>
<td>Transport</td>
<td>406</td>
</tr>
<tr>
<td>21</td>
<td>Respiration and Excretion</td>
<td>436</td>
</tr>
<tr>
<td>22</td>
<td>Support and Locomotion</td>
<td>456</td>
</tr>
<tr>
<td>23</td>
<td>Chemical Control Systems</td>
<td>476</td>
</tr>
<tr>
<td>24</td>
<td>Nervous Control Systems</td>
<td>498</td>
</tr>
<tr>
<td>25</td>
<td>Psychobiology</td>
<td>518</td>
</tr>
<tr>
<td>26</td>
<td>Population Biology</td>
<td>540</td>
</tr>
<tr>
<td>27</td>
<td>The Ecosystem</td>
<td>556</td>
</tr>
<tr>
<td>28</td>
<td>Origin and Distribution of Communities</td>
<td>580</td>
</tr>
<tr>
<td>29</td>
<td>Human Origins</td>
<td>602</td>
</tr>
<tr>
<td>30</td>
<td>Environment</td>
<td>624</td>
</tr>
</tbody>
</table>
APPENDIX H

THE TABLE OF CONTENTS IN ORAM'S LABORATORY INVESTIGATIONS

1. The World of Living Things
2. Life in a Square Meter Community
3. Physical Factors of Soil
4. The Compound Microscopes--A Biological Tool
5. What is in a Bottle?
6. Microscopic Measurement
7. Molecules of Biological Importance
8. Detecting Compounds Made by Living Things
9. Amino Acid Chromatography
10. Basic Cell Structure
11. Qualitative and Quantitative Plasmolysis
12. Extracellular Enzymes
13. Measurement of Calories
14. Yeast Fermentation
15. Leaf Structure and Function
16. Analysis of Plant Pigments
17. Some Aspects of Photosynthesis
18. Spontaneous Generation
19. Significance of Time and Mitosis
20. Probability and Mendelian Genetics
21. Drosophila Genetics
22. Sex-Linked Traits in Drosophila
23. Human Pedigree Genetics
24. Assay of Bacteriophage
25. DNA Models
26. Protein Synthesis
27. Regeneration in Planaria
28. Vegetative Reproduction in Duckweed
29. Budding in Yeast and Hydra
30. Classification of Fruits
31. Development of Seeds
32. Effect of Temperature on Seed Germination
33. Effect of Salt Concentration on Development of Brine Shrimp
34. Development of a Chicken Embryo
35. Variation Within a Species and Between Species
36. Natural Selection in Populations
37. Adaptation
38. Coacervates-The Road of Life
39. Construction and Use of a Dichotomous Key
40. Identification of Aquatic Insect Larva
41. Morphology and Staining of Bacteria
42. Morphology and Growth of Fungi
43. Size and Structure of Protozoa
44. Morphology of Algae
45. Morphology of Lichens
46. Morphology of Mosses
47. Morphology of Ferns
48. Internal Stem Anatomy
49. Internal Root Anatomy
50. External Structure and Adaptations of Roots and Stems
51. Diversity of Invertebrates
52. Diversity of Vertebrates
53. Ingestion and Digestion in Protists
54. Ingestion and Digestion in Hydra and Planaria
55. Digestion of Starches, Proteins, and Fats in Humans
56. Transportation in Plants
57. Capillary Circulation
58. Effect of Exercise on the Heartbeat Rate
59. Typing of Blood
60. Effect of Temperature Changes on Breathing Rate of Fish
61. Effect of Exercise on Carbon Dioxide Release in the Human Body
62. Muscle and Bone Tissue
63. Locomotion in Protozoans and Slime Molds
64. Effects of Iodine Compounds on Tadpole Metamorphosis
65. Tropisms in Plants
66. Taste Perception in Humans
67. Earthworm Anatomy
68. Frog Anatomy
69. Response of Protists to Chemical and Physical Stimuli
70. Response of Multicellular Animals to Light
71. Dandelion and Plantain Populations
72. Microarthropod Populations in Leaf Litter
73. Interspecific Relationships Between Populations
74. Field Studies of a Freshwater Ecosystem
75. Field Studies of a Terrestrial Community
76. Ecological Succession in Microenvironment
77. Evolutionary Changes in Primates
APPENDIX I

THE TABLE OF CONTENTS OF OTTO'S BIOLOGY TEXTBOOK

UNIT I THE NATURE OF LIFE

Chapter 1. The Science of Life 3
2. The Living Condition 13
3. The Chemical Basic of Life 26
4. The Structural Basic of Life 42
5. The Cell and Its Environment 53
6. Photosynthesis, Respiration, and Cell Energy 62
7. Nucleic Acids and Protein Synthesis 78
8. Cell Growth and Reproduction 86

UNIT II THE CONTINUITY OF LIFE

Chapter 9. Principles of Heredity 97
10. The Genetic Material 111
11. Genes in Human Populations 127
12. Applies Genetics 140
13. Organic Variation 148
14. The Diversity of Life 163

UNIT III MICROBIOLOGY

Chapter 15. The Viruses 173
16. Bacteria and Related Organisms 182
17. Infectious Disease 195
18. The protozoans 210
19. The Fungi 221
20. The Algae 235

UNIT IV MULTICELLULAR PLANTS

Chapter 21. Mosses and Ferns 253
22. The Seed Plants 262
23. The Leaf and Its Functions 274
24. Roots and Stems 288
25. Water Relations in Plants 304
26. Plant Growth and Responses 312
27. Plant Reproduction 320

UNIT V BIOLOGY OF THE INVERTEBRATES

Chapter 28. Sponges and Coelenterates 341
29. The Worms 350
30. Mollusks and Echinoderms 366
31. The Arthropods 378
32. Insects--Familiar Arthropods 391

UNIT VI BIOLOGY OF THE VERTEBRATES

Chapter 33. Introduction to the Vertebrates 411
34. The Fishes 421
35. The Amphibians 437
36. The Reptiles 454
37. The Birds 471
38. The Mammals 488

UNIT VII HUMAN BIOLOGY

Chapter 39. Human History 513
40. The Body Framework 523
41. Nutrition 533
42. Transport and Excretion 552
43. Respiration and Energy Exchange 569
44. Body Controls 580
45. Tobacco, Alcohol, and Drugs 597
46. Body Regulators 610
47. Reproduction and Development 620

UNIT VIII ECOLOGICAL RELATIONSHIPS

Chapter 48. Introduction to Ecology 635
49. The Habitat 647
50. Periodic Changes in the Environment 660
51. Biogeography 670
52. The Land We Live In 684
53. Forest and Wildlife Resources 699
APPENDIX J

THE TABLE OF CONTENTS OF OTTO'S BIOLOGY
LABORATORY INVESTIGATIONS

1-1 The Microscope—How is it used?

2-1 How was spontaneous generation disproved?

3-1 How do we test for organic compounds?
3-2 What are enzymes? What factors affect them?

4-1 What are cells?
4-2 Do animal cells differ from plant cells?

5-1 What is a selectively permeable membrane?
5-2 When does osmosis occur in living cells?

6-1 How does light affect photosynthesis?
6-2 What factors affect respiration?

7-1 What is the structure of DNA?

8-1 What are the phases of mitosis and meiosis?

9-1 How does chance influence inheritance?
9-2 How can inheritance be predicted?

10-1 What are sex-linked traits?
10-2 How are fruit flies used to study inheritance?

11-1 What are some human genetic traits?

13-1 What does adaptation mean?

14-1 How do we classify organisms?

15-1 What is a phage virus?

16-1 How are bacteria cultured and distributed?
16-2 How are bacteria classified?

17-1 Do antiseptics and antibiotics work?

18-1 Which protozoans are found in fresh water?
18-2 Do protozoans respond to stimuli?
19-1 What are some forms of fungi?
20-1 How do various algae differ?
21-1 How can plants reproduce without seeds?
22-1 How do plants grow?
23-1 How does leaf structure relate to its function?
23-2 What makes leaves green?
24-1 How do roots grow?
24-2 How do monocot stems differ from dicot stems?
25-1 How does water move through a plant?
26-1 How do plants respond to stimuli?
27-1 How does the flower function in reproduction?
27-2 How do seed parts develop into young plants?
28-1 How is the sponge adapted for a sessile life?
28-2 How do hydra respond to stimuli?
29-1 Are planarians able to regenerate?
29-2 Is the earthworm adapted for underground life?
30-1 What are mollusks?
31-1 How does a crayfish respond to stimuli?
32-1 What are the specialized structures of a grasshopper?
33-1 What are some vertebrate characteristics?
34-1 How is a bony fish adapted for life in water?
34-2 Does water temperature affect fish?
35-1 How is a frog adapted for a double life?
35-2 What are the internal organs of a frog?
36-1 How are snakes and turtles unique reptiles?
37-1 How are birds adapted for varies environments?
38-1 What is the anatomy of the fetal pig?
40-1 What happens during muscular activity?
41-1 How does starch digestion occur?
42-1 What is blood?
42-2 How are blood types determined?

43-1 How can respiration rate be measured?

44-1 Can we test taste, smell, and touch?
44-2 How do we see?

46-1 How can hormones affect development?

47-1 How does an embryo develop?

48-1 What factors affect the water cycle?
48-2 How are plants and animals interdependent?

49-1 What is an ecosystem?

30-1 Do communities in an ecosystem change?
APPENDIX K

THE TABLE OF CONTENTS OF SMALLWOOD'S TEXTBOOK

UNIT I PATTERN OF STRUCTURE

Chapter 1. Biology and Biologists 4
2. Cells and Organelles 20
3. The Molecules of Life 44
4. The Ecological View 64

UNIT II PATTERN OF FUNCTION

Chapter 5. Energy for Organisms 82
6. DNA-The Solution of a Mystery 106
7. Reproduction of Life 132

UNIT III PATTERN OF LIFE

Chapter 8. The Diversity of Life 156
9. Classification and the Simple Organisms 168
10. The Plants 202
11. The Animals 220
12. Mysterious Bones 274

UNIT IV PATTERNS OF MAINTENANCE AND REGULATION

Chapter 13. Transportation and Digestion: Two Key Problems 300
14. Patterns of Digestion 318
15. Transport in Plants and Animals 340
16. Systems for Gas Exchange 366
17. Stability within the Organism 390
18. Hormones Control Cells 404
19. Nervous Control Cells 430

UNIT V PATTERN OF REPRODUCTION

Chapter 20. Patterns of Reproduction and Development: Plants 454
22. Heredity and New Individuals 502
23. Human Genetics 524
UNIT VI ANIMALS HAVE SPECIAL PROBLEMS

Chapter 24. How Animals Receive Information 542
25. Animal Communication 562
26. Patterns of Behavior 582

UNIT VII PATTERN WITHIN THE ENVIRONMENT

Chapter 27. Populations Are Interdependent 600
28. Ecosystems: Rhythms and Change 624
29. Cycles in the Biosphere 640

UNIT VIII PROBLEMS OF PEOPLE IN THEIR ENVIRONMENT

Chapter 30. Challengers from the Environment 658
31. People Challenge Their Environment 674
APPENDIX L

THE TABLE OF CONTENTS OF SMALLWOOD'S LABORATORY INVESTIGATIONS

1. Observe and Question
2. Learning to Use Your Microscope
3. Measuring Microscope Objects
4. Cork: Cells with a History
5. Onion: A Living Plant Cell
6. Elodea: Plant Cells with a Function
7. Human Epithelial Cells
8. Some Cells are Independent
9. Carbohydrates and Proteins
10. The Sequence of Amino Acids Is Important
11. Enzymes, Temperature, and Time
12. Enzymes Affect the Speed of Chemical Reactions
13. Microecosystems
14. Pigments in Plant Leaves
15. Light in Starch Formation
16. CO₂ in Starch Formation
17. Effects of Heat on Fermentation
18. The Syntheses of a Protein
19. A Population Explosion in a Test Tube
20. Chromosomes in Dividing Cells
21. Regeneeration Planaria
22. The Clam
23. Organisms Can Resist Harsh Environments
24. Homology
25. Monerans and Protistans
26. What Is It?
27. The Cell Membrane and Diffusion
28. Small Cells versus Large Cells
29. A Multicellular Problem
30. What Does Too Much Fertilizer Do to Plants?
31. The Earthworm
32. The Grasshopper
33. The Frog
34. Digestion Outside a Cell
35. Measuring Daphnia's Heartbeat
36. The Blood Path
37. Examining Blood Cells
38. Leaf Structure-Stomates
39. Water--Conducting Tissues
40. CO₂ Production in Humans
41. Measuring the Amount of Oxygen Used
42. The Structure and Tissues of A Wing
43. Living Thermostats
44. Hormones in Plants
45. The Effect of Gibberellic Acid
46. The Control of Frog Development by Hormones
47. How Flowers Function
48. How Pollen Germinates
49. The Development of a Seed
50. Developing Frog Eggs
51. The Crayfish
52. Giant Chromosomes
53. Blood Groups
54. Temperature Affects the Color of Bacteria
55. How Fruit Flies Received Information
56. The Structures of a Mammalian Eye
57. A Pheromone Effect
58. Frogs Are Homes For Other Organism
59. Food Webs
60. Isolating Bacteria from Your Environment
61. Observing Bacteria
62. Bacteria and Antibiotic
63. Introduction to a Quadrat
64. The Effect of a Population Explosion
# APPENDIX M

## THE TABLE OF CONTENTS IN WEINBERG'S TEXTBOOK

### UNIT I LIFE

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
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<tbody>
<tr>
<td>1</td>
<td>The Nature of Life</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Cells</td>
<td>11</td>
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<tr>
<td>3</td>
<td>Biochemistry</td>
<td>33</td>
</tr>
<tr>
<td>4</td>
<td>Energy</td>
<td>49</td>
</tr>
</tbody>
</table>

### UNIT II ORGANISMS

<table>
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<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
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<tr>
<td>5</td>
<td>Life and Change</td>
<td>69</td>
</tr>
<tr>
<td>6</td>
<td>Monera and Protists</td>
<td>101</td>
</tr>
<tr>
<td>7</td>
<td>Plants</td>
<td>115</td>
</tr>
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<td>8</td>
<td>Animals</td>
<td>127</td>
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</tbody>
</table>

### UNIT III MAINTENANCE

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<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
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<tr>
<td>9</td>
<td>Food</td>
<td>153</td>
</tr>
<tr>
<td>10</td>
<td>Plant Nutrition and Maintenance</td>
<td>169</td>
</tr>
<tr>
<td>11</td>
<td>Digestion in Animals</td>
<td>193</td>
</tr>
<tr>
<td>12</td>
<td>Circulation</td>
<td>207</td>
</tr>
<tr>
<td>13</td>
<td>Homeostasis</td>
<td>225</td>
</tr>
</tbody>
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### UNIT IV COORDINATION

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<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
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<tbody>
<tr>
<td>14</td>
<td>Chemical Control</td>
<td>239</td>
</tr>
<tr>
<td>15</td>
<td>Stimulus and Response</td>
<td>255</td>
</tr>
<tr>
<td>16</td>
<td>Behavior</td>
<td>277</td>
</tr>
<tr>
<td>17</td>
<td>Social Behavior</td>
<td>291</td>
</tr>
</tbody>
</table>

### UNIT V CONTINUITY

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
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<tbody>
<tr>
<td>18</td>
<td>Cellular Reproduction</td>
<td>307</td>
</tr>
<tr>
<td>19</td>
<td>Animal Development</td>
<td>321</td>
</tr>
<tr>
<td>20</td>
<td>Plant Development</td>
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<td>21</td>
<td>Genetics</td>
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<td>Biochemical Genetics</td>
<td>379</td>
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</table>

### UNIT VI EVOLUTION

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<th>Title</th>
<th>Page</th>
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<tr>
<td>23</td>
<td>The Origin of Species</td>
<td>403</td>
</tr>
<tr>
<td>24</td>
<td>The History of Life</td>
<td>419</td>
</tr>
<tr>
<td>25</td>
<td>The Origin of Life</td>
<td>433</td>
</tr>
<tr>
<td>26</td>
<td>The Human Species</td>
<td>451</td>
</tr>
</tbody>
</table>
UNIT VII ECOLOGY

Chapter 27. The Web of Life 467
  28. Infestation and Immunity 487
  29. Health and Disease 503
  30. The Human Environment 517
APPENDIX N

THE TABLE OF CONTENTS IN WEINBERG'S LABORATORY INVESTIGATIONS

1. The Snail
2. Imitation of Life
3. The Compound Microscope
4. Animal Cells
5. Plant Cells
6. Element and Compound
7. Indicators
8. Metabolism
9. Yeast
10. Enzymes
11. Mitochondria
12. Fossils
13. Paramecium
14. Slime Molds
15. Observing Bacteria
16. Plankton
17. Bread Mold
18. Hydra
19. Planaria
20. Nematodes
21. The Earthworm
22. Earthworm Dissection
23. Daphnia
24. The Frog
25. Nutrient Tests
26. Vitamin C
27. Chromatography of Chlorophyll
28. CO₂ in Photosynthesis
29. Transport in Plants
30. Tonicity
31. Diffusion Through a Membrane
32. Frog Dissection
33. Digestion of Starch
34. Digestion of Protein
35. Circulation
36. Heart Rate in Daphnia
37. Blood Cells
38. Typing Blood
39. Blood Clotting
40. Respiration
41. Neurohumors and Muscles
42. Visual Sensation and Perception
43. Chemical Senses
44. Plant Tropisms
45. Behavior of Crustaceans
46. Chromosomes and Mitosis
47. Chlamydomonas
48. Vegetative Reproduction
49. Frog Development
50. Chick Development
51. Regeneration and Reassociation
52. Mammal Reproduction
53. Fruits and Seeds
54. The Flower
55. Differentiation
56. Laws of Chance
57. Drosophila
58. Human Heredity
59. Biochemical Genetics in Peas
60. Breeding Molds
61. DNA
62. Variation
63. Immunology and Evolution
64. Vertebrate Evolution
65. Reactions to Polarized Light
66. Anthropology
67. Microaquarium
68. Succession
69. Soil Organisms
70. Field Study of a Community
71. A Rotten Log
72. Air Quality
73. Water Quality
74. Identifying Bacteria
75. Antibiosis
### APPENDIX O

**CLASSIFICATION OF CHAPTER AND PAGE NUMBER OF CORRESPONDING CONTENT IN TEXAS AND THAI BIOLOGY TEXTBOOKS**

**THE CONTENT OF BIOLOGY OF THE CELL (1.1)**

<table>
<thead>
<tr>
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<td>1.11 Cell structure and function</td>
<td>7(164-183)</td>
<td>2-2(136-145)</td>
<td>4(63-71)</td>
<td>4(42-51)</td>
<td>2(35-41)</td>
<td>2(18-29)</td>
</tr>
<tr>
<td>1.12 Transport of cellular material</td>
<td>9(197-200, 210-214)</td>
<td>2-3(153-159)</td>
<td>4(71-78)</td>
<td>5(53-60)</td>
<td>13(301-314)</td>
<td>10(186-187)</td>
</tr>
<tr>
<td>1.13 Cell metabolism</td>
<td>23(124-148)</td>
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<td>5(87-103)</td>
<td>6(72-77)</td>
<td>5(94-102)</td>
<td>4(51-54)</td>
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<td>1.14 Photosynthesis</td>
<td>24(150-161)</td>
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<td>5(110-112, 115-121)</td>
<td>6(62-72)</td>
<td>5(87-94)</td>
<td>10(169-178)</td>
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<tr>
<td>1.15 Cell responses</td>
<td>17(2-6)</td>
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<td></td>
<td>18(212, 213-214)</td>
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<tr>
<td>1.16 Concept of the gene</td>
<td>27(21-56)</td>
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<td>9(161-177)</td>
<td>7(78-84)</td>
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APPENDIX 0 (continued)

THE CONTENT OF BIOLOGY OF THE ORGANISMS (1.2)

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<td>6(101-150)</td>
<td>2-1(118-124)</td>
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<td>8(188-195)</td>
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<td>17(341-355)</td>
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<td>19(389-403)</td>
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### APPENDIX O (continued)

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<td>13(225-227, 231-235)</td>
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<td>14(86-109)</td>
<td>5-1(478-495)</td>
<td>1(11-12)</td>
<td>18(212,214-216)</td>
<td>7(133-136,141-147)</td>
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APPENDIX C (continued)

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