This investigation was designed to reveal the relationship of learning outcomes to selected teacher factors and teaching methods in tenth grade biology classes in Oregon during the 1962-1963 school year.

A stratified random sample of 51 public high schools was selected to participate in this investigation. One class and one teacher from each school were involved in the evaluation.

Selected teacher factors and teaching methods were compared for relatedness to five learning outcomes in biological science education: (1) gain in knowledge and understanding of biological facts, concepts, and principles; (2) gain in skill in applying the methods of science; (3) improvement in critical thinking skills; (4) development of an understanding of the nature of science; and (5) development of
more favorable attitudes toward science and scientific careers.

Teacher factors were analyzed by the analysis of covariance, adjusting for general scholastic ability and pre-test knowledge, for statistical relatedness to student gains on each of the selected learning outcomes. Comparative analyses of percentage differences were used to determine the relationship of teacher factors to composite success, teachers of classes achieving high gains on three or more learning outcomes.

Teaching methods and student activities were investigated for their relationship to the five selected learning outcomes by comparing methods and activities utilized in classes with the highest mean gains to classes with the lowest mean gains.

Students were pre-tested in September, 1962, and post-tested in May, 1963. Data were obtained from the Otis Mental Ability Test, Gamma: Form Em; the Nelson Biology Test, Forms Am and Bm; the Watson-Glaser Critical Thinking Appraisal, Forms Ym and Zm; the Reaction Inventory, Attitudes Toward Science and Scientific Careers; and the Student Inventory.

Data concerning teacher factors and teaching methods were obtained from tests, an inventory completed by each teacher, principal ratings, and data from the State Department of Public Instruction.
The following conclusions were drawn from the data analyzed in this investigation:

1. Certain teacher factors were significantly related to each of the five learning outcomes at the .10 level or above.

2. Teachers rated high in personal adjustment by the principals taught classes with higher adjusted gains on four of the five learning outcomes. This factor was also highly related to composite success.

3. During the school year students developed more favorable attitudes toward science and scientific careers.

4. Pupil-centric methods emphasizing problem-solving laboratory procedures with analyses of experimentation were characteristic of a majority of the classes with high composite success.

5. A number of teachers possessed attitudes which indicated lack of information concerning the scientific endeavor and the status of science. These teachers could not be distinguished by age, experience, preparation, or assignment.

6. Teachers with less than 40 quarter hours of preparation in all science areas and less than 30 quarter hours in biology, with one exception, did not teach classes with
positive gains among the highest third on any of the learning outcomes.

7. Data obtained in this investigation revealed that several teachers were not previously cognizant of broad objectives or were not including them in their teaching.

8. Data analyzed indicated that teaching which was planned to achieve a specific objective was more efficient than incidental learning. This was particularly evident in teaching to change attitudes.
THE RELATIONSHIP OF LEARNING OUTCOMES TO SELECTED TEACHER FACTORS AND TEACHING METHODS IN TENTH GRADE BIOLOGY CLASSES IN OREGON

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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>The Problem</td>
<td>4</td>
</tr>
<tr>
<td>Statement of the Problem</td>
<td>4</td>
</tr>
<tr>
<td>Definition of Terms</td>
<td>6</td>
</tr>
<tr>
<td>Basic Assumptions</td>
<td>8</td>
</tr>
<tr>
<td>Importance of the Study</td>
<td>10</td>
</tr>
<tr>
<td>Procedures</td>
<td>12</td>
</tr>
<tr>
<td>Sample Selection of Schools</td>
<td>12</td>
</tr>
<tr>
<td>Sources of Data</td>
<td>12</td>
</tr>
<tr>
<td>Distribution of Evaluation Materials</td>
<td>14</td>
</tr>
<tr>
<td>Administration and Scoring of the Instruments</td>
<td>15</td>
</tr>
<tr>
<td>Analysis of the Data</td>
<td>15</td>
</tr>
<tr>
<td>Delimitation of the Problem</td>
<td>16</td>
</tr>
<tr>
<td>II BACKGROUND AND RELATED LITERATURE</td>
<td>18</td>
</tr>
<tr>
<td>Objectives and Outcomes</td>
<td>18</td>
</tr>
<tr>
<td>Objectives</td>
<td>19</td>
</tr>
<tr>
<td>Outcomes</td>
<td>24</td>
</tr>
<tr>
<td>Teacher Factors</td>
<td>37</td>
</tr>
<tr>
<td>Identification of Teacher Factors</td>
<td>37</td>
</tr>
<tr>
<td>Academic Preparation</td>
<td>52</td>
</tr>
<tr>
<td>Summary</td>
<td>61</td>
</tr>
<tr>
<td>Teaching Methods</td>
<td>63</td>
</tr>
<tr>
<td>Summary</td>
<td>72</td>
</tr>
<tr>
<td>III DESIGN OF THE STUDY</td>
<td>74</td>
</tr>
<tr>
<td>Selection of Sample Schools and Panel of Scientists</td>
<td>75</td>
</tr>
<tr>
<td>Selected Instruments and Statistics Utilized in the Study</td>
<td>79</td>
</tr>
<tr>
<td>Characteristics of Sample Teachers</td>
<td>99</td>
</tr>
<tr>
<td>IV THE STUDY</td>
<td>115</td>
</tr>
<tr>
<td>Student Achievement</td>
<td>117</td>
</tr>
<tr>
<td>General Scholastic Ability</td>
<td>118</td>
</tr>
<tr>
<td>Total Gain in Knowledge and Skills</td>
<td>119</td>
</tr>
<tr>
<td>Critical Thinking Skills</td>
<td>122</td>
</tr>
<tr>
<td>Chapter</td>
<td>Page</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Attitudes Toward Science and Scientific Careers</td>
<td>123</td>
</tr>
<tr>
<td>Interest in Science-Related Vocations</td>
<td>127</td>
</tr>
<tr>
<td>Relationship of Student Learning Outcomes to Size of School</td>
<td>129</td>
</tr>
<tr>
<td>Summary</td>
<td>131</td>
</tr>
<tr>
<td>Teacher Factors</td>
<td></td>
</tr>
<tr>
<td>Teacher Age</td>
<td>135</td>
</tr>
<tr>
<td>Academic Preparation</td>
<td>137</td>
</tr>
<tr>
<td>Teacher Attitudes Toward Science and Scientific Careers</td>
<td>144</td>
</tr>
<tr>
<td>Teacher Attitudes Toward Statements Related to Science Teaching</td>
<td>147</td>
</tr>
<tr>
<td>Teacher Critical Thinking Skills</td>
<td>149</td>
</tr>
<tr>
<td>Teacher-Pupil Relationships</td>
<td>152</td>
</tr>
<tr>
<td>Teacher Personal Adjustment</td>
<td>154</td>
</tr>
<tr>
<td>Total Teaching Experience</td>
<td>157</td>
</tr>
<tr>
<td>Total Biology Teaching Experience</td>
<td>159</td>
</tr>
<tr>
<td>Teacher Salary</td>
<td>161</td>
</tr>
<tr>
<td>Number of Assigned Biology Classes</td>
<td>163</td>
</tr>
<tr>
<td>Relationship of Teacher Factors to</td>
<td></td>
</tr>
<tr>
<td>Composite Success in Teaching Biology</td>
<td></td>
</tr>
<tr>
<td>Summary</td>
<td>166</td>
</tr>
<tr>
<td>Methods of Teaching</td>
<td></td>
</tr>
<tr>
<td>Objective One - The Student Can</td>
<td></td>
</tr>
<tr>
<td>Demonstrate Increased Knowledge and Understanding of Basic Biological Facts, Concepts, and Principles</td>
<td>179</td>
</tr>
<tr>
<td>Objective Two - The Student Is Able to</td>
<td></td>
</tr>
<tr>
<td>Apply the Methods of Science</td>
<td>182</td>
</tr>
<tr>
<td>Objective Three - The Student Can Show</td>
<td></td>
</tr>
<tr>
<td>Evidence of Improving His Ability to Think Critically</td>
<td>186</td>
</tr>
<tr>
<td>Objective Four - The Student Can Demonstrate Attitudes Which</td>
<td></td>
</tr>
<tr>
<td>Indicate an Understanding of the Nature of Science</td>
<td>188</td>
</tr>
<tr>
<td>Objective Five - The Student Can Demonstrate a Desirable Improve-</td>
<td></td>
</tr>
<tr>
<td>ment in His Concept of the Scientist</td>
<td></td>
</tr>
</tbody>
</table>
TABLE OF CONTENTS (Continued)

<table>
<thead>
<tr>
<th>Chapter and of Scientific Careers</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Organization</td>
<td>195</td>
</tr>
<tr>
<td>Summary</td>
<td>198</td>
</tr>
</tbody>
</table>

V SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

<table>
<thead>
<tr>
<th>Summary</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conclusions</td>
<td>205</td>
</tr>
<tr>
<td>Recommendations</td>
<td>208</td>
</tr>
</tbody>
</table>

BIBLIOGRAPHY

APPENDIX

<table>
<thead>
<tr>
<th>A Evaluation Instruments Used in the Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reaction Inventory, Attitudes Toward Science and Scientific Careers</td>
</tr>
<tr>
<td>Reaction Inventory, Attitudes Toward Science, Scientific Careers, and Science Teaching</td>
</tr>
<tr>
<td>Student Inventory</td>
</tr>
<tr>
<td>Teacher Inventory</td>
</tr>
<tr>
<td>Teacher Inventory</td>
</tr>
<tr>
<td>Teacher Rating Scale</td>
</tr>
</tbody>
</table>

| B Letter of Explanation              | 252 |

| C Field Study Plan                   | 254 |

| D Sample Survey Questionnaire        | 257 |

<p>| E Table LVI - Class Means on Evaluation Instruments | 259 |</p>
<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Public High Schools in Each Strata in the State of Oregon - Schools Which Were Drawn, Which Participated, and Which Completed the Study</td>
<td>78</td>
</tr>
<tr>
<td>II</td>
<td>Means of Scientists' Responses to Statements in Attitudes Toward Science and Scientific Careers</td>
<td>88</td>
</tr>
<tr>
<td>III</td>
<td>Means of Scientists' Responses to Statements in Attitudes Toward Science, Scientific Careers, and Science Teaching</td>
<td>90</td>
</tr>
<tr>
<td>IV</td>
<td>High, Low, and Mean Scores on Teacher Rating Scale</td>
<td>93</td>
</tr>
<tr>
<td>V</td>
<td>Ages of Biology Teachers</td>
<td>100</td>
</tr>
<tr>
<td>VI</td>
<td>Quarter Hours of Preparation in Biology, All Sciences, and Professional Education Reported By Sample Teachers</td>
<td>103</td>
</tr>
<tr>
<td>VII</td>
<td>Total Years of Teaching Experience and Years of Experience Teaching Biology</td>
<td>105</td>
</tr>
<tr>
<td>VIII</td>
<td>Number of Years of Experience in Present District</td>
<td>105</td>
</tr>
<tr>
<td>IX</td>
<td>Salaries of Sample Teachers for the 1962-1963 School Year</td>
<td>106</td>
</tr>
<tr>
<td>X</td>
<td>Professional and Scientific Organizations in Which Four or More Teachers Held Membership</td>
<td>107</td>
</tr>
<tr>
<td>XI</td>
<td>Distribution of Teacher Critical Thinking Scores</td>
<td>109</td>
</tr>
<tr>
<td>XII</td>
<td>Total Difference Scores Between Attitudes of Teachers and Means of Scientists Relating to Attitudes Toward Science and Scientific Careers</td>
<td>110</td>
</tr>
<tr>
<td>Table</td>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>-------</td>
<td>----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>XIII</td>
<td>Total Difference Scores Between Individual Teacher Attitudes Toward Science Teaching and Scientists' Means</td>
<td>111</td>
</tr>
<tr>
<td>XIV</td>
<td>Principles' Ratings of Teacher-Pupil Relationships</td>
<td>111</td>
</tr>
<tr>
<td>XV</td>
<td>Principles' Evaluations of Teacher Personal Adjustment</td>
<td>112</td>
</tr>
<tr>
<td>XVI</td>
<td>Principles' Ratings of Teacher Effectiveness</td>
<td>113</td>
</tr>
<tr>
<td>XVII</td>
<td>Principles' Ratings of Teacher Effectiveness Exclusive of Teacher-Pupil Relationships</td>
<td>113</td>
</tr>
<tr>
<td>XVIII</td>
<td>Mean Gamma I.Q.'s For Sample Classes</td>
<td>118</td>
</tr>
<tr>
<td>XIX</td>
<td>Comparison of Expected Frequencies of a Normal Curve and Distribution of Class Mean Gamma I.Q.'s</td>
<td>119</td>
</tr>
<tr>
<td>XX</td>
<td>Mean Gains of Classes on Total Nelson Biology Test</td>
<td>119</td>
</tr>
<tr>
<td>XXI</td>
<td>Mean Gains of Classes on Part A, Nelson Biology Test</td>
<td>120</td>
</tr>
<tr>
<td>XXII</td>
<td>Mean Gains of Classes on Part B, Nelson Biology Test</td>
<td>121</td>
</tr>
<tr>
<td>XXIII</td>
<td>Mean Gains of Classes on Watson-Glaser Critical Thinking Appraisal</td>
<td>122</td>
</tr>
<tr>
<td>XXIV</td>
<td>Mean Gains of Classes on Attitudes Toward Science and Scientific Careers</td>
<td>124</td>
</tr>
<tr>
<td>XXV</td>
<td>Mean Gains of Classes on Selected Items of the Reaction Inventory Relating to Understanding the Nature of Science</td>
<td>125</td>
</tr>
</tbody>
</table>
## LIST OF TABLES (Continued)

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>XXVI</td>
<td>Mean Attitude Change of Each Class in the Direction of the Supervising Teacher's Attitudes</td>
<td>126</td>
</tr>
<tr>
<td>XXVII</td>
<td>Net Scores of Class Interest Changes Regarding Scientific and Technical Vocations</td>
<td>128</td>
</tr>
<tr>
<td>XXVIII</td>
<td>Relationship of School Enrollment to Student Learning Outcomes</td>
<td>130</td>
</tr>
<tr>
<td>XXIX</td>
<td>Relationship of Teacher Age to Student Learning Outcomes</td>
<td>136</td>
</tr>
<tr>
<td>XXX</td>
<td>Relationship of Teacher Preparation in Biology to Student Learning Outcomes</td>
<td>138</td>
</tr>
<tr>
<td>XXXI</td>
<td>Relationship of Teacher Preparation in All Sciences to Student Learning Outcomes</td>
<td>140</td>
</tr>
<tr>
<td>XXXII</td>
<td>Relationship of Breadth and Depth of Teacher Science Preparation to Student Learning Outcomes</td>
<td>143</td>
</tr>
<tr>
<td>XXXIII</td>
<td>Relationship of Teacher Attitudes Toward Science and Scientific Careers to Student Learning Outcomes</td>
<td>146</td>
</tr>
<tr>
<td>XXXIV</td>
<td>Relationship of Teacher Attitudes Toward Science Teaching to Student Learning Outcomes</td>
<td>148</td>
</tr>
<tr>
<td>XXXV</td>
<td>Relationship of Teacher Critical Thinking Skills to Student Learning Outcomes</td>
<td>151</td>
</tr>
<tr>
<td>XXXVI</td>
<td>Relationship of Teacher-Pupil Relationships to Student Learning Outcomes</td>
<td>153</td>
</tr>
<tr>
<td>XXXVII</td>
<td>Relationship of Teacher Personal Adjustment to Student Learning Outcomes</td>
<td>155</td>
</tr>
<tr>
<td>Table</td>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>------</td>
<td>--------------------------------------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>XXXVIII</td>
<td>Relationship of Total Teaching Experience to Student Learning Outcomes</td>
<td>158</td>
</tr>
<tr>
<td>XXXIX</td>
<td>Relationship of Biology Teaching Experience to Student Learning Outcomes</td>
<td>160</td>
</tr>
<tr>
<td>XL</td>
<td>Relationship of Teacher Salary to Student Learning Outcomes</td>
<td>162</td>
</tr>
<tr>
<td>XLI</td>
<td>Relationship of Full Time and Part Time Biology Teachers to Student Learning Outcomes</td>
<td>165</td>
</tr>
<tr>
<td>XLII</td>
<td>Relationship of Teacher Factors to Composite Success in Teaching Biology</td>
<td>167</td>
</tr>
<tr>
<td>XLIII</td>
<td>Relationship of Learning Outcomes to Teacher and School Factors</td>
<td>175</td>
</tr>
<tr>
<td>XLIV</td>
<td>Teachers Who Did and Did Not Plan and Teach for Increased Knowledge and Understanding of Basic Biological Facts, Concepts, and Principles</td>
<td>180</td>
</tr>
<tr>
<td>XLV</td>
<td>Methods Utilized to Teach for Knowledge and Understanding of Biological Facts, Concepts, and Principles</td>
<td>182</td>
</tr>
<tr>
<td>XLVI</td>
<td>Teachers Who Did and Did Not Plan and Teach for the Application of the Methods of Science</td>
<td>183</td>
</tr>
<tr>
<td>XLVII</td>
<td>Methods Utilized to Teach for the Application of the Methods of Science</td>
<td>185</td>
</tr>
<tr>
<td>XLVIII</td>
<td>Teachers Who Did and Did Not Plan and Teach to Improve Critical Thinking Skills</td>
<td>186</td>
</tr>
<tr>
<td>XLIX</td>
<td>Methods Utilized to Teach to Improve Critical Thinking Skills</td>
<td>187</td>
</tr>
</tbody>
</table>
## LIST OF TABLES (Continued)

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Teachers Who Did and Did Not Plan and Teach to Develop an Understanding of the Nature of Science</td>
<td>189</td>
</tr>
<tr>
<td>LI</td>
<td>Methods Utilized to Teach for the Understanding of the Nature of Science</td>
<td>190</td>
</tr>
<tr>
<td>LII</td>
<td>Teachers Who Did and Did Not Plan and Teach to Develop Desirable Attitudes Toward Scientists and Scientific Careers</td>
<td>192</td>
</tr>
<tr>
<td>LIII</td>
<td>Methods Utilized to Teach to Develop Desirable Attitudes Toward Scientists and Scientific Careers</td>
<td>194</td>
</tr>
<tr>
<td>LIV</td>
<td>Plan of Course Organization Reported by Sample Teachers</td>
<td>196</td>
</tr>
<tr>
<td>LV</td>
<td>Relationship of Textbook Form of Class Organization to Student Learning Outcomes</td>
<td>197</td>
</tr>
<tr>
<td>LVI</td>
<td>Class Means on Evaluation Instruments</td>
<td>259</td>
</tr>
</tbody>
</table>
THE RELATIONSHIP OF LEARNING OUTCOMES TO SELECTED TEACHER FACTORS AND TEACHING METHODS IN TENTH GRADE BIOLOGY CLASSES IN OREGON

CHAPTER I

INTRODUCTION

Since the mid 1950's, interest and concern have focused on science education at the secondary school level. Scientific and technological developments since World War II have magnified several problems directly related to science education.

A prime concern of many individuals has been the serious shortage of scientifically and technically educated manpower. Technical competition with the Communist nations, especially evident in the space race, has been a major factor in increased personnel demand. Increased emphasis on scientific research and development in other areas and the population explosion have also added to the shortage of scientists, engineers, technicians, and qualified science teachers.

The need for developing a scientifically literate population has received increased attention. Most aspects of daily living are associated with knowledge or attitudes related to the various sciences. Decisions concerning uses of natural resources, personal health and medical practices, racial problems, appropriations for scientific
expenditures, as well as other problems must be intelligently determined by the average citizen. Evidence has been accumulated which indicates many persons are not scientifically literate.

As these concerns crystallized, federal and private organizations began to evolve and publicize plans and programs to improve science education in the secondary schools. State and national committees have identified problems and needs of biology and other secondary science programs. Considerable emphasis has been focused on teacher education and curriculum development.

Improvement of biology teaching has been an area of major concern. A greater percentage of high school students enroll in biology each year than in any other high school science course (82, p. 93). The potential role of the biology course for providing desirable educational experiences has been widely recognized.

Objectives of the modern high school biology course have been studied, evaluated, and reported by individuals and organizations. Interested and influential individuals and groups have included science educators, national and state education and science committees, professional education and science organizations, textbook authors, and curriculum committees. While there has not been unanimous agreement on all objectives for the course, there has been general consensus on several. It has been generally agreed that as a result
of his experiences in a biology class the student should:

1. Demonstrate increased knowledge and understanding of basic biological facts, concepts, and principles.

2. Show improvement in his ability to apply the methods of science.

3. Show evidence of improvement in his ability to think critically.

4. Demonstrate attitudes which indicate an improved understanding of the nature of science.

5. Demonstrate an improvement in his concept of the scientist and of scientific careers.

The responsibility for the attainment of these or other outcomes rests with the individual biology teacher. It is the teacher who makes the final decisions concerning the objectives toward which he will guide his students and the content and methods he will utilize to achieve these objectives.

Recognizing the key role of the teacher in the science classroom, colleges and universities have examined, debated, and evaluated new plans and standards of teacher preparation for biology teachers. The National Science Foundation and other interested organizations have also supported programs to improve the competencies of biology teachers.
It is apparent that there is a lack of adequate research providing information needed to assist in reaching decisions concerning teacher preparation for secondary school biology teachers.

THE PROBLEM

Statement of the Problem

This study was designed to determine the relationship of learning outcomes to selected teacher factors and teaching methods in tenth grade biology classes in Oregon. More specifically, answers were sought for the following two major questions:

1. What selected teacher factors have a significant relationship to the attainment of specific learning outcomes by students?

2. What teaching methods or combinations of methods have a significant relationship to the attainment of the same specific learning outcomes by students?

These two basic problems were divided into several subproblems for specific analysis. The null hypotheses were:

1. Selected teacher factors are not significantly related to student gains in knowledge and understanding of biological facts, concepts, and principles.

2. Selected teacher factors are not significantly related to
student gains in the skill of applying the methods of science.

3. Selected teacher factors are not significantly related to student achievement in critical thinking skills.

4. Selected teacher factors are not significantly related to the development of students with desirable attitudes toward science, scientific careers, and the interaction of science and society.

5. Students' attitudes toward science, scientific careers, and the interaction of science and society do not change in the direction of the attitudes held by their biology teachers.

6. Selected teaching methods or combinations of methods are not related to student gains in knowledge and understanding of biological facts, concepts, and principles.

7. Selected teaching methods or combinations of methods are not related to student gains in skill in applying the methods of science.

8. Selected teaching methods or combinations of methods are not related to student gains in critical thinking skills.

9. Selected teaching methods or combinations of methods
are not related to the development of students with
desirable attitudes toward science, scientific careers,
and the interaction of science and society.

Definitions of Terms

Learning outcomes. An educational experience may result in
many learning outcomes to students. Learning outcomes are interpreted as changed behaviors which result from learning (47, p. 381). The term as used in this study refers to the following outcomes:

1. Knowledge and understanding of facts, concepts, and
   principles of biology.

2. Skill in the application of the methods of science.

3. Development of desirable attitudes concerning the nature
   of science, scientific careers, and the interaction of
   science and society.

4. The improvement of critical thinking skills.

Teacher factors. Teacher factors are defined as those factors resident in the teacher which would be removed if the specific teacher were not in the classroom. The term as used in this study refers to the following factors:

1. Teacher age.

3. Academic preparation in all sciences.
4. Fulfillment of the American Association for the Advance-
   ment of Science course recommendations.
6. Attitudes toward science and scientific careers.
7. Attitudes toward science teaching.
8. Critical thinking skills.
9. Teacher-pupil relationships.
10. Teacher personal adjustment.
11. Total years of teaching experience.
12. Years of experience teaching biology.
13. Number of years of experience in present district.
14. Participant in National Science Foundation Institutes.
15. Membership in professional and science organizations.
16. Teacher salary.

Teaching methods. Good (51, p. 553) defined a teaching method
as, "A rational ordering and balancing in the light of knowledge and
purpose of the several elements that enter into the educative pro-
cess, the nature of the pupil, materials, and total learning situa-
tion."

The following teaching methods were investigated in this
study:
1. Recitations from textbook assignments.

2. Free discussion based on topical assignments.

3. Lecture-demonstration combination.

4. Demonstration-discussion combination.

5. Lecture.

6. Laboratory.

7. Laboratory-discussion combination.

8. Project.

Other methods and descriptions of student behaviors submitted by the sample teachers were also analyzed.

Basic Assumptions

In this study it is assumed that:

1. The Otis Quick Scoring Mental Ability Test, Gamma: Form Em, provides an evaluation of the student's general scholastic ability.

2. The Nelson Biology Test, Forms Am and Bm, reveals the student's knowledge and understanding of facts, concepts, and principles in biology. It further indicates the student's skill in the application of the methods of science.
3. The **Watson-Glaser Critical Thinking Appraisal, Forms** Ym and Zm, reveals the student's ability to use critical thinking skills.

4. The **Reaction Inventory, Attitudes Toward Science and Scientific Careers**,\(^1\) indicates the student's opinions and attitudes toward science and scientific careers.

5. The **Reaction Inventory, Attitudes Toward Science, Scientific Careers, and Science Teaching**,\(^2\) reveals the opinions and attitudes of the teachers and the scientists toward science, scientific careers, and science teaching.

6. The secondary school principal is in a position to sense emotional relationships between teachers and pupils, and can discriminate between teachers with extremely high and extremely low pupil rapport (118, p. 6).

7. The teacher's responses to the **Teacher Inventory**\(^3\) reveal the objectives which the teacher planned and taught to achieve.

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1. Appendix A.

2. Ibid.

3. Ibid.
8. The teacher's responses to the Teacher Inventory reveal the methods or combination of methods utilized to teach for specific objectives.

Importance of the Study

There has been an increased awareness for quality science education for high school students. Desirable cognitive and non-cognitive learning objectives have been identified for secondary school biology. These objectives may be attained by planned teaching; they may be attained as incidental outcomes. However, they may not be realized, either due to lack of planning or ineffective teaching.

The process of education toward desired objectives is believed to be influenced by factors resident in the teacher, the pupil, and the school environment; by selected learning materials and procedures; and by the interaction of these factors in the learning process. Research investigations have indicated that factors influencing cognitive and non-cognitive learning are not the same. To improve the quality of biological science education, specific factors which influence the learning process need to be identified.

The teacher has been suggested as a key to the improvement of the learning situation by Maul (75, p. 174), Fitzpatrick (46, p. 10), and Brandwein (17, p. xii). The teacher has the final
responsibility for determining the objectives toward which he will guide the class and the procedures which will be utilized to obtain desired outcomes.

Insufficient evidence is presently available to guide the formulation of needed pre-service and in-service teacher education programs. Teacher factors related to specific learning outcomes in biology have not been clearly identified. Learning procedures which have been effectively utilized to develop specific outcomes also need to be more clearly identified.

It is, therefore, important to determine the objectives toward which Oregon biology teachers are teaching. Knowledge of neglected areas of learning should provide valuable information for teacher educators and science supervisors. It is also desirable to know which objectives are being attained and those which are not being attained.

If significant relationships exist between specific learning outcomes and selected teacher factors and teaching methods, knowledge of these relationships should be of value to teachers, science educators, and school administrators.

The analyses of the data obtained in this study should provide important information for the institutional training of science teachers, the education of teachers in-service, the administration of teaching staffs, and serve as a basis for further research.
PROCEDURES

Sample Selection of Schools

Schools were randomly selected from a stratified list of the 218 public high schools in Oregon (91). Categories were established for schools with student enrollments numbering 1-250, 251-500, 501-750, 751-1000, 1001-1500, and 1501 and over. To provide a representative sample of adequate size for statistical analyses, schools were selected on the basis of one for each four in the state proportional to the school enrollment ratio.

Fifty-four schools were involved in the fall phase of the study, 51 of which participated in the entire testing program during the school year 1962-63.

Sources of Data

Data used in this study were obtained from tests, inventories, questionnaires, ¹ a rating scale, ² teacher certification records of the State Department of Public Instruction, conferences with school administrators and teachers, and a review of the literature.

¹ Appendix A.
² Ibid.
Student evaluation. Students were pre-tested during the last two weeks of September, 1962, to provide statistical control of general scholastic ability and previous relevant knowledge. The following instruments were utilized in the fall:

1. The Otis Quick Scoring Mental Ability Test, Gamma:
   Form Em.
2. The Nelson Biology Test, Form Am.
3. The Watson-Glaser Critical Thinking Appraisal, Form Ym.
4. The Reaction Inventory, Attitudes Toward Science and Scientific Careers developed by Allen (1).
5. The Student Inventory.

Post-testing was conducted in May, 1963, to determine the outcomes of the educational experiences in biology classes. Instruments employed in the spring evaluation included:

1. The Nelson Biology Test, Form Bm.
2. The Watson-Glaser Critical Thinking Appraisal, Form Zm.
3. The Reaction Inventory, Attitudes Toward Science and Scientific Careers developed by Allen (1).
4. The Student Inventory (shortened form).
Teacher evaluation. Teachers were evaluated in the spring to determine their critical thinking skills and their attitudes toward science, scientific careers, and science teaching. The following instruments were employed:

1. The Watson-Glaser Critical Thinking Appraisal, Form Zm.

2. The Reaction Inventory, Attitudes Toward Science, Scientific Careers, and Science Teaching adapted from attitude inventories by Allen (1) and by Behnke (13).

At the end of the school year the teachers completed a questionnaire concerning their educational preparation, educational experience, teaching methods, and personal data.

The administrator in each school completed a Teacher Rating Scale relating to teacher-pupil relationships and the teacher's personal adjustment. The instrument utilized for this portion of the study was adapted by S. E. Williamson from the principal's rating scale used by C. H. Leeds (118, p. 10).

Distribution of Evaluation Materials

Fall testing materials were distributed by the researcher to 52 of the 54 participating schools. The science teacher and the administrator of 44 of the participating schools, and either the science
teacher or the principal in five of the schools were contacted to explain the study and to clarify the purposes and procedures. At three schools visited by the researcher, no science teacher or principal was available; testing materials and a letter of explanation were left at these schools. Testing materials with a letter of explanation were mailed to the other two schools.

Materials used in the spring were mailed to the schools and returned by mail to the researcher.

**Administration and Scoring of the Instruments**

Student evaluation materials were administered by the classroom teacher according to specified directions which were provided; the materials were returned to the researcher for scoring.

The Reaction Inventory, Attitudes Toward Science, Scientific Careers, and Science Teaching and the Critical Thinking Appraisal for the teachers were mailed to the principals with directions for administering the instruments. Completed forms were mailed to the researcher for scoring.

**Analyses of the Data**

Data from the various sources were tabulated on data sheets and unisort analysis cards. Selected teacher factors were investigated for significant relationships to learning outcomes utilizing the
analysis of covariance on class means adjusted for general scholastic ability and previous relevant knowledge.

Teaching methods were analyzed for their relationships to learning outcomes by comparing groups of teachers with classes who achieved the highest gains to teachers with classes who achieved the lowest gains.

Other analyses were conducted directly from the data sheets and unisort cards.

**Delimitation of the Problem**

The study has been delimited as follows:

1. The problem was limited to the state of Oregon to provide a general analysis of the teachers and the teaching of biology in Oregon.

2. The study was further limited to a stratified sample of 54 public high schools selected by use of a random number table from the 218 public high schools in Oregon. The sample was considered by experts in statistics and education to be representative and of adequate size for statistical treatment.

3. One teacher and one biology class were selected from each participating school.

4. The learning outcomes which were investigated by this
study were listed in the definition of terms. While these do not include all the outcomes of secondary biological science, they represent major outcomes which have been stressed by science educators and science committees.
CHAPTER II

BACKGROUND AND RELATED LITERATURE

Extensive research has been pursued in many areas of education to determine teacher factors and teaching methods which are related to pupil growth. There have been, however, relatively few studies in the science areas and specifically in biology.

A review of selected, pertinent investigations and related literature from 1930 to the present is discussed in this chapter. The chapter is divided into three sections:

1. Studies concerned with objectives and outcomes.
2. Studies concerned with teacher factors.
3. Studies concerned with teaching methods.

OBJECTIVES AND OUTCOMES

The first phase in curriculum design is usually based on determining objectives, goals which students should realize. Objectives provide a framework for the selection of content and methods for educational experiences. Evaluation should be utilized to determine if the outcomes of the teaching, learned behaviors, correspond to the desired objectives. The importance of stated objectives to the
teaching process and the measurement of learning outcomes have been given considerable attention by national, state, and local organizations, magazine publications, and textbooks.

Objectives

In the decade from 1940 to 1950 interest was focused on the question of the role of science in the secondary education of American youth.

A report, Education for All American Youth, by the Educational Policies Commission of the National Education Association in 1944 was concerned with redirecting secondary education. Science was recognized as an integral element in the education of youth. Attitudes and appreciations of science were to be stressed through social problems. The cultural outcomes expected from the teaching of science were stated as follows (40, p. 133):

1. An educated person will understand that science is based upon methods which man must slowly and painstakingly develop for discovering, verifying, interpreting, and organizing the facts of the world in which we live and about the people in it.

2. He will know that the use of scientific methods has made revolutionary changes in man's way of living and thinking.

3. He will see that the methods of science are one of mankind's chief instruments for making further progress.
4. He will know that scientific advances have depended upon precise measurement and active calculations; that mathematics is indispensable to scientific inquiry.

5. He will recognize that problems in human society as well as in the physical world should be attacked by scientific methods and a scientific point of view.

6. He will be familiar with certain fundamental principles and facts from the sciences, which when taken together, give him a sound view of the nature of the world in which he lives.

In *Science Education in American Schools*, Part I of the 46th Yearbook of the National Society for the Study of Education (81, p. 28-29), the general objectives of science teaching were listed as:

(1) Functional information; (2) Functional concepts; (3) Functional understanding of principles; (4) Instrumental skills; (5) Problem-solving skills; (6) Attitudes; (7) Appreciations; and (8) Interests.

Nelson (83, p. 20-21) has indicated that these objectives may logically be grouped into three categories: (1) Knowledge; (2) Intellectual Abilities and Skills; and (3) Affective Domain.

The President's Scientific Research Board in its report, *Science and Public Policy* (55, p. 91) felt that all youth should gain an understanding of:

(1) The methods of science; (2) the influence of science upon human life and thought; (3) the facts and principles essential to an understanding of themselves and their environment; and
(4) an appreciation of the scientific enterprise.

The Cooperative Committee for the Teaching of Science composed of representatives from five scientific societies reported to the AAAS Council in 1949 that the goals for science instruction should include (55, p. 104):

1. A functional understanding of the basic principles of both the biological and physical sciences.

2. An understanding of the elements of scientific methods and facility in their use.

3. Possession of scientific attitudes.

Isenbarger (57, p. 93-94) identified the contributions of biology as:

1. The understanding and ability to use in everyday life the major principles and concepts of science as they apply to the living world.

2. The ability and desire to use the scientific method in solving problems of life.

3. Certain emotionalized habits such as appreciation of nature and of science, interest in biological environment, and 'scientific attitudes'.

In *Science in General Education* McGrath stated (70, p. 9) that to show what science is like, what scientific procedure is like, and what scientists are like are the most important things we can expect from a science course. He also believed (70, p. 7) we should
encourage a scientific attitude and critical thinking in general life.

Hurd (55, p. 212) analyzed 1,373 science articles from 1901-1951 for the educational concepts of secondary school science teachers. He found the objectives since 1930 had moved toward:

1. Training students in the scientific method of thinking.

2. Developing certain scientific attitudes within the student.

3. Developing an appreciation of the contribution of science to society.

4. Aiding the student to discover a vocational interest.

The Southeastern Conference on Biology Teaching held during the summer of 1954, was attended by 85 high school and college teachers. These included high school biology teachers, college biology teachers, science education specialists, and administrators from colleges, public schools, and state departments of education. The following goals for teaching secondary school biology were suggested (19, p. 36):

1. An understanding of the basic principles of biology....

2. An understanding of themselves and of the human life cycle.

3. An understanding of how the organisms and physical environment in a given situation form a community with many complex interrelationships.
4. An understanding of how biology can be used in later life.

5. An understanding of scientific methods and attitudes through experiences in the biology course.

6. A positive approach to physical and mental health.

7. Avocational interests and appreciations related to living things.

The Science Section of the Evaluative Criteria used in secondary school evaluations indicated that emphasis in science should be upon (79, p. 209):

1. The importance of major scientific principles and their discovery, understanding, and application.

2. The development of competence in the use of the methods of science.

3. The development of desirable attitudes, interests, and appreciations related to science and its applications.

4. The recognition of, and preparation for, the role of science in the evolving atomic and space age.

Summary. Learning has been defined as a change in the student's ways of thinking, feeling, and acting (47, p. 386). Biological science education is, thus, a system of learning experiences designed to bring about desired changes in student behavior. While there is not agreement on all objectives of biological science education, general consensus as indicated in the literature supports
that a student should:

1. Demonstrate increased knowledge and understanding of basic biological facts, concepts, and principles.

2. Show improvement in his ability to apply the methods of science.

3. Show evidence of improvement in his ability to think critically.

4. Demonstrate attitudes which indicate an improved understanding of the nature of science.

5. Demonstrate an improvement in his concept of the scientist and of scientific careers.

**Outcomes**

The five objectives summarized in the previous section provide guidelines for biological science education. Studies which have investigated the attainment of these objectives are reviewed in this section.

**Facts, concepts, and principles.** The desired outcomes of biological science education included developing knowledge and understanding of biological facts, concepts, and principles.

Cognitive changes in learners are those which most teachers attempt to evaluate in their own tests of progress and in their final examinations. These are also the changes which are usually
emphasized in the materials of instruction, in the interaction between teachers and learners, and in the reward system which teachers and the schools employ (47, p. 379).

Several investigations of biology teaching have employed gain in knowledge as a criterion.

Jacobs and Bollenbacher (58, p. 399-405) investigated the learning outcomes of a full year of biological instruction by live television in Cincinnati. They reported knowledge gained in biology as one criterion of learning. The Cooperative Biology Test, Form X was used as a pre-test and Form Y was used as a post-test. The mean raw score on the pre-test was 46.7 and the mean raw score on the post-test was 58.1. The maximum possible raw score on the instrument was 89.

Anderson, Montgomery, Smith, and Anderson (6, p. 43-54) conducted a study in 1956 utilizing the Nelson Biology Test, Forms Am and Bm, as a criterion of learning. In a second investigation by Smith and Anderson (106, p. 34-37) a mean pre-test score of 31.6 on the Nelson Biology Test, Form Am, and a mean post-test raw score of 35.4 on the Nelson Biology Test, Form Bm were reported. The maximum raw score on the Nelson Test was 75 points.

Johnson (22, p. 260) utilized achievement tests in biology to determine loss of facts after three months. He reported a loss of
43.4 percent. Analysis of studies by Tyler (47, p. 392) and Wert (116) tend to support Johnson's findings, that facts are forgotten rapidly. Their studies also indicated that principles are retained over a longer period of time.

The high pre-test mean scores appear to indicate that students possess much of the knowledge which is tested by standardized achievement tests prior to instruction in the formal biology class. The mean gains which are reported are but a small percentage of the original means for total classes. It is possible much of the knowledge which is presented is repetitious of previously learned facts. It is also possible that new knowledge is presented as isolated facts, rather than principles and concepts and, therefore, not retained. The study by Smith and Anderson (106) revealed classes taught by a principles approach showed a significant gain compared to classes taught by a conventional approach.

Method investigations by Weismann (55), Owens (95), Crall (28), H. Taylor (110), Oliver (89), and Kastrinos (60) utilized facts and principles as a criterion of learning. Summaries of these studies are on pages 63-69.

Methods of science. Another important outcome of the biology
class should be an improvement in the student's scientific attitudes and his skill in applying the methods of science. Curtis (31, p. 816-819) developed a list of the elements of the scientific method which were distinct from scientific attitudes. Crowell (29, p. 525-531) listed attitudes and skills which were essential to the scientific method. Noll (86, p. 145-154) presented scientific attitudes which were deemed most important from an analysis of the literature. In a later study Keeslar (61, p. 212-216) clearly identified elements of the methods of science.

Evidence has been presented by several researchers that scientific attitudes and methods can be taught. Caldwell and Lundeen (24, p. 246-266) noted that high school students possess many unfounded beliefs about science. They found that specific instruction directed toward the correction of unfounded beliefs resulted in more desirable attitudes. Permanence of the changed attitudes was not determined. The investigators felt that many science misconceptions exist simply because there has not been instruction that would inform pupils otherwise. Lampkin (68, p. 26) reported a thorough knowledge of a field of subject matter is conducive to the formation of useful hypotheses in a field. Dressel et al. (82, p. 47-48) reviewed several studies which indicated that scientific methods and attitudes are developed more adequately by direct teaching than by
incidental learning. Noll (87, p. 28) concluded from a study that instruction in scientific attitudes is retained to a considerable extent for some time after the instruction has been given. He also found evidence of a positive correlation between brightness quotients and scientific attitudes.

While the teaching for the methods of science is frequently listed as an objective, several science educators have not found teaching guided toward this goal. Richardson (99, p. 251) stated, "The 'scientific method' is a goal of science teaching which exemplifies a whole series of objectives to which lip service is paid, but which are too often otherwise ignored." Hurd (55, p. 181-182) noted:

...Although teaching of the "scientific method" typically ranks first as an objective of biology teaching, teaching practices that might accomplish this goal are seldom found. Textbooks frequently contain an introductory chapter describing the methods of biology, but afterwards little reference is made to the topic. Studies on testing and evaluation fail to show that growth in the ability "to solve problems scientifically" receives serious consideration when teachers judge student achievement. On the other hand, to assume that the objectives of science teaching can be achieved from unstructured teaching as a concomitant result of learning the facts of the science does not seem to be supported by psychological research or the intuitive judgment of research scientists.

Progress in this area of learning appears to be slow. Barnard (11, p. 178-183) and Mills and Dean (76) are among those
who have published suggestions for teaching students the attitudes and methods of science.

Critical thinking. Critical thinking has been listed with increasing frequency as an important objective of science education. Richardson (98, p. 8-9), Burnett (22, p. 20-24) Barnard (10, p. 110), Mills and Dean (76, p. 10) and Dressel and Mayhew (39, p. 273) have indicated that students in secondary school science classes should gain attitudes and skills to enable them to effectively solve problems.

Burton, Kimball, and Wing (23, p. 256) have indicated that abstract and inductive reasoning capabilities mature most rapidly during adolescence. Students in the secondary schools are, thus, able to profit from experiences designed to improve these important abilities.

Burton, Kimball, and Wing (23, p. 243) also reported that knowledge of a field does not assure that the information will be properly applied. They stated:

Even though academic skills are necessary, they are not sufficient. A wide variety of studies by Burack, Burack and Moos, Bloom and Broder, Duncker, Horrocks, Maier, and Maltzman and others have established clearly that knowledge of the principles in a particular field of knowledge in no way assures that these principles will be properly applied in problem solving situations.
Several factors have been found to be correlated with problem-solving ability or critical thinking skills. Alpern (3, p. 220-229) found that the ability of high school students to devise or choose tests of scientific hypotheses correlated with I.Q. Teichman (112, p. 268-279) in a study of high school students also reported intelligence was related to the ability to reach conclusions on science items. The Watson-Glaser Critical Thinking Appraisal has been found to be correlated to several standardized intelligence tests between .48 and .68 (114, p. 10)(50, p. 6).

Understanding the content and procedures in a particular field is necessary for problem-solving. Exhaustive reviews of pertinent research by Kimball and Wing (23, p. 244-245) indicated that desirable experiential factors and knowledge of procedural factors are related to the development of critical thinking. Dressel et al. (82, p. 52) reviewed several studies and determined that success in science showed high correlation with verbal reasoning, numerical ability, and certain aspects of language usage. Critical thinking, or general reasoning would appear to be an essential objective of biology teaching. Investigations have indicated in most instances that critical thinking can be directly taught.

Method studies by Weismann (55), Mason (74), Kastrinos (60), T. Edwards (42), Aylesworth (8), Dressel and Mayhew (39),
and Wellington and Wellington (115) which relate to critical thinking are reviewed on pages 63-66.

Attitudes toward science and scientific careers. The development of constructive attitudes and an intelligent point of view toward science, scientists, and scientific careers is becoming an increasingly more important goal of science education. A number of investigations related to this study have recently been conducted to determine present attitudes and outcomes of educational experiences.

Allen (1, p. 2) conducted an investigation in 1957 to determine: if high school seniors had positive attitudes toward science and the scientific endeavor; if high school seniors who chose scientific careers possessed more positive attitudes toward science than those choosing other careers; if the intelligence of the student were related to his attitudes; and if there were a difference in attitudes between high ability students who planned careers in science and engineering and those who planned careers in other areas.

A 95-item reaction inventory was developed and submitted to the students. Implied in all phases of the study was the notion that attitudes favorable to science could be identified. Several scientists and professors of science served as a jury of experts to determine the positiveness or negativeness of the statements. The correlations of the judge's scores were reported to be high
From the analysis of the data Allen concluded that the high school seniors taken as a total group had positive and constructive attitudes toward science. The item analysis, however, indicated that on many important statements related to the image of science and scientists there was lack of understanding or possible ignorance on the part of a substantial number of the seniors responding to the issues and problems. Items bearing on the scientist and his work and the nature of science were areas which indicated the most misunderstanding (1, p. 19). Further analysis indicated that there was a relationship between intelligence and favorable, constructive attitudes toward scientists and the scientific enterprise (1, p. 26).

In his conclusions and recommendations Allen indicated that perhaps the most important area of need disclosed in the study was the evident misunderstanding and ignorance of the nature of science. He also observed that a clear need existed to introduce into the science program materials on the sociology of science. He concluded that the teacher was in a key position to help students gain a constructive understanding of the scientific endeavor and that his training should include ample opportunity to study science as a vital social enterprise. He stated (1, p. 38-40), "Vital as it is, competence in the subject matter of organized science is no longer enough."
Allen (2) conducted a follow-up investigation in 1959 with groups of students investigated in the previous study. The reaction inventory utilized in this study contained 29 statements which discriminated at either the .01 or the .05 confidence levels between the high intelligence group choosing science careers and high intelligence students choosing non-science careers in the 1957 study (2, p. 41-42).

Questionnaires were sent to a sample of 127 individuals who had indicated in the 1957 study that they had not chosen and were not interested in a career in science. None of the 64 who responded had changed to a scientific career, indicating that individuals in this category are unlikely to change in favor of a career in the scientific enterprise (2, p. 31).

Allen found that attitudes had changed considerably during the two year period on several items. It was found that there was more agreement with the responses expected by the judges on ten items pertaining to the scientist and his work and the nature of the scientific enterprise. It was presumed that college experiences affected the 1959 responses (2, p. 47).

Belt (15, p. 3625) studied the attitudes toward science and scientists of 516 college bound seniors in 12 New Jersey high schools. His analyses indicated that the students generally had
positive attitudes, and that high ability students had more favorable attitudes toward science and scientists than did a representative cross-section of high school seniors.

Mead and Metraux (9, p. 230-246) conducted an investigation with 35,000 students in 120 high schools to determine student attitudes toward science and scientists. The image of the scientist was found to be very positive when no personal career involvement of the student was mentioned. However, when the question of a personal career choice or a choice of a husband was involved, the image was overwhelmingly negative (9, p. 230-231). The results of the investigation indicated there was a lack of delight for intellectual activity. The study suggested the importance of participation as opposed to passive watching in class activities and the role which the personality of the teacher plays in attitudes toward science.

Investigations by Withey (9, p. 153-159) and Beardslee and O'Dowd (9, p. 247-258) also indicated that the knowledge of the scientific enterprise and the attitudes toward science and scientists of adults and students were less than desirable.

Frances Behnke (13) conducted an investigation concerning the opinions of a selected group of high school science teachers and scientists on some issues related to science and science
teaching. She stated (13, p. 2):

The importance of the study rests on the assumption that the opinions and attitudes of science teachers toward science and its relation to American life directly and significantly influence the quality of science teaching.

It may well be that disclosures of recent studies on the disturbing attitudes of young people toward science can be traced in part to the science classroom.

The investigation examined the attitudes of the scientists and the teachers to statements concerned with four areas. These included (1) the nature of science; (2) science and society; (3) the scientist and society; and (4) the teaching of science. Analyses were conducted to compare the responses of the scientists and the teachers and subgroups of teachers.

When the number of semester hours of science was studied as a variable, it was found that teachers with more credits were closer to scientists especially on statements pertaining to the nature of science. However, the differences among the teachers were not as evident as might be expected (13, p. 47-48).

Teachers with 0-5 years teaching experience were also compared to those who had taught 20 or more years. Those who had taught 20 or more years were found to have attitudes which were closer to those of the scientists (14, p. 204).
The section dealing with the nature of science provided the most discrimination between groups, though there were several statements in other sections which elicited less than desirable responses. It was interesting to note that over 50 percent of the teachers did not think the findings of science were tentative (13, p. 57).

Evidence indicates that many students do not develop desirable concepts of science and the scientific enterprise. Lack of sufficient scientific manpower and a low level of scientific literacy among many citizens in the United States is of real concern.

Klopfer (65, p. 8-15) recently published a report of The History of Science Cases for High Schools study which indicated that students taught by this technique made excellent gains in understanding of science and scientists compared to students taught entirely by conventional methods. The instrument utilized as a criterion of growth was the Test on Understanding Science. Dressel and Mayhew support the conclusion of Klopfer's report; they state (39, p. 241) generally low correlations between attitude tests and more cognitive ones suggest that attitudes and knowledge or thinking about the same matters can develop quite independently of each other.

Research studies suggest that attitudes need to be taught deliberately and not left to incidental experiences. Teachers' attitudes
may also be of significance as noted by Behnke (13), Richardson (99, p. 250), and Allen (1, p. 40).

**TEACHER FACTORS**

Many investigations have been conducted which analyze one or more teacher factors believed to relate to pupil behavior and pupil learning. Barr (12, p. 203-283) in a summary of investigations dealing with measuring and predicting teacher efficiency lists 150 major research studies; Domas and Tiedeman (35, p. 99-218) list 1,006 articles and research studies relating to this problem; and Getzels and Jackson (47, p. 506-582) list about 150 publications and research studies related to teacher characteristics.

**Identification of Teacher Factors**

Anderson (5) conducted one of the first statistical studies in science education to determine the factors inherent in the pupil and in the teaching situation which related to the achievement of learning objectives by pupils. Anderson investigated these factors in high school biology and chemistry classes. Four outcomes of science teaching used as criteria by Anderson were the learning of facts, principles, the scientific methods, and scientific attitudes (5, p. 3).

Anderson conducted the investigation in 56 high schools in Minnesota during the 1946-1947 school year. Careful attention was
given to selecting a representative sample from population centers of under 5,000 persons, 5,000 or more persons, and from large cities. It was found that 87 percent of the high schools were in category one, eight percent in category two, and five percent in category three. Sample schools were selected by use of a random number table (5, p. 29-32).

The students were pre-tested utilizing the Otis Mental Ability Test and state examinations in biology and chemistry developed by Anderson. Post-tests also utilized state examinations designed by Anderson (5, p. 33).

The teachers completed a test which sampled their understanding of the scientific method, and a questionnaire which requested information on the teacher's background, teaching practices and methods, and teaching responsibilities (5, p. 33).

Data from the teacher schedule indicated that the median enrollment in biology classes was 23 students. Biology classes were taught by teachers with a median of 27 quarter hours of preparation in biology and a total of 51 quarter hours of science in all areas. The teachers reported a median of 4.2 years experience teaching biology (5, p. 36-37).

A large percentage of the teachers reported using the science laboratory. One of the major functions of the laboratory was to develop an understanding and to use the scientific method (5, p. 39-40).

Demonstrations were used by most of the biology teachers. The
demonstration was indicated as one of the major procedures utilized to develop an understanding of scientific principles; however, Anderson reported that developing an understanding of scientific principles appeared to be an incidental outcome (5, p. 42).

A list of procedures utilized by the teachers to habituate the students to scientific attitudes revealed that few teachers consciously planned for this outcome. Laboratory experiences and discussions were among the main procedures reported by teachers (5, p. 43).

An analysis of the teacher schedule also indicated that most of the teachers did not plan for procedures to develop the ability to use the scientific method. Procedures utilized were the laboratory and discussion (5, p. 39-40).

An analysis was conducted on those teachers placing in the upper quarter and the lower quarter on the items of the teacher schedule to investigate the relationship of teacher factors to learning outcomes. An analysis was also conducted to determine the effect of school size on learning outcomes. Pupils in the three different classifications of schools according to school size did not differ in achievement in biology (5, p. 115).

F tests were determined holding the I.Q. score and pre-test score constant. There was no significant difference in achievement by students in classes comparing the following factors:

1. Teachers with six preparations compared to those with one
and two preparations (5, p. 116).

2. Teachers in the upper fourth of quarter hours of preparation in biology (46 or more hours) compared to those in the lower quarter (16 or fewer hours) (5, p. 117).

3. Teachers scoring in the upper quarter on the scientific method test compared to those scoring in the lower quarter (5, p. 122).

A greater achievement by the students in biology was indicated when (5, p. 158):

1. The teacher was in the upper quarter in terms of quarter hours of all sciences (77 or more hours) compared to the teacher in the lower quarter (32 hours or less).

2. Students were in classes receiving 60 or more hours of laboratory per year compared to those receiving 12 or less per year.

3. The teacher was granted an undergraduate degree by a private college compared to a state university or a teachers' college.

4. The teacher possessed a master's degree compared to those with no master's degree.

5. The students were in classes of 29 or more compared to those of 17 or less.
Brandwein (17, p. 66) studied the characteristics of 82 teachers in junior and senior high schools who were successful in stimulating youngsters to enter science.

The teachers studied generally had students in one of the following groups (17, p. 65):

1. Youngsters who were taking the Science Talent Search.

2. In junior high school, regular entry of one or more students with prize winning projects in three or more science fairs.

3. A national reputation including two or more winners in the Westinghouse Talent Search.

4. Reputation among colleagues and former students outside of school; that is frequent mention by others of success in stimulating students to enter science.

The following items were among those which were characteristic of the successful teachers (17, p. 66-67):

1. More than 90 percent of the 82 (65 men, 17 women) had a Master's Degree in Science, in addition to the requisite work in education. They were exceptionally well versed in the subject matter of science.

2. More than 90 percent of the 82 had published at least one paper in science or education.

3. All but one had been an officer in a local or national organization of teachers.

4. All had, at one time or another, been members of a committee to formulate courses of study or a curriculum in the school district in which they taught.
5. The average age of the 82 was 40 years (plus or minus two).

Brandwein's study indicated that certain teachers are much more successful in kindling science interest than others. He identified three factors related to successful teachers of students with science potential: high training in science, opportunity to teach, and successful relations with children in a teaching situation (17, p. 68).

Shannon (105, p. 168-176) conducted a study of 782 elementary and secondary school teachers. The teachers selected included 430 "best" teachers and 352 "worst" teachers. Elements of merit which were found to contribute most to teaching success were teaching skill, personality, teacher-pupil relations, and knowledge of the subject for secondary teachers.

Reed (97, p. 205-229) conducted a study to identify selected behaviors that related to desirable pupil learning. Pupil gains in learning were identified as the most valid criteria of teacher competence. The objectives were measured by subject matter tests and an evaluation of student attitudes and interest.

The analysis of this study indicated the following generalizations:

1. There is a positive relationship between teacher warmth, defined as relaxing interpersonal tension, and pupil
interest in science (97, p. 206).

2. Moderate demand is most effective (97, p. 206).

3. Training in use of intrinsic motivation may be more successful if the student already possesses the attributes of warmth or can be helped to acquire them (97, p. 227).

T. Taylor (111, p. 2943-44) sought to determine the relationships between growth in interest and achievement of high school science students and science teachers' attitudes, preparation, and experience. The researcher reported that none of the four teacher factors measured - teacher attitude, professional education, science courses, and teaching experience - produced a significant relationship. The composite of the four factors was significant at the five percent level. Taylor suggested a study of the interaction of one or more factors might show a relationship.

Van Allenstein (113, p. 4288) studied the effectiveness of high school teachers related to two behavior aspects, technical competence and warmth. The purpose was to determine which aspect accounted for the greater variation in teaching effectiveness. Van Allenstein's criterion of teacher effectiveness was the extent to which pupils became involved in subject matter of the class. Technical competence included subject matter knowledge, communication,
demand, and management. Teacher warmth was determined by evaluation of teacher-pupil relationships.

Results of the study indicated that the greater the technical competence or warmth, the greater the efficiency. Highest efficiency was associated with those who were highest in both. While not significant at the five percent level, it was found that teachers high in technical competence and low in warmth were more effective than teachers low in technical ability and high in warmth (113, p. 4288).

Hansen (54, p. 2717-18) conducted a study in 1961 to make a comparison of science programs in Iowa secondary schools ranking high and low in science achievement. The problem was to isolate and describe differences that existed between science programs of two groups of schools differing markedly in growth during the first three years of high school as measured by science sub-tests of Iowa Tests of Educational Development. School size was not directly related to the differences in achievement (54, p. 2717).

Characteristics of teachers in high groups compared to teachers in low groups indicated the following patterns (54, p. 2718):

1. They were less experienced.

2. They had served for a shorter period of time at the sample school.
3. They had participated in institutes.

4. The teachers belonged to professional organizations.

Neivert (88, p. 386) investigated the problems of identifying secondary students with science potential and of determining what factors were responsible for their selecting science as a career. He concluded necessary factors were: high intelligence, opportunities for development, and personal attributes. He further concluded that the science teacher was the single most important factor in the school environment conducive to the development of science students with high potential.

The Teacher Characteristics Study which was directed by Ryans (102) for the American Council on Education investigated teacher behavior dimensions. During the study approximately 100 separate research projects were conducted, and more than 6,000 teachers in 1,700 schools and about 450 school systems participated in the investigation.

The purposes of the study were to develop a better understanding of teacher characteristics and associated conditions; and to improve professional courses, selection of teacher candidates, and curricula (102, p. 11). Ryans based his study on the theoretical construct that teacher behavior is a function of situational factors and characteristics of the individual teacher.
Three patterns of teacher behavior stood out from separate factor analyses of observational data (47, p. 567):

1. **Pattern X** - warm, understanding friendly vs. aloof, egocentric, restricted teacher behavior.

2. **Pattern Y** - responsible, businesslike, systematic vs. unplanned, slipshod, evading teacher behavior.

3. **Pattern Z** - stimulating, imaginative, surgent vs. dull routine teacher behavior.

From the analyses of data obtained by observers and from scores on the Teacher Characteristic Schedule, several personal qualities were identified which appeared to distinguish teachers selected to be "high" from teachers selected to be "low" with respect to overall classroom behavior. The "high" group (compared with the "low" group)(102, p. 361):

1. Indicated greater enjoyment of pupil relationships (i.e., more favorable pupil opinions).

2. Indicated greater preference for nondirective classroom procedures.

3. Is superior in verbal intelligence.

4. Is more satisfactory with regard to emotional adjustment.

Davis (33) conducted a study to determine "Factors of Effectiveness in Science Teaching and Their Application to the Teaching of Science in Ohio's Public Secondary Schools". His research was
concerned with several problems which included the following (34, p. 15):

1. What factors are related to the effectiveness of a learning situation in secondary science?

2. What evidence exists that "factor" effectiveness of a teacher is actually related to overall effectiveness?

A list of factors of effectiveness related to science teaching was developed by submitting a preliminary list of factors to all members of the National Association for Research in Teaching, to a selected sample of the National Science Teachers Association, and to random samples of the American Association of School Administrators and the National Association of Secondary School Principals (34, p. 15).

A final list of 17 factors was selected. Included among the factors were the following (33, p. 151-152):

1. Other factors being equal, effective learning is more likely to occur when the teacher has a broad background of knowledge in the particular science he is teaching as well as in related areas.

2. Other factors being equal, effective learning is more likely to occur when the teacher has a functional knowledge of how children develop and learning takes place.

3. Other factors being equal, effective learning is more likely to occur if the teacher knows about, understands, and uses a variety of methods of instruction as opposed to exclusive use of one or two methods.
4. Other factors being equal, learning will proceed more effectively when the teacher is skilled in the use of classroom aids and devices, when he is familiar with, has accumulated and uses teaching materials of various kinds, and when he knows about and uses sources of information beyond the single text.

5. Other factors being equal, learning will proceed more effectively when the teacher has established rapport with the learners and when the learners believe that the teacher is well informed and effective.

6. Other factors being equal, learning will proceed more effectively when considerable attention is given to problem solving, development of critical thinking, and science attitudes.

These factors stressed the importance of variations in the teacher's personality, the relationship between teachers and pupils, the amount and type of training and experience, and factors related to conditions for teaching.

Questionnaires were mailed to 928 teachers; 539 were returned (33, p. 464). A detailed study was also conducted with 40 teachers selected as outstanding in effectiveness. Davis' findings included the following inferences:

1. Most science teachers rated as excellent were declared excellent in subject matter (33, p. 634).

2. Competence in methodology appears to be closely related to competence in teaching (33, p. 641).
3. Rapport with students is directly related to teaching effectiveness (33, p. 653).

Davis (33, p. 152) concluded that the summation of a teacher's effectiveness may be greater than the average of his effectiveness as judged by reference to a series of factors. Particular strengths or weaknesses in any one of the more "intangible" factors such as pupil-teacher rapport may overcome contrary ratings on other more tangible factors.

H. Grobman (53) conducted an evaluation of student learning with BSCS biology materials versus traditional materials during the 1961-1962 school year. The study was based on an experimental population of 269 teachers and 20,453 students and a control of 136 teachers and 3,944 students (53, p. 3). Participating schools were drawn from cities of primarily over 25,000 population. Sixty-three schools were in cities of 25,000 or over; 34 in communities of 2,500 to 25,000; and three in communities of less than 2,500 (53, p. 6).

Instruments used in the evaluation were the School and College Ability Test, Test on Understanding Science, BSCS Comprehensive Achievement Test, BSCS Impact Test, the Cooperative Biology Test, and Ten Semantic Differential Concepts (53, p. 4).

Variables which were investigated included grouping, laboratory facilities, class size, size of school, student time, teaching
load, salary of the teacher, percent of students going to college, and the teacher's experience and academic background (53, p. 4).

The analyses of the data indicated the following results (53, p. 4):

1. The BSCS materials are not intended for and are not suitable for use with the lowest 20 percent who take high school biology.

2. BSCS students scored significantly higher on the BSCS Comprehensive Examination than did the control.

3. The control group scored higher on the Cooperative Biology Test.

4. Test scores on the Impact Test yielded small differences, but favored the control group.

5. Data on the Test on Understanding Science was inconclusive and was being subjected to further analysis.

6. Boys outscores girls on both the Cooperative Test and the BSCS Comprehensive Examination.

The variables were analyzed by a 2x2 chi square table; teacher mean scores were adjusted for School and College Abilities Test scores and sex of students (53, p. 5).

Student achievement on the BSCS Comprehensive Test was significantly related at the one percent level of significance to teacher
salary, percent of students in the graduating class going to college, and class size. Student achievement was related to laboratory facilities at the three percent level of significance (53, p. 6).

Jones (59, p. 85-99) in a study of 65 teachers in 15 subject areas attempted to predict teaching efficiency from objective measures. Supervisory ratings and pupil gain scores were utilized as criterion of efficiency. Teaching experience was found to have a -.07 correlation with supervisor ratings and .04 with pupil gain.

Previous studies cited by Anderson (5), Brandwein (17), Ryans (102), and H. Grobman (53) also reported consideration of age and experience factors in relation to the teaching-learning situation.

Several investigations have indicated certain teachers are more effective in influencing students and guiding learning than their colleagues.

Knapp and Goodrich (25, p. 21) asked a group of scientists to identify the factor which had been most important in their career decisions. For those who had graduated prior to 1918, 13 percent indicated a high school teacher had been the most important factor. The same was true for 19 percent graduated since 1934.

In a similar study by Visher (109, p. 42), scientists were asked to indicate individuals who had exerted a personal influence
on their choice of a career. High school teachers were identified by 16 percent, college teachers by 42 percent, father by 15 percent, and other relatives by ten percent.

MacCurdy (109, p. 42) and Brandwein (109, p. 42) also reported evidence that science interests and careers were strongly motivated by specific science teachers.

In a review of work in this area Cole stated (25, p. 21):

Perhaps the most important source of encouragement to future scientists is the teacher. More than anyone else, the teacher is in a position to stimulate a youngster with scientific talent and to direct his thinking towards a scientific or engineering career. Scientists have consistently pointed out the crucial role which their own teachers played in helping to shape their career decisions.

Super and Bachrach (109, p. 42) surveyed key persons and experiences which influenced scientists; they concluded that we need to know how these factors operate.

Academic Preparation

The desirable academic preparation for science teachers and biology teachers, in particular, has been an area of much discussion and some research. Federal and private funds have supported educational programs for improving the subject matter foundation of the science teachers. The American Association for the
Advancement of Science recently considered the various science fields and recommended a desired preparation for biology teachers. Researchers have investigated the status of the preparation of biology teachers, and a few studies have been conducted to determine the relationship of academic preparation to teacher competence.

The Committee on the Teaching of Biology of the Union of American Biological Societies sponsored a study by Riddle and others in 1942 (100). The sample included 31 replies from teachers in Oregon. These teachers were teaching in schools enrolling 3,518 pupils, or 26.8 percent of the total state enrollment during that school year (100, p. 18). The sampling throughout the country was relatively concentrated in cities above 10,000 in population and was low in the rural areas (100, p. 27).

The summary yielded the following conclusions (100, p. 36):

1. The average secondary school teacher of the sample had about 37 semester hours of preparation in biology courses, including both graduate and undergraduate levels.

2. The teachers wanted more subject matter courses in their training programs, but with the provision they be functional.

3. The teachers suggested a need for better special methods
courses. They especially desired improved training in laboratory and demonstration techniques and courses in observation and practice teaching that really function.

Several researchers have determined the subject matter preparation of biology teachers in different content areas.

Koelsche studied 143 part time and 97 full time teachers of biology in 175 high schools in Ohio to determine their academic and teaching backgrounds (67, p. 136). His analysis included the following findings:

1. The median semester hours of biology teachers in combined science areas was 33.

2. The median semester hours in biology was 24. Ten percent of the teachers had ten semester hours or less.

3. Fifty-one percent of the biology teachers had earned some credits in chemistry. The median number of semester hours for those who had obtained credits was 13.

4. Physics was included in the background of 32 percent of the instructors teaching biology. The median number of credits earned was nine.

5. Geology was included in the background of 16.7 percent
of the teachers. The median number of credits earned was four (67, p. 137).

Gardner and Richardson (48, p. 69) also obtained data on science teachers in Ohio. Their data indicated five percent of the biology teachers had no semester hours of college biology; nine percent had 1-14 hours; and 44 percent had 15-30 hours. They concluded (48, p. 69) that a majority of the teachers did not have the desirable academic background for their teaching area.

Finkel (45, p. 153-157) studied factors which affected the high school student's choice regarding a science career. There were a large number of teachers who were teaching a science class, not their specialty. Others were without an undergraduate minor in the science they taught; few had taken graduate work in their area of teaching, but had taken work in professional education (45, p. 154).

The analysis also indicated that the students were aware of several problems: (1) They felt the teacher was unprepared, and (2) one-third of the students had at one time considered science as a career, but had since changed (45, p. 154).

Finkel indicated (45, p. 157) that the analysis of his study revealed that most young people find things related to science of interest in their formative years. Somewhere in their later experience, this interest often wanes. The cause lies somewhere in the school, in the preparation of teachers, in the psychology of
teaching, in the facilities of the school plant, and/or in the guidance and motivation received by the students.

The National Association for the Advancement of Science and the National Association for Teacher Education and Certification conducted a national survey in 1960-1961 of the characteristics and service loads of mathematics and science teachers for the National Science Foundation. A questionnaire was mailed to a stratified random sample of 3,957 teachers; 3,012 usable questionnaires were returned within the allotted time. A sample of those who did not respond was also investigated (78, p. 1).

The survey indicated (78, p. 5) that many of the teachers were teaching in divergent areas. Sixteen percent of the teachers were teaching one or more science classes, 28 percent three or four science classes, and 56 percent five or more classes.

The sample included 562 teachers who taught one or more classes of biology (78, p. 1). The most common teaching assignments for these teachers were biology and general science or biology and chemistry (78, p. 6).

A great variance in teacher preparation was indicated. Eleven percent of the biology teachers had completed nine or fewer semester hours; 16 percent had completed 9-17 semester hours; 22 percent had completed 18-29 hours; and 51 percent had completed 30
or more hours. Biology teachers were the best prepared science teachers in terms of hours of preparation. For teachers preparing to teach two or more science subjects, the AAAS recommendations suggest 18 hours in each field during the undergraduate program. By these standards, it would appear that 73 percent of the biology teachers had met that standard (78, p. 8).

Several important conclusions were developed from an analysis of the data (78, p. 10):

1. There is often little opportunity for science teachers to specialize due to multiple teaching assignments.

2. There are many teachers with academic backgrounds which would indicate they would benefit from NSF or conventional graduate programs.

3. There are teachers with some hours of preparation of science not prepared for conventional graduate courses who need new programs developed for them.

Pella (96, p. 115-122), Winier (119), and others have also reported data on the academic preparation of biology teachers. Their findings tend to agree closely with the previously cited research findings.

As a result of studies and surveys such as those cited, considerable effort has been expended to improve the preparation of
biology teachers by developing lists of recommended course work, increasing certification requirements, and providing financial assistance for teacher education through federal and private support.

Noll presented a summary of course work recommended for biology teachers. From Noll's point of view a desirable program for a biology teacher would have included (87, p. 210-211):

1. An orientation course in the field of natural science--6 semester hours.
2. A major in .... biology--18 semester hours.
3. Two minors--12 semester hours each. (These to be in two sciences not selected for the major).
4. General psychology plus professional courses--15 semester hours.
5. Practice teaching--6 semester hours.
6. Mathematics--6 semester hours.
7. English--at least 12 semester hours.
8. Social Science--at least 6 semester hours.

A report in 1959 of the sub-committee on teacher certification of the Cooperative Committee on the Teaching of Science and Mathematics of the American Association for the Advancement of Science provided recommendations for the academic preparation of biology teachers (78, p. iv). The committee stated (49, p. 283) that one-half of the student's 120 semester hours undergraduate program
should be in science; the other half should be free for the humanities, social science, and professional education courses. Need for science education in both breadth and depth was stressed by the committee.

A four year total of 59 semester hours was recommended. This included 30 hours in biology, 12 hours of chemistry, eight hours of physics, three hours of earth science, and six hours of mathematics (49, p. 284).

The course work in biology included ten hours in the principles of biology, eight hours of plant and animal physiology and anatomy, four hours of ecology and conservation, five hours of developmental anatomy and genetics, and four hours in the preparation and use of biological materials. Additional course work in biology was also recommended in the fifth year (49, p. 284).

Recommendations by the AAAS provide a general suggested list of areas to include in the undergraduate preparation of the biology teacher. From an analysis of state certification requirements (7), these recommendations were above those of most states.

Some states have increased their certification requirements in the last few years. New basic and standard norms for biology teachers will become effective in Oregon on July 1, 1965. The basic norm will require 36 quarter hours in the biological sciences
including preparation in general biology, anatomy, physiology, developmental biology, genetics, evolution, and ecology. The standard norm (five year norm) will require 54 quarter hours in science including the 36 hours required for the four year norm in the science area to which the teacher is assigned (90, p. 10).

Colleges and universities have organized new programs for teacher education. Due to diversified teaching assignments, broad extensive preparation is being required for majors in several institutions. Summer research assistantships are also available to enable the science teacher to gain research experience and knowledge.

Innovations in master's degree requirements have been established to provide increased subject matter preparation for science teachers with varying needs. Special courses have been designed for science teachers which may apply toward a master's degree. Programs leading to the master's degree have been designed in connection with Academic Year Institutes. Other new degree plans have included a Master's in Basic Science which allows the teacher to gain breadth and depth in undergraduate science courses. The master's degree in science education, combining equal study in science content and professional education areas, has also evolved to increase the competency of the teacher.
Several investigators have previously investigated the relationship of hours of preparation to student gain in factual understanding. The question may be further extended to see if hours of preparation are significantly related to several of the basic outcomes of biology teaching and if specific suggested course backgrounds are more significantly related to student gain than accumulated hours. Previous studies which have correlated hours versus gain have found no significant difference beyond 18 hours preparation in a science area. If selected preparation is more significantly related to student gains, this would give further direction to science educators, school administrators, and state departments of education.

Summary

From the research investigations concerning teacher factors summarized, the following conclusions may be drawn:

1. The personality of the teacher influences the teaching-learning situation.

2. Teacher-pupil relationships have been found to be related to student achievement.

3. A number of biology teachers do not have extensive preparation for teaching biology.

4. Many biology teachers have extensive preparation in
biology, but not in other science areas.

5. There is a wide range in the scientific and professional preparation of the teachers.

6. The teacher's attitudes towards science are believed to have an influence on the student's learning.

7. Verbal intelligence has been found to be related to the teacher's total classroom behavior. The relationship of verbal intelligence, language usage, and critical thinking skills to teaching success is still not clear.

8. The significance of the teacher's age and teaching experience to teaching success is questionable.

9. Science teachers have influenced students to enter science and science related careers.

Several questions are suggested by the above generalizations. In what ways do these factors affect the learning of students in biology classes? Are certain teacher factors related to specific student outcomes in biology? What are the factors which influence teaching in biology which may be improved or provided in teacher education experiences? Which factors related to specific learning outcomes in biology could best be solved by administrative assignment?
TEACHING METHODS

Method grows out of the concept of the objectives and aims that are sought in any given learning experience. It should be based on research and consideration of reasons for teaching. As teachers and researchers have been concerned with the effects of the action of the teacher upon the pupils, investigations of this relationship have been conducted by both educators and psychologists.

Katona demonstrated (80, p. 436-437):

...that problem-solving which is based upon understanding is superior to problem-solving based upon memorization; second, that understanding is a matter of degree, that varying degrees of understanding affect problem-solving differently, and that the degree of understanding engendered is a function of the kind of instruction given; and third, that form of instruction which enables the learner to best organize his previous experiences or learnings is to be preferred to other kinds.

In a review of several investigations, Hurd noted that (55, p. 206):

Weissman used six high school classes as an experimental group and six other classes as a control. He found that with the proper methods students could be taught to interpret biological data and to think critically, but to obtain these results a course must be organized around problems and activities of a problem-solving nature. Pupils in the experimental class learned more facts and biological principles than the students taught in the conventional
manner. Weissman concluded that the direct teaching of interpretation of data is considerably more effective than teaching that regards this objective as merely concomitant.

William Kastrinos (60, p. 2251-2252) investigated the relationship of the textbook-recitation method versus the principles-critical thinking method of teaching high school biology students. One class was taught by each of the two techniques by the investigator. The Watson-Glaser Critical Thinking Appraisal was utilized as a post-test, and the Nelson Biology Test as a pre-test and post-test.

The results of Kastrinos' study indicated that critical thinking can be improved in one semester. A second finding was that the class taught by the textbook-recitation method did not exceed the principles-critical thinking group in any area tested.

Aylesworth (8, p. 370) compared the expressed attitudes of high school science teachers with their classroom methodology. Little disagreement was found between the teacher's responses of stated activity and observational data. Background and experience seemed to make little difference in the teacher's responses. Aylesworth deduced (8, p. 373) that Michigan science teachers who had had a number of science education courses did no better than those who had not. The teachers had evidently been taught the importance of problem-solving, but had not learned the techniques of
teaching this method directly.

T. Edwards studied the development of students' thinking ability in successive grades in school and found little improvement. He concluded (42, p. 271) we should study the experiences of the school child with a view to improving the rate at which he acquires skill in critical thinking.

In an experiment to improve critical thinking skills, Kemp (64, p. 322) found students with "open" belief systems progressed better than students with "closed" belief systems. He further concluded that improvement in critical thinking skills was accelerated by favorable conditions. These conditions included permissive small groups and directed instruction. An important implication of his study was that schools should be concerned with the development of individuals with open minds.

Mason conducted a study in the teaching of scientific thinking in biological science on the college level and developed the following conclusions (74, p. 283):

1. The telling method of teaching can be an effective method for teaching students factual information.

2. Ability to think scientifically can be a concomitant outcome of science instruction.

3. Ability to think scientifically can be taught more effectively when the students are given direct training in the methods of science than when they do not receive such training.
4. Scientific attitudes can be concomitant outcomes of science instruction.

5. Scientific attitudes can be taught more effectively when students are given direct practice in developing such attitudes.

6. Problem-solving can be an effective method for teaching both facts and skills inherent in the methods of science.

Wellington and Wellington (115, p. 136) reviewed studies which indicated that discussion is generally equal or superior to the lecture in securing retention and in stimulating critical thinking. They found that discussion also has a greater effect on attitude and contributes better to desirable classroom relations. They further observed that while these research findings justify the use of the discussion, further research is needed.

Dressel and Mayhew (39, p. 285) reported that teachers trying to modify their technique for the purpose of achieving better results in critical thinking achieved small differentials in gains over those taught by the customary approach. These gains were often smaller than those made by students of other teachers in classes where no special effort was made with respect to the objectives. They stated "...minor changes in techniques imposed upon a course wherein the major emphasis remains on coverage of content are inadequate as a solution to the problem."

In another publication, Dressel et al. (82, p. 41) reviewed
research in which some evidence indicated that for relatively easy material, the inductive method of deriving the concept out of many specific examples is adequate for difficult material. When the possibility of error in concept formation is great, a deductive approach in which the presentation of the concept is followed by extensive application is preferable. A combination of the two methods appears to be superior to either method alone. He further stated that the conclusions were tentative and required more research.

Downing (32, p. 92) investigated the length of time needed to teach certain principles of biology to the point of mastery under ordinary classroom conditions. It apparently takes about four weeks to develop a principle to the point that a student can make an application from it.

Owens (95, p. 53) studied the ability of students in experimental and control biology classes to recognize and to apply scientific principles to new situations. From statistical data he concluded (95, p. 58) better gains were made by classes provided with this instruction. The ability to apply scientific principles was also found to be related to mental ability.

Crall (28) conducted a controlled experiment with high school biology students. The experimental class was taught by a procedure which required the students to learn and apply important
principles. Written tests and observations were used to assess student growth. Both the control - a class taught by ordinary methods - and the experimental group made progress. Crall concluded (28, p. 113) that direct methods produced better gains in the ability to apply biological principles and in critical thinking skills. Several other objectives were also evaluated. No statistical analysis of the data was performed.

H. Taylor (110, p. 442-446) investigated the relative merits of two methods of teaching high school biology. The methods involved lecture and small-group work. Groups were established by random and sociometric procedures.

Taylor arrived at the following conclusions (110, p. 442):

1. High school biology students will achieve as much knowledge of biology whether taught by the lecture method or the group discussion method using either random groups or sociometric groups.

2. Regardless of the initial knowledge of biology when compared with others of the same initial level of achievement, high school biology students will learn as much knowledge of biology whether taught by the lecture method or the group discussion method using either random groups or sociometric groups.

3. On the basis of factors measured in this study, one must conclude that the methods of instruction investigated were equally effective.

In 1957 Newman (85, p. 2940) compared the effectiveness of
three methods of teaching high school biology using the Nelson Biology Test as a criterion of learning.

The three methods utilized were (1) lecture-discussion and outside reading, (2) lecture-discussion and in-class reading, and (3) lecture-discussion and no reading.

None of these methods were found statistically superior either for bright or slow students.

Oliver (89, p. 2293) conducted a study to compare the relative efficiency of three methods of teaching biology in high schools. Three classes utilized during the 1957-1958 and 1958-1959 years were compared by means of achievement scores. Outcomes evaluated were the acquisition of factual information, overall achievement, application of principles, attitudes toward science, and attitudes toward the scientist. Mental ability was controlled utilizing test intelligence scores of the Otis Mental Ability Test. Other instruments used were the Nelson Biology Test and the Indiana High School Biology Test.

Results of the evaluations indicated that there were no significant differences in outcomes of classes taught by each of the three methods. In the area of attitudinal development, it was found that students with over 100 I. Q. on the Otis Mental Ability Test had more desirable attitudes toward science and scientists than did
lower students.

An investigation was conducted to determine the effectiveness of the History of Science Cases instruction method for improving the student's understanding of science and scientific activity (65, p. 8-15). Each of the experimental classes studied two units of the HOSC materials; control groups did not use the HOSC method. Student results as indicated by the Test on Understanding Science indicated that the experimental classes made highly significant gains compared to the control groups. There appeared to be little or no difference in student achievement in usual subject matter content.

Several investigations have attempted to determine the relative merit of the individual laboratory and the lecture-demonstration method of teaching science. Cunningham (30, p. 70-82) reviewed 37 research studies, eight of which were in biology, concerning the relative effectiveness of the lecture-demonstration versus the individual laboratory. W. E. Cole (26, p. 95-96) and Hurd (55, p. 216) also have summarized a number of studies concerning the effectiveness of the laboratory and the demonstration methods.

The three reviewers agreed that if the exercise was to acquire a knowledge of facts or to reinforce the retention of facts, the choice of a particular method was a question of economy in time or cost. They stated that for economy of cost or time, the laboratory-demonstration plan was favored. On the other hand, if the purpose
of the exercise were to develop skill in the manipulation of laboratory apparatus, the laboratory experiment was superior to demonstration techniques.

Which method is superior for the development of the nature of science through "sciencing" has not been adequately tested. Hurd stated (55, p. 227), ". . . the success of the student and the effectiveness of an experiment are judged in terms of how effective was the exercise in developing critical thinking and providing experience in the 'ways' of science."

Selberg (104, p. 186-188) indicated that demonstrations can provide experiences in the use and development of problem-solving skills. She listed several suggestions for improving procedures.

Schwab (103), Richardson (98, p. 259), and Hurd (55) are among science educators who have stressed the need for biological science courses based on appropriate laboratory and field experiences. Direct investigation through observation, experimentation, and research should be exemplified in each course.

Simon (55, p. 210-211) investigated the teaching methods used by high school biology teachers and found that demonstration-discussion techniques, lectures, and test-recitation were the most often cited methods. From his investigation it was disclosed:

Laboratory work was not considered a primary method for teaching biology; only 3% of the
teachers stated the method was frequently used, while 34% classified it as a less commonly used technique. Individualized methods, projects and research-problem approaches were used by 1% of the teachers. Older experienced teachers were more inclined to lecture and teachers rated as conservative by a jury spent two-thirds of their teaching time in a lecture-textbook-recitation routine. Teachers rated progressive by a jury spent 69% of their teaching time in laboratory work, projects, or demonstrations and also had more students entering science fairs.

Simon noted that the methods rated as the most effective by teachers were not the methods they usually used.

Summary

A review of pertinent studies revealed that desired outcomes were obtained most effectively by planned teaching. Methods were analyzed which proved successful for teaching facts, principles, critical thinking skills, and attitudes.

Barnard (10, p. 111), Fitzpatrick (46, p. 208), and Hurd (55, p. 212) have stated there is no one best method of teaching science. The reviewers agreed that different objectives and student groups required different methods and procedures. Active involvement and conceptualizing of knowledge by the learner were believed to be needed in all methods for students to most effectively acquire and retain knowledge, skills, and attitudes.

The question, thus, is not which "method" is superior for teaching biology, but which method and pattern of pupil behavior
is related to gains in specific learning outcomes and may be effectively utilized by biology teachers in functional classrooms.

A teaching method is selected to obtain specific pupil activity or behavior. An important phase of this study was to analyze teaching methods and descriptions of pupil behaviors which were related to the realization of specific objectives.
CHAPTER III

DESIGN OF THE STUDY

This chapter is divided into three sections:

1. Selection of sample schools and panel of scientists.
2. Selected instruments and statistics.

In the first section, the procedures used to select the participating schools and the panel of scientists are described in detail. The second section presents important information concerning the instruments and their specific application to this study. Statistical procedures used for analyzing teacher factors and student attitudes are described. The following characteristics of the sample teachers are discussed in section three: sex; age; academic preparation; teaching experience; salary; membership in professional organizations; teaching assignments; non-teaching employment; teacher critical thinking skills; teacher attitudes toward science, scientific careers, and science teaching; teacher-pupil relationships; teacher personal adjustment; and teacher effectiveness.
Selection of Sample Schools

The selection of sample schools was guided by a consideration of several factors: (1) The administration and the teacher should be sufficiently interested in participating in the investigation to complete the total evaluation program. (2) A representative sample of public high schools was desired. (3) School enrollments had been found to be a factor in student achievement gains in several previous studies (47, p. 569, 1023). (4) A random selection of schools was a required assumption for the use of the analysis of covariance.

School interest in the problem was determined by mailing a letter of explanation and a field study plan of the proposed investigation to each of the 218 public high schools in the state of Oregon. A sample survey questionnaire and a self-addressed envelope were enclosed to enable the schools to indicate whether they desired to participate in the study and to obtain data for the sample selection.

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1 Appendix B.
2 Appendix C.
3 Appendix D.
Of the 181 schools which returned survey questionnaires, 167 indicated interest in participating in the study. This response indicated the schools possessed considerable interest concerning the investigation.

To obtain a representative sample of schools experts in education and statistics recommended dividing the public high schools into six strata based on the school enrollment in grades 9-12 for four year high schools and on enrollment in grades 10-12 for three year high schools. The Report Summary of Standard Terminal High Schools for Year of 1961-1962 (91, p. 1-11) and assistance from personnel in the State Department of Public Instruction were utilized to establish strata for schools with enrollments numbering 1-250, 251-500, 501-750, 751-1000, 1001-1500, and 1501 and over.

It was further recommended by experts in statistics and education that a sample of approximately one-fourth of the public high schools would provide a sample which would permit appropriate statistical analyses for subgroups of teachers in the study.

Schools in each strata were numbered beginning with 00 and proceeding with 01, 02, 03, and continuing until all schools in each strata were assigned numbers. Schools were selected by entering a random number table (27, p. 354-355) and selecting numbers until the needed number of schools for each strata were
obtained.

A total of 54 schools were selected with five replacement schools also selected, one for each of the strata over 250 pupils.

Letters were mailed to schools which were selected to participate and which had indicated a previous interest in the study. Individual letters were mailed to those schools selected as part of the stratified random sample who had not previously indicated an interest in participating in the study.

Of the 59 schools which were contacted, five had to withdraw. Previous commitment to research of the Biological Science Curriculum Study program eliminated three schools. A fourth school decided not to participate because of a new administrator and a new biology teacher. The fifth school could not participate because biology was placed at the ninth grade level.

One teacher and one class were selected from each school to participate in the study. Several of the schools randomly selected the class with the assistance of the investigator while other classes were selected by the participating schools. In some of the smaller schools in which only one biology class was offered, selection of the school automatically selected the teacher and the class for participation.

The total number of schools in each strata in the state, the
number of schools in each strata selected by the random number procedures, the number of schools utilized in the study, and the number of schools which participated in both the fall and the spring evaluations are listed in Table I.

**TABLE I**

PUBLIC HIGH SCHOOLS IN EACH STRATA IN THE STATE OF OREGON
SCHOOLS WHICH WERE DRAWN, WHICH PARTICIPATED, AND WHICH COMPLETED THE STUDY

<table>
<thead>
<tr>
<th>Average Daily Membership</th>
<th>Total</th>
</tr>
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<tr>
<td>Under 250</td>
<td>500</td>
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<tr>
<td>Number of Schools in State</td>
<td>113</td>
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<tr>
<td>Number Drawn</td>
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<tr>
<td>Number Participating</td>
<td>28</td>
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<tr>
<td>Number Completed</td>
<td>26</td>
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</table>

Selection of Panel of Scientists

A panel of scientists determined the desirable means for the reaction inventories, *Attitudes Toward Science and Scientific Careers* and *Attitudes Toward Science, Scientific Careers, and Science Teaching*. The scientists were selected from a stratified random sample of the staff members in the departments of Zoology,
Microbiology, Botany, and Entomology at Oregon State University.

Utilizing the staff lists in the Oregon State University Bulletin (93, p. 88-89), the number of staff members in each department was determined. A total sample of 25 scientists was selected from the departments according to the percentage of personnel in the department compared to the total in the four departments.

Each department was stratified according to academic rank - Professor, Associate Professor, Assistant Professor, and Instructor. The sample selected from each department was selected proportional to those of each rank in the department. The members of each rank were assigned numbers beginning with 00, 01, etc. A random table (27, p. 354-355) was entered selecting the needed number for that rank.

Two of the sample were not available due to assignment out of the country. Thus, the final sample was 23 scientists. Seventeen completed inventories were received and analyzed.

SELECTED INSTRUMENTS AND STATISTICS UTILIZED IN THE STUDY

Otis Quick Scoring Mental Ability Test

The Otis Quick Scoring Mental Ability Test, Gamma: Form Em was selected to statistically control the mental ability of the students. The test consisted of 80 multiple choice items with an
answer sheet attached to the booklet. Administration time for the test was 30 minutes.

Standardization norms (94) for the Form Em Test were based on a comparison of scores on Form Em with Form Am by means of an experiment in which 1176 pupils in grades 10-12 were tested. The odd versus even item reliability coefficient for Form Em, corrected by the Spearman-Brown formula, was .92 for tenth grade students. The standard error of measurement was 3.0 points.

The Otis Mental Ability Tests have been widely used and are accepted as general mental ability tests.

The Nelson Biology Tests

The Nelson Biology Tests were developed by Nelson of Michigan State University. These instruments were selected to measure the student's knowledge and understanding of biological facts, concepts, and principles; they also measured his ability to apply the methods of science.

There are two comparable forms, Am and Bm, each consisting of 75 test items selected on the basis of curricular validity and satisfaction of rigid statistical requirements (84, p. 1). The tests are produced in non-expendable booklets with separate answer sheets. Working time is 40 minutes.

The tests measured the student's achievement in the following
areas (84, p. 1-2):

1. Knowledge of biological facts, concepts, and principles.

2. Understanding of biological facts, concepts and principles.

3. Ability to recognize cause-effect relationships.

4. Ability to interpret data and to draw sound conclusions therefrom.

5. Ability to recognize and to test hypothesis; to recognize and to solve problems.

6. Ability to evaluate critically experimental procedures and real situations having scientific implications.

Subject content of the tests was determined by an analysis of scientific publications and textbooks, and on the basis of expert judgment of scientists and science educators. Included were the following areas (84, p. 2):

1. Orientation in biological science; methodology of science and scientific reasoning.

2. Characteristics common to living organisms.


4. Processes essential to the life of the individual.

5. Conservation of our biological resources.


7. Parasitism, Disease, and Health.


Both forms of the Nelson Test are divided into two parts, Part A and Part B. Part A, consisting of 40 multiple choice items, is designed to measure the student's knowledge and understanding of biological facts, concepts, and principles. Part B consists of 35 multiple choice and matching items; it is designed to measure the student's ability to apply the methods of science.

Reliability of the Nelson Biology Test, based on corrected split-half reliability coefficients was .87 in one investigation and .88 in another (84, p. 3). An alternate form reliability of .81 has been computed for Forms Am and Bm. Statistical analyses indicated that the forms were comparable both in content and difficulty. Thus, any (84, p. 3) "...differences between results of administration of the two forms are accurate reflections of changes that have taken place from one administration to the other within the limits of the reliability of the test and are not consequences of any systematic differences between the forms."

The Nelson Biology Test has been utilized in numerous studies. Anderson, Montgomery, Smith and Anderson (6, p. 43-54) selected the Nelson Biology Test to measure student gain in a study to determine the effective use of sound motion pictures in high school biology. They stated, "The Nelson Biology Test was chosen since its general
objectives are consistent with objectives of instruction in modern science teaching."

A committee of the National Science Teachers Association analyzed the Nelson Biology Test (37, p. 344); they indicated strong approval of the instrument and objectives which it was designed to measure.

**Watson-Glaser Critical Thinking Appraisals**

The Watson-Glaser Critical Thinking Appraisal was selected to evaluate student progress in critical thinking. Form Ym was used as a pre-test and Form Zm as a post-test. Each form contained five subtests designed to reveal how well the student was able to reason logically and analytically. These subtests were: (1) Inference, 20 items; (2) Recognition of Assumptions, 16 items; (3) Deductions, 25 items; (4) Interpretation, 24 items; and (5) Evaluation of Arguments, 15 items. The 100 items were multiple choice and true-false. Separate answer sheets were provided with reusable test booklets. Time for administration was 50 minutes.

The Manual of Directions stated (114, p. 1), "The Critical Thinking Appraisal is designed to provide problems and situations which require the application of some of the important abilities involved in critical thinking." The authors' concept of critical thinking involves three areas (114, p. 8):
1. An attitude of wanting to have supporting evidence for opinions or conclusions before assuming them to be true.

2. Knowledge of the methods of logical inquiry which help determine the weight of different kinds of evidence and which help one to reach unwarranted conclusions.

3. Skill in employing the above attitude and knowledge.

The reliability of Form Ym has been computed for 180 ninth grade students and 200 senior college women using corrected split-half reliability coefficients. With standard errors of 3.8 and 3.7, the coefficients of .82 and .85 for the ninth grade and college senior women respectively represent satisfactory test reliabilities (50, p. 4).

The two forms have different difficulty levels (16). Form Zm is more difficult than the alternate Form Ym. At grade ten, a score of 62 on Form Ym is equivalent to a score of 56 on Form Zm. A score of 69 on Form Ym is equivalent to a score of 62 on Form Zm. A mean of 61.7 on Form Ym is equivalent to a mean of 56.4 on Form Zm.

Correlation of the Watson-Glaser Critical Thinking Appraisal with the Otis Gamma Test has been computed to be .66, and .68 with the California Test of Mental Maturity Total Score (50, p. 6). The CTA also was correlated with the California Non-Language
resulting in a r of .43. These correlations, and other correlations with divergent thinking tests (50, p. 9), indicate the Critical Thinking Appraisal measures convergent thinking skills and is different from scholastic aptitude tests.

Rust (101, p. 177-181) conducted a factor analytic study in 1955 utilizing three critical thinking tests including the Critical Thinking Appraisal, Form Bm. While there were low intercorrelations obtained among the tests of critical thinking, nearly all sub-tests in the Critical Thinking Appraisal were high on Rust's Factor A which she considered to be a General Reasoning Factor.

The Watson-Glaser Critical Thinking Appraisal was selected to evaluate student gains in critical thinking after examination of the instrument, related statistical data, and the concept of critical thinking which it purports to measure. Watson and Glaser's concept of critical thinking is in general agreement with those stressed by reviewers and investigators in the field.

Student Reaction Inventory, Attitudes Toward Science and Scientific Careers

Student attitudes toward science, scientists, and the interaction of science and society were obtained from responses to the Reaction Inventory, Attitudes Toward Science and Scientific Careers. Allen, (1, p. 7) prepared the attitude scale by reviewing
current periodicals and especially noting derogatory statements which appeared in the literature. From interviews with scientists and high ability high school students a 95-item inventory was developed. Statements were classified into five categories: (1) Science's Impact on Society, (2) Society's Impact on Science, (3) The Scientist, (4) Scientific Work, and (5) Nature of Science.

Allen submitted the statements to a panel of scientists to determine the desirable response to each item. Responses of the panel were used to estimate the extent to which the responses of the students were favorable and constructive with respect to the scientific enterprise. Specific findings in Allen's investigation have been previously reviewed.

Allen's original inventory was adapted by this investigator for administration to the students in this study. Statements 12 (1, p. 48) and 45 (1, p. 50) were eliminated after the attitude scale had been reviewed and evaluated by a sample of Oregon biology teachers.

Students were directed to respond to the statements on a five point scale:

1. AA--complete agreement with the item.
2. A--partial agreement with the item.
4. D--partial disagreement with the item.

5. DD--total disagreement with the item.

Student responses were assigned the following point values: AA=0, A=1, N=2, D=3, and DD=4. Non-responses were scored as two points, and did not amount to greater than three percent of the responses to any one statement.

To estimate the favorableness of the student's responses, 91 of the statements on the inventory were submitted to biological scientists at Oregon State University. Items 33 and 40 on the adapted Reaction Inventory related to student abilities rather than directly to attitudes; therefore, they were omitted from this aspect of the analysis. The means of the judges' responses are listed in Table II.
### TABLE II

**MEANS OF SCIENTISTS' RESPONSES TO STATEMENTS IN ATTITUDES TOWARD SCIENCE AND SCIENTIFIC CAREERS***

<table>
<thead>
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<th>Item Number</th>
<th>Mean</th>
<th>Item Number</th>
<th>Mean</th>
<th>Item Number</th>
<th>Mean</th>
<th>Item Number</th>
<th>Mean</th>
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<td>71.</td>
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*Items 30 and 44 related to student abilities and were not on the inventory submitted to the scientists.

The teacher's attitudes toward science, science careers, and science teaching were determined by use of the Reaction Inventory,
Attitudes Toward Science, Scientific Careers, and Science Teaching which was adapted from attitude inventories used in previous investigations by Allen (1) and Behnke (13).

The inventory consisted of 101 statements. Ninety-one of the statements were from Allen's reaction inventory and corresponded to the same numbered items on the student inventory. Statements 30, 44, 94, 95, 96, 97, 98, 99, 100, and 101 were selected from Behnke's inventory; these items were utilized because they had shown previous discrimination between scientists and biology teachers. Behnke suggested that teachers who had different attitudes toward science than scientists might be those who were inculcating undesirable student attitudes (14, p. 193).

Teachers indicated their responses by circling the desired response:

1. AA--complete agreement with the item.
2. A--partial agreement with the item.
4. D--partial disagreement with the item.
5. DD--total disagreement with the item.

Teacher responses were assigned the following point values: AA=0, A=1, N=2, D=3, and DD=4. Statements which were unmarked were given a two point value.
The favorableness of the teacher's responses were estimated from the means of the scientists' responses to Attitudes Toward Science, Scientific Careers and Science Teaching. The judges' means for the statements are listed in Table III.

TABLE III

MEANS OF SCIENTISTS' RESPONSES TO STATEMENTS IN ATTITUDES TOWARD SCIENCE, SCIENTIFIC CAREERS, AND SCIENCE TEACHING

<table>
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<td>3.471</td>
<td>93.</td>
<td>.588</td>
</tr>
<tr>
<td>18.</td>
<td>.294</td>
<td>44.</td>
<td>1.706</td>
<td>69.</td>
<td>.176</td>
<td>94.</td>
<td>1.529</td>
</tr>
<tr>
<td>19.</td>
<td>2.529</td>
<td>45.</td>
<td>2.235</td>
<td>70.</td>
<td>.412</td>
<td>95.</td>
<td>1.294</td>
</tr>
<tr>
<td>20.</td>
<td>3.294</td>
<td>46.</td>
<td>3.000</td>
<td>71.</td>
<td>3.176</td>
<td>96.</td>
<td>3.235</td>
</tr>
<tr>
<td>21.</td>
<td>2.059</td>
<td>47.</td>
<td>1.529</td>
<td>72.</td>
<td>2.588</td>
<td>97.</td>
<td>1.706</td>
</tr>
<tr>
<td>22.</td>
<td>2.471</td>
<td>48.</td>
<td>2.765</td>
<td>73.</td>
<td>3.824</td>
<td>98.</td>
<td>3.588</td>
</tr>
<tr>
<td>23.</td>
<td>3.294</td>
<td>49.</td>
<td>1.294</td>
<td>74.</td>
<td>3.941</td>
<td>99.</td>
<td>1.176</td>
</tr>
<tr>
<td>24.</td>
<td>.941</td>
<td>50.</td>
<td>3.765</td>
<td>75.</td>
<td>3.706</td>
<td>100.</td>
<td>.941</td>
</tr>
<tr>
<td>25.</td>
<td>3.824</td>
<td>51.</td>
<td>.765</td>
<td>76.</td>
<td>3.529</td>
<td>101.</td>
<td>.706</td>
</tr>
<tr>
<td>26.</td>
<td>1.529</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Teacher Rating Scale

The Teacher Rating Scale was completed by the principals to assess the teacher-pupil relationships and the personal adjustment of each participating teacher.

The scale was divided into two major parts: (A) Teacher-Pupil Relationships and (B) Teacher Personal Adjustment. Part A of the instrument was modified by Williamson from a scale used by Leeds (118, p. 43). The scale included five major areas:

1. What is the status of this teacher's disciplinary ability?

2. Does the teacher have a "student" or subject matter point of view?

3. What is the nature of this teacher's attitude toward children?

4. What is the teacher's understanding of pupil behavior problems?

5. What is the attitude of the pupils toward this teacher?

Part B was designed by Williamson (118, p. 43-44) to reveal the personal adjustment problems of the teacher. It was divided into six areas:

1. Is the teacher capable of analytical thinking?

2. What are the social attitudes of the teacher?
3. What emotional attitudes are shown by the teacher?

4. To what extent does the teacher demonstrate confidence in self?

5. To what extent does the teacher develop satisfactory personal relations?

6. Does the teacher understand and develop desirable home satisfactions?

The sixth area of Part B concerned with home satisfactions was removed from the scale on the request of several principals and teachers who reviewed the instrument. They believed a better return would be obtained with this item deleted.

Each area was divided into five parts; each part described a teacher's attitude, ranging from most desirable to least desirable (118, p. 44). A numerical score for Parts A and B was obtained by assigning a numerical value to each part of the area. Values were assigned to responses ranging from one point for the most undesirable attitude consecutively to five points for the most desirable attitude. The maximum possible score on both Part A and Part B was 25, for a combined total of 50.

Using the complete rating scale in a study of teachers with 0-5 years teaching experience, Williamson (118, p. 44) obtained high, low, and mean scores listed in Table IV.
TABLE IV

HIGH, LOW, AND MEAN SCORES ON TEACHER RATING SCALE

<table>
<thead>
<tr>
<th>Teacher Rating Scale</th>
<th>High Score</th>
<th>Low Score</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part A--Teacher-Pupil Relationships</td>
<td>25</td>
<td>7</td>
<td>20.03</td>
</tr>
<tr>
<td>Part B--Teacher's Personal Adjustment</td>
<td>30</td>
<td>10</td>
<td>24.77</td>
</tr>
<tr>
<td>Parts A and B</td>
<td>55</td>
<td>17</td>
<td>44.70</td>
</tr>
</tbody>
</table>

Statistical Controls and Analyses of Data

Identification of teacher factors significantly related to learning outcomes. The effectiveness of teachers and of teaching methods has been evaluated primarily by ratings of supervisors, by student responses, and my measures of pupil gain. A review of previous studies and recommendations of investigators indicated evaluation of pupil growth toward broad objectives was desirable. Bloom (47, p. 369) stated, "...unless the criteria of effectiveness are related to changes in students, the researcher has avoided the primary criterion, and has used only proximate criteria."

Pupil achievement was evaluated in five areas of biological science education during the 1962-1963 school year. General scholastic aptitude and relevant previous achievement were measured by pre-testing in September, 1962. The *Otis Mental Ability Test* provided an estimate of the general scholastic aptitude of the sample classes. The *Nelson Biology Test, Form Am*, provided information
concerning the students previous knowledge of biological facts, concepts, and principles, and their ability to apply the methods of science. Critical thinking abilities of the students were sampled by the Watson-Glaser Critical Thinking Appraisal, Form Ym. Attitudes of the students at the beginning of the school year were assessed by the Reaction Inventory, Attitudes Toward Science and Scientific Careers.

Final evaluations to determine student gains were completed during the final two weeks in May, 1963. The Nelson Biology Test, Form Bm, the Watson-Glaser Critical Thinking Appraisal, Form Zm, and the Reaction Inventory were completed by the students.

Statistics were computed from data of students who completed both the fall and spring testing. Data of students who withdrew from or who entered into a sample class after the fall pre-testing were not used in the computations.

Class means were calculated for tests administered in the fall and spring. Means were determined for the total Nelson Test (75 items), Part A (40 items) and Part B (35 items). Means were also computed for the total Watson-Glaser Critical Thinking Appraisal (100 items). The mean for each test or section was computed by totaling the raw scores for each class and dividing by the number of students.
An estimate of the desirability of the students' attitudes toward science and scientific careers was determined in the fall and spring. The arithmetic mean of the responses to each item was computed for individual classes. The difference between the mean response of scientists and the class mean was computed for each of the 91 items which were analyzed. A total difference between the attitudes of each class and the panel of scientists was obtained by summing computed differences for each of the 91 items.

Data concerning teacher factors were obtained from materials completed by the principal and the teacher and from teacher certification records of the State Department of Public Instruction. A Teacher Rating Scale was submitted by each participating school principal. Teachers completed the Watson-Glaser Critical Thinking Appraisal, Form Zm, the Reaction Inventory, Attitudes Toward Science, Scientific Careers, and Science Teaching, and the Teacher Inventory. Data from teachers were compared to available state certification records for accuracy. Requested information which was not furnished by the teachers was also obtained from these records when available.

Data for each teacher factor were tabulated; upper and lower groups of teachers were selected. Extreme teacher groups selected varied from the upper 20-35 percent and the lower 20-35 percent
depending on the distribution of the data. Each selected teacher factor was tested for statistical significance. Class means of upper and lower groups of teachers were analyzed on each of the five selected learning outcomes by the analysis of covariance.

The analysis of covariance is a useful statistical procedure to employ when differences among groups are known to influence or suspected to influence the criterion. Adjustments are made for differences in scholastic ability and relevant previous knowledge. Basic assumptions underlying the analysis of covariance are (117, p. 184):

1. Random selection of the sample.
2. No significant differences between the means of the pre-test scores of the pooled groups.
3. No significant differences between the variances of the pooled groups.

To fulfill the first assumption which is basic to statistical analysis the sample was randomly selected from a stratified population of public high schools in Oregon.

Recent research has indicated that the latter two assumptions are not as critical as formerly believed. Wert (117, p. 183) stated, "...it is becoming more apparent that the analysis of variance technique is sufficiently satisfactory even when there is considerable departure from the strict fulfillment of the assumptions."
Experts in statistics at Oregon State University recommended conducting the t test (117, p. 136) on the pooled variance of the subgroups on the Otis means ($X_1$) and pre-test knowledge means ($X_2$). The t test revealed whether there was a statistical difference between the means; this information was used in interpreting the results of the analysis of covariance.

The analysis of covariance was computed by procedures outlined by Wert (117, p. 345-349). Teacher factors which were significant at the .10, .05, or .01 level of significance were identified.

Identification of relationships between student outcomes and methods of teaching. Class gains were determined for each objective by computing the difference between the fall and spring raw scores on the criterion instruments. Gains were tabulated and analyzed. High and low extreme groups were established on the basis of student gains. Depending upon the distribution of the student gains, upper and lower groups were each composed of 20-35 percent of the participating classes. The methods utilized by teachers of the upper classes in student gain were analyzed and compared to the teachers of the lower classes. Methods or combinations of methods which were associated with the greatest gains were identified and described.
Determination of changes in student attitudes. Student attitudes were determined from responses to the Reaction Inventory, Attitudes Toward Science and Scientific Careers in the fall and in the spring. The differences between class means and scientists' means were calculated for each item. The differences between the class means and the individual teacher's attitude were also calculated for each item.

A total difference between the attitudes of the students in each class and the scientists was obtained for both the fall and the spring testing. The total difference was calculated by summing the item differences from the inventory. A total difference of 0 would indicate the students possessed attitudes corresponding to those of the scientists' mean.

Changes in student attitudes were determined by comparing the fall and spring total differences. If the total difference between the class and the scientists were smaller in the spring than in the fall it was determined that the class had made a positive gain in attitudes toward science and science careers. If the total difference were higher in the spring, it was determined the class had not made positive gains in scientific attitudes.

A total difference was also calculated from the differences between the attitudes of each individual teacher and his class for both
fall and spring testings. A total difference of 0 would indicate the mean of the students' attitudes corresponded to the reaction responses of the teacher. If the total difference between the class and the teacher were lower in the spring than in the fall, this revealed that the attitudes of the students had changed in the direction of the teacher's attitudes. If the total difference between the class and the teacher were greater in the spring, this indicated student attitudes did not change in the direction of the teacher's attitudes.

To determine if there were significant changes in the attitudes of the total sample, the t test (117, p. 136) was computed on the fall and spring total differences between the students and the scientists. The t test was also calculated on the fall and spring total differences between the class and the teacher.

CHARACTERISTICS OF SAMPLE TEACHERS

Characteristics of the teachers were determined from responses to the Watson-Glaser Critical Thinking Appraisal; the Reaction Inventory, Attitudes Toward Science, Scientific Careers, and Science Teaching; the Teacher Inventory; the Teacher Rating Scale; and from teacher certification records of the State Department of Public Instruction. Forty-four Critical Thinking Appraisals and Reaction Inventories, and 46 Teacher Inventories were returned.

The number of teachers for each characteristic will, therefore,
not always number 51.

Sex and Age

Men constituted 82 percent of the biology teachers in Oregon during the 1962-1963 school year (92, p. 1-5). The teacher sample was composed of 90 percent men and ten percent women which closely approximated the state percentage. The median age of the teachers was in the 25-34 year category. Most of the teachers, 80 percent, were 44 years and under; thus, they would have many more years of teaching service ahead. Table V lists the number of teachers in each age category.

<table>
<thead>
<tr>
<th>TABLE V</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGES OF BIOLOGY TEACHERS</td>
</tr>
<tr>
<td>Age in Years</td>
</tr>
<tr>
<td>Number of Teachers Reporting</td>
</tr>
</tbody>
</table>

Preparation

Sixty-eight percent of the teachers obtained their undergraduate preparation in Oregon institutions. While the majority of the teachers were educated in this state, Oregon schools also attracted
teachers from many other states. Teachers reported receiving undergraduate work in colleges and universities from California to Pennsylvania.

A variety of emphasis in undergraduate training was indicated by the teachers. Physical education was listed by 34 percent of the teachers, biology by 23 percent, and general science and other sciences by 25 percent as first undergraduate teaching areas. Most common second teaching areas were biology and other sciences. It was apparent that physical education teachers and coaches comprised a large percentage of the biology teachers in this study.

Nearly all the teachers had obtained educational experiences at the graduate level. Only one teacher who had taught more than one year had not completed any graduate work. Most of the teachers selected Oregon institutions for graduate education. Biology was the first area of concentration at the graduate level followed by professional education and related science courses. Twenty-one of the teachers had received the master's degrees in various fields.

Biology teachers in this study were better prepared in the biological sciences than those reported in several earlier studies (5) and (67). The median preparation in biology was from 40-49 quarter hours. Only five teachers had fewer than 30 hours of preparation in biology.
Preparation by the sample teachers in other science areas was limited. The median number of quarter hours of preparation in chemistry was 12; however, 11 of the teachers had completed no academic work in chemistry. Nearly half of the teachers, 22 of those who responded, had not completed any courses in physics. The median preparation was four quarter hours. Very little preparation in geology and other science areas was evident.

Seventy percent of the teachers reported preparation in mathematics. The median number of quarter hours was nine.

Preparation in professional education varied from 22 to over 200 quarter hours. A majority of the teachers reported between 30 and 55 quarter hours of course work. The median preparation was between 40-50 quarter hours.

In Table VI quarter hours of preparation in biology, all sciences, and professional education are listed. The number of teacher responses are listed under the quarter hours of preparation in each of the three categories.
Four patterns of preparation appeared to be characteristic of the sample teachers.

One group of 15 teachers had substantial preparation in biology and considerable work in other science fields. Seven of them would qualify for the new basic Oregon norm, while four had sufficient breadth and depth of work to fulfill the AAAS suggested preparation.

A second group of 11 teachers had considerable preparation in two or more science and mathematics areas. These teachers may or may not have had adequate preparation for teaching biology. Many of them had multiple teaching assignments in smaller schools.

Limited preparation in the biological sciences and very little preparation in any other science area was characteristic of ten teachers.
A fourth group was composed of seven teachers who had little or no preparation in any science area. These teachers had a total of 35 or fewer quarter hours in all science areas.

National Science Foundation institutes have improved the subject matter preparation of many of the teachers. Seventeen teachers, 37 percent of those who responded, indicated that they had attended NSF institutes. Summer institutes were most commonly listed. It was interesting to observe that most of the teachers who had attended NSF institutes were among the better prepared. It would appear that a large number of inadequately prepared biology teachers for various reasons are not applying to appropriate institutes or are not being selected.

Teaching Experience

The total teaching experience reported by the teachers indicated most had received recent preparation. Very few of the teachers had been teaching for more than fifteen years. The median total teaching experience was in the four to nine year category which included 33 percent of the teachers. An analysis of Table VII reveals several teachers had changed to teaching biology or were teaching biology by administrative decision. The median teacher had also taught biology between four and nine years.
TABLE VII

TOTAL YEARS OF TEACHING EXPERIENCE AND YEARS OF EXPERIENCE TEACHING BIOLOGY

<table>
<thead>
<tr>
<th>Number of years of Teaching Experience</th>
<th>1</th>
<th>2-3</th>
<th>4-9</th>
<th>10-15</th>
<th>16-25</th>
<th>26 or More</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers Reporting Total Teaching Experience</td>
<td>8</td>
<td>3</td>
<td>18</td>
<td>11</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Teachers Reporting Biology Teaching Experience</td>
<td>10</td>
<td>6</td>
<td>17</td>
<td>9</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Considerable moving from district to district was revealed by the number of years the teachers had been in their present districts. Approximately 50 percent of the sample as indicated in Table VIII had been teaching in their present districts for three or fewer years. Only seven had been teaching in their present district for ten or more years.

TABLE VIII

NUMBER OF YEARS OF EXPERIENCE IN PRESENT DISTRICT

<table>
<thead>
<tr>
<th>Years in Present District</th>
<th>1</th>
<th>2-3</th>
<th>4-9</th>
<th>10 or More</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers Reporting</td>
<td>9</td>
<td>14</td>
<td>16</td>
<td>7</td>
</tr>
</tbody>
</table>
Salary

The median teacher salary was in the $5,000 to $5,999 category. Table IX lists salaries reported by the teachers. The higher salaries were reported by teachers with ten or more years experience and individuals with coaching and/or counseling assignments.

**TABLE IX**

**SALARIES OF SAMPLE TEACHERS FOR THE 1962-1963 SCHOOL YEAR**

<table>
<thead>
<tr>
<th>Salary</th>
<th>$4,000-4,999</th>
<th>$5,000-5,999</th>
<th>$6,000-6,999</th>
<th>$7,000-7,999</th>
<th>$8,000-8,999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers</td>
<td>10</td>
<td>15</td>
<td>10</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

**Professional Organizations**

The average teacher was a member of two professional education or scientific organizations. Nearly all of the teachers were members of the National Education Association. The National Science Teachers Association, the National Association of Biology Teachers, and the American Institute of Biological Sciences were listed second in frequency. Thirty-three percent of the teachers were members of one or more of the three preceding organizations. Table X lists organizations in which four or more teachers indicated membership.
### TABLE X

PROFESSIONAL AND SCIENTIFIC ORGANIZATIONS IN WHICH FOUR OR MORE TEACHERS HELD MEMBERSHIP

<table>
<thead>
<tr>
<th>Organization</th>
<th>Number of Teachers Reporting Membership</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Education Association</td>
<td>39</td>
</tr>
<tr>
<td>National Science Teachers Association</td>
<td>18</td>
</tr>
<tr>
<td>National Association of Biology Teachers</td>
<td>17</td>
</tr>
<tr>
<td>American Institute of Biological Sciences</td>
<td>17</td>
</tr>
<tr>
<td>Oregon Science Teachers Association</td>
<td>8</td>
</tr>
</tbody>
</table>

**Teaching Assignments**

While flexible scheduling and block classes were evident in teacher assignments, 55 percent of the teachers reported they taught five periods per day. The number of biology classes taught by teachers varied extensively. The median assignment was three biology classes per day, though 40 percent of the sample taught only one or two classes of biology per day. The total number of class preparations reported varied from one to six with a median of three.

**Employment During the School Year**

Several studies have indicated that teachers are not devoting adequate time to their classes because of employment outside the school during the school year. This investigation did not reveal this...
trend. Only 13 percent of the teachers reported outside employment. Several teachers derived extra income from school assignments, primarily coaching. Thus, while only a few were employed outside the school, several teachers had other school assignments which also required additional time. Seven teachers offered comments that coaching two or more sports, and driver training assignments required time they could have used to prepare for their classes.

Critical Thinking Skills

The biology teachers were evaluated for their critical thinking abilities by the Watson-Glaser Critical Thinking Appraisal, Form Zm. Raw scores ranged from 53 to 89 with a median score of 71. Data indicated the teachers possessed approximately a normal range of critical thinking abilities for college educated adults. A research report (50) which analyzed Form Ym indicated a percentile rank of 50 for a score of 75 for senior college women. Considering the difference in the difficulty level of the two instruments, a score of 71 on Form Zm would be above, but relatively close to, the 50 percentile rank, and in the fifth stanine.

Teacher scores are listed in Table XI.
TABLE XI

DISTRIBUTION OF TEACHER CRITICAL THINKING SCORES

<table>
<thead>
<tr>
<th>Raw Score</th>
<th>52</th>
<th>57</th>
<th>62</th>
<th>67</th>
<th>72</th>
<th>77</th>
<th>82</th>
<th>87</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interval</td>
<td>56</td>
<td>61</td>
<td>66</td>
<td>71</td>
<td>76</td>
<td>81</td>
<td>86</td>
<td>91</td>
</tr>
</tbody>
</table>

| Number of Teachers | 2  | 10 | 6  | 5  | 11 | 5  | 2  | 3  |

Teacher Attitudes Toward Science, Scientific Careers, and Science Teaching

The rounded total difference between the teacher's attitudes toward science and science careers and the mean response of the scientists is indicated in Table XII. The total difference was computed using item differences on statements one through 93 and 97, 99, and 100 from the Reaction Inventory, Attitudes Toward Science, Scientific Careers, and Science Teaching. Total difference scores ranged from 57 to 105 with a median total difference of 74. The analyses revealed a majority of the teachers possessed generally positive attitudes toward science. Six teachers expressed attitudes which differed considerably from the scientists.
Behnke (13, p. 29-30) had found in a previous investigation that biology teachers differed from scientists on several statements related to science teaching. These items, numbers 94, 95, 96, 98, and 101, were grouped and a total difference was computed for each teacher from the differences between the teacher's attitude and the mean of the scientists' responses. Rounded total differences ranged from two to eleven points, with a median of five. Teachers who differed considerably from the scientists on items related to science teaching also differed on attitudes toward science and scientific careers. Total difference scores between the attitudes of the teacher and the scientists toward science teaching are listed in Table XIII.
TABLE XIII

TOTAL DIFFERENCE SCORES BETWEEN INDIVIDUAL TEACHER ATTITUDES TOWARD SCIENCE TEACHING AND SCIENTISTS' MEANS

<table>
<thead>
<tr>
<th>Total Difference</th>
<th>2-3</th>
<th>4-5</th>
<th>6-7</th>
<th>8-9</th>
<th>10-11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Teachers</td>
<td>7</td>
<td>16</td>
<td>14</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Teacher-Pupil Relationships

Teachers were rated by their principals concerning teacher-pupil relationships. Part A of the Teacher Rating Scale was utilized to evaluate this teacher factor.

Scores ranged from eight to 25 with a median rating of 21. It was evident that the principals believed a majority of the teachers developed effective teacher-pupil relationships.

Principals provided statements to justify most low ratings given to teachers. Lack of understanding of slow students and an ineffective concept of discipline were most often cited.

Teacher scores for Part A are listed in Table XIV.

TABLE XIV

PRINCIPALS' RATINGS OF TEACHER-PUPIL RELATIONSHIPS

<table>
<thead>
<tr>
<th>Rating Score</th>
<th>8-10</th>
<th>11-13</th>
<th>14-16</th>
<th>17-19</th>
<th>20-22</th>
<th>23-25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Teachers</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>8</td>
<td>19</td>
<td>12</td>
</tr>
</tbody>
</table>
Teacher Personal Adjustment

The teacher's personal adjustment was estimated from the principal's response to Part B of the Teacher Rating Scale. Scores ranged from 11 to 25 with a median of 20. It was evident that the large majority of the teachers were believed to be well adjusted. An analysis of the ratings indicated that nearly all teachers rated low in personal adjustment also tended to be low in teacher-pupil relationships. The principal's evaluations of the teacher's personal adjustment are listed in Table XV.

| TABLE XV |
| PRINCIPALS' EVALUATIONS OF TEACHER PERSONAL ADJUSTMENT |
|---|---|---|---|---|---|
| Rating Score | 11-13 | 14-16 | 17-19 | 20-22 | 23-25 |
| Number of Teachers | 1 | 4 | 12 | 21 | 10 |

Effectiveness of the Teacher

Principals were asked to indicate the effectiveness of the teacher based on a five part scale. Evaluations of the teacher's effectiveness by the principals are listed in Table XVI.
TABLE XVI
PRINCIPALS' RATINGS OF TEACHER EFFECTIVENESS

<table>
<thead>
<tr>
<th>Degree of Effectiveness</th>
<th>Number of Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outstanding in effectiveness</td>
<td>9</td>
</tr>
<tr>
<td>Quite effective</td>
<td>31</td>
</tr>
<tr>
<td>Effectiveness questionable</td>
<td>6</td>
</tr>
<tr>
<td>Somewhat effective</td>
<td>2</td>
</tr>
<tr>
<td>Very ineffective</td>
<td>0</td>
</tr>
</tbody>
</table>

An analysis of Table XVI reveals 81 percent of the biology teachers were judged quite effective or outstandingly effective. The effectiveness of 17 percent of the teachers was evaluated as questionable or ineffective. The eight teachers rated as questionable or ineffective were also given low personal adjustment ratings.

A second question asked the principal to rate the teacher's effectiveness disregarding the teacher's relationship with pupils. The principals' ratings are presented in Table XVII.

TABLE XVII
PRINCIPALS' RATINGS OF TEACHER EFFECTIVENESS EXCLUSIVE OF TEACHER-PUPIL RELATIONSHIPS

<table>
<thead>
<tr>
<th>Degree of Effectiveness</th>
<th>Number of Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective</td>
<td>42</td>
</tr>
<tr>
<td>Not effective</td>
<td>2</td>
</tr>
<tr>
<td>Effectiveness questionable</td>
<td>4</td>
</tr>
</tbody>
</table>
Ratings received by the teachers corresponded quite closely to the ratings of general effectiveness. Two teachers whose effectiveness had been rated as questionable and ineffective were considered to be effective when teacher-pupil relationships were disregarded.

Principals' responses to the two items concerning teacher effectiveness indicated they believed the large majority of their biology teachers to be effective. Only 13 percent of the teachers were rated as ineffective or questionable in effectiveness.
CHAPTER IV
THE STUDY

This investigation was designed to determine the relationship of learning outcomes to selected teacher factors and teaching methods in tenth grade biology classes in Oregon. Selected teacher factors were analyzed by analysis of covariance for statistical relatedness to five learning outcomes in biological science education. The same teacher factors were analyzed by comparative percentages to composite success, classes ranking in high gain subgroups on three or more of the learning outcomes. Methods of teaching which were utilized by teachers of classes obtaining highest gains were analyzed for each specific outcome. Analyses were also conducted to determine the influence of school size on student achievement and to determine the significance of changes in student attitudes.

Data utilized in the analyses were secured from students, teachers, and principals in 51 public high schools and certification records in the State Department of Public Instruction. The students participated in a pre-testing program the last two weeks of September, 1962, to provide statistical controls for general scholastic ability and pre-test knowledge and understanding of biological facts, concepts, and principles; application of the methods of science;
critical thinking skills; and attitudes toward the nature of science and scientific careers. Final testing was conducted the last two weeks in May, 1963, to determine the student achievement in these areas during the school year.

Teachers completed evaluation instruments which revealed their critical thinking abilities and attitudes toward science, scientists, scientific careers, and science teaching. They also completed a questionnaire which provided data concerning teacher preparation, experience, professional activities, teaching methods, and job responsibilities.

Principals rated the teachers on their teacher-pupil relationships and personal adjustment.

Data related to several teacher factors were obtained from certification records in the State Department of Public Instruction when the teacher did not provide the requested information or information submitted was not in agreement with official documents.

All data were transferred to a master sheet for general analyses. A unisort card was established for each teacher to provide efficient separation of teacher groups.

Data which will be presented and interpreted in this chapter will be discussed in three areas:

1. Student Achievement.
2. Relationship of learning outcomes to selected teacher factors.

3. Relationship of learning outcomes to teaching methods.

STUDENT ACHIEVEMENT

This section presents data concerning the general scholastic level of the students and the learning outcomes of the classes during the school year. Class gains are presented for the following instruments: the total Nelson Test; Nelson Test, Part A; Nelson Test, Part B; Watson-Glaser Critical Thinking Appraisal; the Reaction Inventory, Attitudes Toward Science and Scientific Careers; and selected statements from the Reaction Inventory related to the understanding of the nature of science. Changes in student vocational interests toward science-related careers and the relationship of school size to student achievement are also discussed.

A table presenting complete evaluation data on each class is listed in Appendix E. Class means are rounded to the nearest tenth or whole number.

The student sample was comprised of 1191 students in biology classes in 51 public high schools in Oregon. The students were pre-tested in September, 1962, and post-tested in May, 1963. Testing was conducted to provide a control of the student's scholastic ability and to determine learning outcomes in knowledge, skills, and
attitudes. Data utilized in all analyses were class means since the class was the sampling unit.

General Scholastic Ability

The Otis Mental Ability Test, Gamma: Form Em was utilized to determine the general scholastic ability of the students. Class means are presented in Table XVIII.

TABLE XVIII

<table>
<thead>
<tr>
<th>MEAN GAMMA I.Q.'S FOR SAMPLE CLASSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Gamma I.Q.</td>
</tr>
<tr>
<td>Number of Classes</td>
</tr>
</tbody>
</table>

The median class Gamma I.Q. was 108 for students completing the testing program. The median class I.Q. was 106 at the first of the year. This difference was influenced by withdrawals during the school year of several students with I.Q.'s below 105.

The class means yielded nearly a normal curve. Table XIX indicates the expected frequencies of a normally distributed population and the frequencies actually obtained. The sample curve is slightly skewed to the higher I.Q.'s but closely approximates a normal curve.
TABLE XIX

COMPARISON OF EXPECTED FREQUENCIES OF A NORMAL CURVE AND DISTRIBUTION OF CLASS MEAN GAMMA I.Q.'S

<table>
<thead>
<tr>
<th>Intervals</th>
<th>-3σ</th>
<th>-2σ</th>
<th>-1σ</th>
<th>Mean</th>
<th>+1σ</th>
<th>+2σ</th>
<th>+3σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Frequencies</td>
<td>2%</td>
<td>14%</td>
<td>34%</td>
<td>34%</td>
<td>14%</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Class Mean I.Q.</td>
<td>2%</td>
<td>10%</td>
<td>35%</td>
<td>43%</td>
<td>6%</td>
<td>4%</td>
<td></td>
</tr>
</tbody>
</table>

Total Gain in Knowledge and Skills

Nearly all classes indicated a mean gain on the total raw score of the Nelson Biology Test. Class means on the pre-test, Form Am, ranged from 25 to 45 with a median of 33. Class means ranged from 23 to 56 on the post-test, Form Bm, with a median of 39. Total possible score on the Nelson Biology Test was 75.

Mean class gains ranged from -5 to +13 points, with a median gain of six. Table XX indicates the frequency distribution of class mean gains on the total Nelson Test.

TABLE XX

MEAN GAINS OF CLASSES ON TOTAL NELSON BIOLOGY TEST

<table>
<thead>
<tr>
<th>Class Mean Gain</th>
<th>-6</th>
<th>-3</th>
<th>0</th>
<th>+3</th>
<th>+6</th>
<th>+9</th>
<th>+12</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>to</td>
<td>to</td>
<td>to</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-4</td>
<td>-1</td>
<td>+2</td>
<td>+5</td>
<td>+8</td>
<td>+11</td>
<td>+14</td>
</tr>
</tbody>
</table>

Number of Classes | 1 | 3 | 6 | 12 | 20 | 7 | 2 |
Facts, concepts, and principles. Most of the gain by classes on the Nelson Test was on Part A, which measures the student's knowledge and understanding of facts, concepts, and principles. Class means ranged from 13 to 24 on the pre-test, with a median of 17. On the post-test, class means were from 13 to 32, with a median of 23. Total possible score on Part A was 40 points.

Mean class gains ranged from -1 to +11 points with a median gain of five points. A frequency analysis of class mean gains is listed in Table XXI.

<table>
<thead>
<tr>
<th>Class Mean Gain</th>
<th>-2</th>
<th>+1</th>
<th>+4</th>
<th>+7</th>
<th>+10</th>
</tr>
</thead>
<tbody>
<tr>
<td>to 0</td>
<td></td>
<td></td>
<td>to</td>
<td></td>
<td>to</td>
</tr>
<tr>
<td>to +3</td>
<td></td>
<td></td>
<td>+6</td>
<td>+9</td>
<td>+12</td>
</tr>
</tbody>
</table>

| Number of Classes | 3 | 8 | 25 | 14 | 1 |

Application of the methods of science. Part B of the Nelson Biology Test measured the student's ability to apply the methods of science. Items were included which required the student to interpret data and to draw conclusions; to recognize and to test hypotheses; to recognize and to solve problems; and to critically evaluate experimental procedures and real situations having scientific
implications (86, p. 1-2).

Class means varied from 11 to 21 points on the pre-test with a median of 16. Post-test class means ranged from 10 to 25 with a median of 17. Total possible score on Part B was 35 points.

Mean class gains were tightly grouped between -4 to +4 points. The median gain was 0. Table XXII lists mean class gains for Part B of the Nelson Biology Test.

<p>| TABLE XXII |</p>
<table>
<thead>
<tr>
<th>MEAN GAINS OF CLASSES ON PART B, NELSON BIOLOGY TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Mean Gain</td>
</tr>
<tr>
<td>and</td>
</tr>
<tr>
<td>-4</td>
</tr>
<tr>
<td>Number of Classes</td>
</tr>
</tbody>
</table>

The lack of any appreciable gain in this area of learning as measured by the Nelson Test deserves careful consideration. It is possible that some classes may not have studied all areas sampled by the instrument. Questions which were missed, however, indicated there was a lack of understanding by many students of important aspects of science. A large number of students could not distinguish between a problem, a hypothesis, a generalization, and a fact. Another area of learning which was weak was the ability to interpret graphical information. Eight teachers stated they did not
plan or teach for the application of the methods of science.

**Critical Thinking Skills**

The *Watson-Glaser Critical Thinking Appraisal* was utilized to measure the critical thinking abilities of the students. It was planned to analyze total test scores and subtest scores; however, it has been determined that subtest scores are not valid for individual analysis (50, p. 5).

*Form Ym* was used as the pre-test. Class means ranged from 47 to 73, with a median of 60. Post-test class means on *Form Zm*, adjusted for differences in difficulty between the two forms, ranged from 56 to 77, with a median of 64. Total possible score on the *Critical Thinking Appraisal* was 100 points.

Class gains ranged from -4 to +11 with a median gain of +4 points. Table XXIII lists the class mean gains for the *Watson-Glaser Critical Thinking Appraisal*.

**TABLE XXIII**

<table>
<thead>
<tr>
<th>Class Mean Gain</th>
<th>-6</th>
<th>-3</th>
<th>0</th>
<th>+3</th>
<th>+6</th>
<th>+9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Classes</td>
<td>1</td>
<td>3</td>
<td>9</td>
<td>27</td>
<td>9</td>
<td>2</td>
</tr>
</tbody>
</table>
Adjusted scores were computed for the spring post-test because it has been determined that the two alternate forms are not directly comparable. Form Zm is more difficult than Form Ym. Tables of equivalence are currently being prepared for the two tests (16, p. 1). At grade 10, a Ym raw score of 69 is equivalent to a Zm raw score of 62; a Ym raw score of 62 is equivalent to a Zm raw score of 56.

**Attitudes Toward Science and Scientific Careers**

Student attitudes toward science and scientific careers were sampled by the Reaction Inventory, Attitudes Toward Science and Scientific Careers.

The students decided whether they were in complete agreement (AA), partial agreement (A), neutral (N), partial disagreement (D), or complete disagreement (DD) toward each statement. Responses were scored 0, 1, 2, 3, and 4 respectively. A blank response was given a value of 2. Fewer than three percent of the responses to any question were blank.

Criterion means were obtained by submitting the items to a panel of scientists at Oregon State University. Differences were computed between the class means and the means of scientists' responses for each item. Summing these differences yielded a
total difference between the class and the scientists and provided an indication of the distance of the class from the attitudes of the scientists.

Total differences on the fall inventory varied from 36 to 77 with a median of 52. Class differences in the spring ranged from 32 to 74 with a median of 49. All except 11 classes indicated more positive responses in the spring. The median gain was -3 points. A negative gain between fall and spring indicated attitudes changed in the direction of the scientists' means.

The attitudes of the total sample were analyzed for a significant change during the school year by computing a t-value (117, p. 136) on the pooled variance of the fall and spring means. A t-value of 1.84 with 100 degrees of freedom was calculated. This is significant at the .10 level and approached significance at the .05 level.

Table XXIV lists the class mean gains in the direction of the scientists' attitudes.

### TABLE XXIV

**MEAN GAINS OF CLASSES ON ATTITUDES TOWARD SCIENCE AND SCIENTIFIC CAREERS**

<table>
<thead>
<tr>
<th>Class Mean Gain</th>
<th>+9</th>
<th>+4</th>
<th>-1</th>
<th>-6</th>
<th>-11</th>
<th>-16</th>
</tr>
</thead>
<tbody>
<tr>
<td>to to to to to to to to to</td>
<td>+5</td>
<td>0</td>
<td>-5</td>
<td>-10</td>
<td>-15</td>
<td>-20</td>
</tr>
</tbody>
</table>

| Number of Classes | 2   | 9   | 31  | 6   | 1   | 2   |

* A negative class mean gain indicates attitudes changed in the direction of the scientists during the school year.
Great stress has recently been placed on developing an understanding of the nature of science. The statements which related to this aspect of science education were analyzed separately. These statements included numbers 2, 15, 17, 21, 22, 31, 37, 43, 46, 56, 59, 60, 69, and 85 (1, p. 53). The total differences on these items ranged from six to 17 in the fall and from five to 15 in the spring. The median difference in the fall was ten, while the median difference in the spring was nine. The median gain was +.7 points in the direction of the scientists' attitudes.

Table XXV lists the class mean gain in understanding of the nature of science as measured by selected items in the Reaction Inventory.

**TABLE XXV**

<table>
<thead>
<tr>
<th>Class Mean Gain</th>
<th>above +4.0</th>
<th>to +1.0</th>
<th>to -1.1</th>
<th>to -4.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Classes</td>
<td>1 6 26 15 3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*A negative class mean gain reveals a positive attitude change.

While the classes indicated attitudes to several statements which were not in close agreement with the scientists, the analysis indicated these classes had generally positive attitudes. Most
classes indicated attitudinal changes during the school year in the
direction of those held by the scientists.

Differences were also calculated between each teacher's re-
sponses to 91 items on the inventory and student class means. A
total difference for the class was obtained by summing the differ-
ences for each item. The total difference between the teacher and
his class was greater in most instances in the fall than in the
spring indicating a general change of student attitudes in the direc-
tion of the attitudes of the teacher. Table XXVI lists the class mean
change in the direction of the teacher's attitudes.

### TABLE XXVI

<table>
<thead>
<tr>
<th>Class Mean Change</th>
<th>+10</th>
<th>+5</th>
<th>-1</th>
<th>-6</th>
<th>-11</th>
</tr>
</thead>
<tbody>
<tr>
<td>to</td>
<td>to</td>
<td>0</td>
<td>to</td>
<td>to</td>
<td>and</td>
</tr>
<tr>
<td>+6</td>
<td>+1</td>
<td>-5</td>
<td>-10</td>
<td>below</td>
<td></td>
</tr>
</tbody>
</table>

| Number of Classes | 3  | 6  | 3  | 19 | 12 | 2  |

* A negative change indicates a change in the direction of the
teacher's attitudes.

Inspection of Table XXVI reveals that the attitudes of the stu-
dents in a majority of the classes changed in the direction of the at-
titudes of the classroom teacher. Thirty-three classes changed in
the direction of the teacher. Only nine classes developed attitudes
which differed more in the spring. Seven of the teachers in these
nine classes did not teach specifically to change student attitudes toward science and scientific careers.

The t test (117, p. 136) was calculated to determine if the attitudes of the sample of 45 classes changed significantly in the direction of their teacher's attitudes. A significant value was not obtained.

**Interest in Science-Related Vocations**

The shortage of qualified scientists, engineers, technicians, and teachers has been apparent for several years. Investigators have reported school experiences are primary factors in vocational choices. One study by Finkel (45) indicated that students had more interest in science at the junior high level and lost this interest in later school years.

To determine student vocational interest toward science-related careers, the students completed inventories in the fall and the spring. Students checked whether they were interested, not interested, or undecided concerning scientific, engineering, and science teaching vocations. Numerical scores were assigned to changes which occurred from fall to spring. The following values were assigned for each student change:

- No to Yes. ....................... +2
- No to Undecided. ............... +1
Undecided to Yes........................ +1
Yes to Undecided........................ -1
Undecided to No........................... -1
Yes to No................................ -2

Changes for each student were totaled, yielding an estimate of the net change for the class. A positive score indicated a gain in vocational interests; a negative score indicated a net loss of interest in science-related vocations.

Table XXVII lists the class net scores for changes in vocational interests related to scientific and technical careers.

**TABLE XXVII**

| NET SCORES OF CLASS INTEREST CHANGES REGARDING SCIENTIFIC AND TECHNICAL VOCATIONS |
|-----------------------------------------------|----------------|----------------|----------------|----------------|----------------|
| Net Score | -15 | -10 | -5 | +1 | +6 | +11 | Over |
|           | to  | to  | to  | to | to | to  | +16 |
| Number of Classes | 2 | 2 | 7 | 4 | 23 | 5 | 4 | 4 |

Analyses of the data related to vocational interest changes revealed a range from -14 to +26. The median score was +3. The data disclosed student interest in scientific and technological careers increased during the school year.

The largest percentage of the positive gains occurred in classes of teachers with two characteristic patterns: (1) young
teachers rated high in personal adjustment and teacher-pupil relationships and (2) experienced teachers rated high in personal adjustment and with depth and breadth in science preparation.

Nearly all low interest scores occurred in classes of teachers with the following characteristics: (1) young teachers rated average or below average in personal adjustment and teacher-pupil relationships and (2) experienced teachers rated average or below average in either teacher personal adjustment or teacher-pupil relationships.

Further analyses of these teacher factors are presented in the next section, and on Table XLIII, page 175.

Relationship of Student Learning Outcomes to Size of School

Previous investigations by Ryans (102) and others have indicated that student achievement was related to school size. To test this variable for significance, the schools were divided into two groups: (1) schools with over 250 students and (2) those with under 250 student enrollment. Group one was composed of 25 schools while group two was composed of 26 schools.

The null hypothesis, school size does not significantly influence student achievement, was tested for acceptance or rejection at the .05 level of significance by the analysis of covariance.

Table XXVIII lists data and statistics comparing learning outcomes in schools with average daily membership of 250
### TABLE XXVIII

**RELATIONSHIP OF SCHOOL ENROLLMENT TO STUDENT LEARNING OUTCOMES**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Subgroups School Enrollment</th>
<th>k*</th>
<th>( \overline{X}_1^* )</th>
<th>( \overline{X}_2^* )</th>
<th>( \overline{Y}^* )</th>
<th>SS Adjusted for ( X_1 ) and ( X_2 )</th>
<th>F (df:1, 47)</th>
<th>Level of Significance</th>
<th>Adjusted Criterion Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nelson</td>
<td>Over 250</td>
<td>25</td>
<td>110.9</td>
<td>35.3</td>
<td>41.9</td>
<td>404.035</td>
<td>403.988</td>
<td>.048</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>250 &amp; Under</td>
<td>26</td>
<td>105.4</td>
<td>32.3</td>
<td>36.9</td>
<td>210.230</td>
<td>194.176</td>
<td>.386</td>
<td>.10</td>
</tr>
<tr>
<td>Part A, Nelson</td>
<td>Over 250</td>
<td>25</td>
<td>110.9</td>
<td>18.2</td>
<td>23.8</td>
<td>121.722</td>
<td>121.100</td>
<td>.241</td>
<td></td>
</tr>
<tr>
<td></td>
<td>250 &amp; Under</td>
<td>26</td>
<td>105.4</td>
<td>16.8</td>
<td>21.6</td>
<td>113.860</td>
<td>112.983</td>
<td>.364</td>
<td></td>
</tr>
<tr>
<td>W. G. Critical</td>
<td>Thinking</td>
<td>25</td>
<td>110.9</td>
<td>61.4</td>
<td>59.1</td>
<td>224.824</td>
<td>220.303</td>
<td>.943</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Appraisal</td>
<td>26</td>
<td>105.4</td>
<td>58.0</td>
<td>56.0</td>
<td>750.428</td>
<td>747.416</td>
<td>.189</td>
<td></td>
</tr>
<tr>
<td>Attitudes</td>
<td>Over 250</td>
<td>25</td>
<td>110.9</td>
<td>49.2</td>
<td>47.2</td>
<td>113.860</td>
<td>112.983</td>
<td>.364</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>250 &amp; Under</td>
<td>26</td>
<td>105.4</td>
<td>55.5</td>
<td>51.5</td>
<td>113.860</td>
<td>112.983</td>
<td>.364</td>
<td></td>
</tr>
<tr>
<td>Attitudes</td>
<td>Nature of Science</td>
<td>25</td>
<td>110.9</td>
<td>10.1</td>
<td>9.6</td>
<td>113.860</td>
<td>112.983</td>
<td>.364</td>
<td></td>
</tr>
<tr>
<td></td>
<td>250 &amp; Under</td>
<td>26</td>
<td>105.4</td>
<td>11.1</td>
<td>10.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* \( k^* \) = Number of classes in each subgroup.

\( \overline{X}_1^* \) = Subgroup mean Gamma I.Q.

\( \overline{X}_2^* \) = Subgroup mean on pre-test.

\( \overline{Y}^* \) = Subgroup mean on post-test.
students and over to those with under 250 pupils.

To be significant at the .05 level of significance, the F-value with 1 and 47 degrees of freedom must equal or exceed 4.05 (117, p. 421). No significant differences at this level were obtained. A F-value of 3.886, significant at the .10 level, indicated classes in the smaller schools had greater adjusted gains in knowledge and understanding of facts, concepts, and principles.

Summary

A sample of students in 51 Oregon high schools were tested in the fall and spring of the 1962-1963 school year. Student evaluations included: the Nelson Biology Test; the Watson-Claser Critical Thinking Appraisal; the Reaction Inventory, Attitudes Toward Science and Scientific Careers; and the Student Inventory. The following conclusions may be drawn:

1. Gain in knowledge and understanding of facts, concepts, and principles was the primary outcome of participating schools. Students in 48 schools indicated improvement in this area.

2. Gain in skills of applying the methods of science as measured by the Nelson Test, Part B, was not realized by 27 of the 51 schools. This data supported a discussion of teaching problems by Richardson (99, p. 249-252).
in which he indicated teaching for the methods of science is only given "lip service".

3. Gain in critical thinking skills was achieved by 44 of the 51 schools. Gains which occurred, however, were slight.

4. In 40 classes student attitudes toward science and scientific careers were more positive at the end of the school year. While the gain was not large, it was significant at the .10 level and approached the .05 level.

5. Attitudes related to understanding the nature of science showed positive gains in 40 classes. The gains were small, however, and the attitudinal change for the total sample was not statistically significant.

6. Student attitudes tended to become more like those of their teachers during the school year. Thirty-three classes had net attitude changes in the direction of those held by their teachers.

7. Student vocational interest in science-related careers showed an increase during the year.
TEACHER FACTORS

Research has focused on many aspects of teaching to determine factors which contribute to effective learning. One of the complex variables in the school learning situation is the teacher. Research investigations have disclosed teacher factors which have shown significance and lack of significance in various teaching areas.

This section presents statistical analyses of the relationship of learning outcomes to selected teacher factors in biological science education. The relationship of composite success on the learning outcomes is analyzed by comparative percentages to the same teacher factors.

High and low teacher subgroups were identified for the following teacher factors:

1. Teacher age.
3. Total academic preparation in all sciences.
4. Preparation in the sciences in both breadth and depth.
5. Attitudes toward science and scientific careers.
6. Attitudes toward statements related to science teaching.
7. Critical thinking skills.
8. Teacher-pupil relationships.
9. Teacher personal adjustment.
10. Total years of teaching experience.

11. Experience teaching biology.

17. Teacher salary.

13. Number of assigned biology classes.

The significance of each teacher factor was evaluated against five learning outcomes:

1. Gain in knowledge and understanding of facts, concepts, and principles measured by Part A of the Nelson Biology Test.

2. Gain in ability to apply the methods of science measured by Part B of the Nelson Biology Test.

3. Improvement in critical thinking skills measured by the Watson-Glaser Critical Thinking Appraisal.

4. Increased understanding of the nature of science estimated by selected items on the Reaction Inventory, Attitudes Toward Science and Scientific Careers.

5. Development of more positive attitudes toward science and scientists estimated by 91 items on the Reaction Inventory, Attitudes Toward Science and Scientific Careers.

The raw score gain on the total Nelson Test was also investigated.

The class means of teachers in each subgroup were combined
and analyzed by the analysis of covariance adjusting for general scholastic ability and relevant pre-test knowledge. Table XLIII on page 175 summarizes the factors which were significantly related to the learning outcomes.

Teacher Age

Previous research studies have indicated conflicting data concerning the relationship of teacher age to effective teaching. Many investigations have indicated low correlations and insignificant relationships between age and selected criteria. Brandwein (17, p. 67) indicated outstanding teachers in his study averaged approximately 40 years of age.

In the present study, two subgroups of teachers were established. One group comprised teachers 35 years and over, and the other teachers under 35. Available data identified 20 teachers over 35 and 28 under 35 years of age.

Table XXIX lists data from the analysis of covariance computed on the pooled class means for all instruments. To be significant at the .05 level, the F-value with 1 and 44 degrees of freedom must be 4.06 or larger (117, p. 421). Teacher age was not related to any outcome at this level of significance.
TABLE XXIX

RELATIONSHIP OF TEACHER AGE TO STUDENT LEARNING OUTCOMES

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Subgroups Age</th>
<th>k*</th>
<th>X1*</th>
<th>X2*</th>
<th>Y*</th>
<th>SS Adjusted for X1 and X2</th>
<th>F (df1, 44)</th>
<th>Level of Significance</th>
<th>Adjusted Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nelson</td>
<td>35 &amp; Over</td>
<td>20</td>
<td>109.8</td>
<td>35.5</td>
<td>40.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>28</td>
<td>106.6</td>
<td>32.3</td>
<td>38.2</td>
<td>891.328 841.924</td>
<td>2.581</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part A, Nelson</td>
<td>35 &amp; Over</td>
<td>20</td>
<td>109.8</td>
<td>18.2</td>
<td>23.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>28</td>
<td>106.6</td>
<td>16.8</td>
<td>22.1</td>
<td>208.379 204.136</td>
<td>.914</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part B, Nelson</td>
<td>35 &amp; Over</td>
<td>20</td>
<td>109.8</td>
<td>17.2</td>
<td>17.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>Total</td>
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<td>20</td>
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<td>28</td>
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<td>10.5</td>
<td>10.3</td>
<td>108.709 105.982</td>
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k* = Number of classes in each subgroup.
X1 = Subgroup mean Gamma I.Q.
X2 = Subgroup mean on pre-test.
Y = Subgroup mean on post-test.
Academic Preparation

The academic preparation for teaching at specific levels and/or specific subjects has been an area of controversy and concern. Fundamental changes have occurred in the biological sciences since World War II. Broad objectives, including those examined in this investigation, have been identified as learning goals which need to be realized.

Patterns of teacher preparation have been previously analyzed by several investigators (5)(35), though not utilizing exactly the same learning outcomes as employed in this investigation.

Preparation in biology. Two teacher subgroups were established on the basis of quarter hours of preparation in biology. Data indicated 12 teachers had completed 60 or more quarter hours, while 15 teachers had credits for 40 or fewer quarter hours.

Table XXX lists statistics from the analysis of covariance on pooled class means to determine the significance of biological science preparation to learning outcomes.

To be significant at the .05 level, the F-value with 1 and 23 degrees of freedom of 4.28 or larger must be obtained (117, p. 420). No F-values with this significance were computed. Differences at the .10 level of significance were computed on the
### TABLE XXX

RELATIONSHIP OF TEACHER PREPARATION IN BIOLOGY TO STUDENT LEARNING OUTCOMES

<table>
<thead>
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<th>Criteria</th>
<th>Subgroups</th>
<th>Quarter Hours</th>
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<th>$\bar{X}_1*$</th>
<th>$\bar{X}_2*$</th>
<th>$\bar{Y}$*</th>
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<th>F (df:1, 23)</th>
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<tr>
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<td>Under 40</td>
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<tr>
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</tr>
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<td>111.3</td>
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<td>Science</td>
<td>Under 40</td>
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</tbody>
</table>

* $k$ = Number of classes in each subgroup.
* $\bar{X}_1$ = Subgroup mean Gamma I. Q.
* $\bar{X}_2$ = Subgroup mean on pre-test.
* $\bar{Y}$ = Subgroup mean on post-test.
application of the methods of science and development of desirable attitudes.

Classes taught by teachers with over 60 quarter hours of preparation in biology had higher adjusted gains in application of the methods of science than classes taught by teachers with less than 40 hours preparation. Positive changes in student attitudes were related to teachers with less preparation in biology.

**Total preparation in all sciences.** Subgroups were established for teachers with over 100 quarter hours of preparation in all sciences and for those with fewer than 50. Twelve teachers composed the former group, and 11 teachers the latter.

The analysis of covariance was computed on the pooled class mean scores to determine the relationship of preparation in all sciences to learning outcomes. Table XXXI lists data and statistics used in the analysis.

To be significant at the .05 level, the F-value with 1 and 19 degrees of freedom must be 4.38 or greater (117, p. 420). Significant F-values at this level were obtained on the Nelson total score and on Part A of the Nelson Test.

The adjusted mean scores on Part A of the Nelson Test were 20.499 for teachers with over 100 quarter hours of preparation and 22.365 for teachers with under 50 hours. This data indicated that
### TABLE XXXI

**RELATIONSHIP OF TEACHER PREPARATION IN ALL SCIENCES TO STUDENT LEARNING OUTCOMES**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Subgroups</th>
<th>Quarter Hours</th>
<th>( k^* )</th>
<th>( \bar{X}_1^* )</th>
<th>( \bar{X}_2^* )</th>
<th>( \bar{Y}^* )</th>
<th>SS Adjusted for ( X_1 ) and ( X_2 )</th>
<th>( F ) (df:1, 19)</th>
<th>Level of Significance</th>
<th>Adjusted Criterion Means</th>
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<td>12</td>
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<td>37.3</td>
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<td>11</td>
<td>105.2</td>
<td>31.4</td>
<td>36.5</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Part A,</td>
<td>100 &amp; Over</td>
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<td>17.0</td>
<td>21.3</td>
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<td>52.8</td>
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<td>10.9</td>
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</table>

\( k^* = \) Number of classes in each subgroup.

\( \bar{X}_1^* = \) Subgroup mean Gamma I. Q.

\( \bar{X}_2^* = \) Subgroup mean on pre-test.

\( \bar{Y}^* = \) Subgroup mean on post-test.
students in classes taught by teachers with less than 50 hours preparation in all sciences realized better adjusted gains in knowledge and understanding of facts, concepts, and principles than did classes of teachers with more than 100 quarter hours of science.

Comparison of the Nelson total score was also significant primarily due to gains on Part A of the Nelson Test.

The t test (117, p. 136) was computed on the difference between the subgroup means on $X_1$ and the difference between the subgroup means on $X_2$ for both the total Test and Part A. Neither of the t-values were significant.

A difference significant at the .10 level was obtained on attitudes toward science and scientific careers. Data indicated that students in classes of teachers with 100 or more quarter hours of preparation in all sciences had a more positive adjusted gain.

Breadth and depth in science preparation. It was originally planned to investigate the relationship of teachers who fulfilled the AAAS recommended standards (49, p. 281-289) and new Oregon norms for biology teachers compared to those who were most deficient in suggested preparation. Data revealed few teachers in this sample fulfilled either of the above two standards; several individuals, however, lacked only one or two courses to qualify.

Broad training was investigated by establishing two
subgroups. Sixteen teachers were identified who lacked no more than two courses or one physical science area to fulfill the AAAS recommended standard. Thirteen teachers were selected who lacked depth in biology and/or suggested preparation in other science areas.

Statistics and related data from the analysis of covariance comparing teacher subgroups with and without breadth and depth of preparation are listed in Table XXXII.

To be significant at the .05 level, the F-value with 1 and 25 degrees of freedom must be 4.24 (117, p. 420) or greater. An examination of the statistics indicate that no F-values were significant at this level. It may be inferred that breadth and depth of science preparation is not significantly related to the achieving of any single selected outcome.

None of the preparation factors - 60 or more quarter hours in biology, 100 or more hours in all sciences, or breadth and depth in science - were significantly related to separately analyzed student learning outcomes at the .05 level. Extensive preparation in biology approached significance on adjusted mean scores related to the application of the methods of science, Part B of the Nelson Test. Total hours in all sciences was negatively related to the gain in knowledge and understanding of facts, concepts, and principles. Breadth and
TABLE XXXII

RELATIONSHIP OF BREADTH AND DEPTH OF TEACHER SCIENCE PREPARATION TO STUDENT LEARNING OUTCOMES

<table>
<thead>
<tr>
<th>Criteria</th>
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<th>( \bar{X}_2^* )</th>
<th>( \bar{Y}^* )</th>
<th>( \text{SS Adjusted} )</th>
<th>( F )</th>
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<th>Adjusted Criterion Means</th>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Total</td>
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<td></td>
</tr>
<tr>
<td>Nelson</td>
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<td>110.1</td>
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<td>58.8</td>
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<td>558.343</td>
<td>500.422</td>
<td>2.894</td>
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* \( k^* \) = Number of classes in each subgroup.
\( \bar{X}_1^* \) = Subgroup mean Gamma I. Q.
\( \bar{X}_2^* \) = Subgroup mean on pre-test.
\( \bar{Y}^* \) = Subgroup mean on post-test.
depth in science preparation was not significantly related to any individual selected outcome.

Data presented and interpreted in the latter part of this section and in the section on teaching methods bear sharply on the results obtained in this area.

Teacher Attitudes Toward Science and Scientific Careers

The development of favorable and realistic attitudes toward the scientific enterprise and the scientist has become an important objective of secondary school science. Evidence was presented which revealed many students did not have positive attitudes (9, p. 230-246). Other studies have disclosed that while students generally had positive attitudes, they were ignorant or lacked understanding of important science areas (1, p. 38).

Behnke (13, p. 2) suggested that the teachers with unfavorable attitudes toward science and the scientific enterprise might be those who were developing undesirable student attitudes.

To investigate the relationship of the teacher's attitudes toward science and scientific careers to learning outcomes, two subgroups of teachers with attitudinal differences were established. Fourteen teachers with total difference scores on the Reaction Inventory of 70 or less were assigned to a "more positive" group, while 14 teachers with total difference scores of 81 or more were assigned
to a "less positive" group.

Data and statistics from the analysis of covariance comparing learning outcomes to teacher attitudes toward science and scientific careers are presented in Table XXXIII.

To be significant at the .05 level, the F-value with 1 and 24 degrees of freedom must be 4.26 (117, p. 420) or greater. No F-values at this level were obtained.

The analysis comparing the more positive and less positive teacher subgroups on understanding the nature of science yielded the F-value of 4.207, significant at the .10 level. The data indicated that the teachers with less positive attitudes produced greater improvement in student attitudes when class mean gains were adjusted for general scholastic ability and pre-test knowledge.

These results tend to suggest a major obstacle to the development of desirable student attitudes is due to a factor other than the teacher with less positive attitudes. Data analyzed concerning teaching methods and procedures related to developing desirable student attitudes toward science and scientific careers indicated a relatedness between planned teaching for the objective and behavior changes.
### TABLE XXXIII

RELATIONSHIP OF TEACHER ATTITUDES TOWARD SCIENCE AND SCIENTIFIC CAREERS TO STUDENT LEARNING OUTCOMES

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<tr>
<th>Criteria</th>
<th>Subgroups</th>
<th>Attitudes of Teachers</th>
<th>k*</th>
<th>$\bar{X}_1*$</th>
<th>$\bar{X}_2*$</th>
<th>$\bar{Y}$*</th>
<th>SS Adjusted for $X_1$ and $X_2$</th>
<th>F (df1, 24)</th>
<th>Level of Significance</th>
<th>Adjusted Means</th>
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<td>More Positive</td>
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<td>38.1</td>
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<tr>
<td></td>
<td>Less Positive</td>
<td>14</td>
<td>108.6</td>
<td>34.8</td>
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<td>107.4</td>
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<tr>
<td></td>
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<td>14</td>
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<td></td>
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<tr>
<td>Nature of Science</td>
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<td>14</td>
<td>107.4</td>
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</table>

* $k^*$ = Number of classes in each subgroup.
* $\bar{X}_1$ = Subgroup mean Gamma I.Q.
* $\bar{X}_2$ = Subgroup mean on pre-test.
* $\bar{Y}$ = Subgroup mean on post-test.
Teacher Attitudes Toward Statements Related to Science Teaching

In a previous study Behnke (13) formed five statements which evoked significantly different responses from scientists and teachers. She suggested that teachers with unfavorable attitudes might be inculcating undesirable student attitudes.

Two subgroups of teachers were formed to test the significance of teacher attitudes related to science teaching. Seven teachers with "more positive" attitudes comprised one group; nine teachers with "less positive" attitudes formed a second group. The two groups were compared for differences in learning outcomes achieved by their classes.

Data and statistics of the analysis of covariance comparing student outcomes of the two teacher groups are presented in Table XXXIV.

To be significant at the .05 level, the F-value with 1 and 12 degrees of freedom must be 4.75 (117, p. 419) or greater. A value significant at this level was obtained on only one outcome. A value of 5.790 was calculated on student understanding of the nature of science. Adjusted criterion means were 10.952 for the classes of the upper group, and 8.505 for those of the lower group. There were no significant differences between subgroup means on general scholastic ability ($X_1$) or pre-test knowledge ($X_2$).
### Table XXXIV

**Relationship of Teacher Attitudes Toward Science Teaching to Student Learning Outcomes**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Subgroups of Teachers</th>
<th>( k^* )</th>
<th>( \bar{X}_1^* )</th>
<th>( \bar{X}_2^* )</th>
<th>( \bar{Y}^* )</th>
<th>SS Adjusted for ( X_1 ) and ( X_2 )</th>
<th>( F ) (df1, 12)</th>
<th>Level of Significance</th>
<th>Adjusted Criterion Means</th>
</tr>
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<tbody>
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<td><strong>Nelson</strong></td>
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<td>7</td>
<td>106.6</td>
<td>33.9</td>
<td>38.4</td>
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<td>109.2</td>
<td>34.7</td>
<td>40.0</td>
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<tr>
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<td>More Positive</td>
<td>7</td>
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<td>18.0</td>
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<td>109.2</td>
<td>18.0</td>
<td>23.7</td>
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<tr>
<td><strong>Part B, Nelson</strong></td>
<td>More Positive</td>
<td>7</td>
<td>106.6</td>
<td>15.9</td>
<td>16.3</td>
<td>49.317</td>
<td>48.763</td>
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<td>109.2</td>
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<td>17.1</td>
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<tr>
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<td>Thinking</td>
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<td>106.6</td>
<td>58.0</td>
<td>56.9</td>
<td>91.648</td>
<td>84.778</td>
<td>.946</td>
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<td>109.2</td>
<td>60.2</td>
<td>57.3</td>
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<td><strong>Attitudes</strong></td>
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<td>106.6</td>
<td>52.6</td>
<td>49.0</td>
<td>119.198</td>
<td>118.888</td>
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<td>109.2</td>
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<tr>
<td><strong>Nature of Science</strong></td>
<td>More Positive</td>
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<td>57.155</td>
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<td>10.9</td>
<td>9.6</td>
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</tbody>
</table>

\( k^* \) = Number of classes in each subgroup.

\( \bar{X}_1^* \) = Subgroup mean Gamma I. Q.

\( \bar{X}_2^* \) = Subgroup mean on pre-test.

\( \bar{Y}^* \) = Subgroup mean on post-test.
Two limiting conditions must be considered in interpreting this data. Only five statements relating to science teaching were analyzed. A large difference on one or two items strongly influenced the composition of the subgroups. Secondly, the subgroups were small due to the distribution of the teacher difference scores.

Considering these limitations, the analysis of covariance provided evidence which supports a previous finding in this study. Knowledge and preparation in a particular field, or attitudes which were favorable to science were not significantly related to learning outcomes when analyzed separately. Other factors were operating in the teaching process which appeared to be equally important or more important than the teacher possessing single factors of wide preparation or favorable attitudes.

Teacher Critical Thinking Skills

Verbal intelligence and critical thinking skills have been suggested as needed abilities for successful teaching. The increased emphasis on critical thinking as a major outcome of education has furthered this assumption.

To analyze the relationship between the teacher's critical thinking skills and student learning outcomes, two teacher subgroups were selected. One group was composed of thirteen
teachers who obtained raw scores of 76 or above on the Watson-Glaser CTA, Form Zm. Twelve teachers with raw scores of 61 and below comprised the second group.

Table XXXV lists data and statistics from the analysis of covariance calculated to determine the relationship of teacher critical thinking skills to student learning outcomes.

To be significant at the .05 level, the $F$-value with 1 and 21 degrees of freedom must equal or exceed 4.32 (117, p. 420). No $F$-values were obtained at this level of significance.

A $F$-value of 4.194, significant at the .10 level, was calculated on the adjusted class mean scores obtained from the Watson-Glaser Critical Thinking Appraisal. While this did not reveal a strong relationship, it indicated that classes taught by teachers with high critical thinking abilities made greater adjusted gains than those taught by teachers with less ability in this area. Aspects of this relationship should be further investigated to provide more data to guide teacher preparation curriculums.
### RELATIONSHIP OF TEACHER CRITICAL THINKING SKILLS TO STUDENT LEARNING OUTCOMES

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Subgroups Teacher Raw Score</th>
<th>k*</th>
<th>$\bar{X}_1$</th>
<th>$\bar{X}_2$</th>
<th>$\bar{Y}$</th>
<th>SS Adjusted for $X_1$ and $X_2$</th>
<th>F (df:1,21)</th>
<th>Level of Significance</th>
<th>Adjusted Criterion Means</th>
</tr>
</thead>
<tbody>
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<td>76 &amp; Over</td>
<td>13</td>
<td>106.8</td>
<td>32.8</td>
<td>38.5</td>
<td>272.391</td>
<td>252.276</td>
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<tr>
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<td>61 &amp; Under</td>
<td>12</td>
<td>110.3</td>
<td>34.8</td>
<td>41.6</td>
<td>272.391</td>
<td>252.276</td>
<td>1.670</td>
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</tr>
<tr>
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<td>76 &amp; Over</td>
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<td>106.8</td>
<td>16.8</td>
<td>22.0</td>
<td>106.266</td>
<td>105.491</td>
<td>.154</td>
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<tr>
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<td>110.3</td>
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<td>106.8</td>
<td>16.0</td>
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<td>16.6</td>
<td>16.6</td>
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<tr>
<td></td>
<td>61 &amp; Under</td>
<td>12</td>
<td>110.3</td>
<td>16.8</td>
<td>17.6</td>
<td>16.6</td>
<td>16.6</td>
<td>.092</td>
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</tr>
<tr>
<td>W. G. Critical Thinking</td>
<td>76 &amp; Over</td>
<td>13</td>
<td>106.8</td>
<td>58.9</td>
<td>57.7</td>
<td>116.850</td>
<td>97.300</td>
<td>4.194</td>
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<td>110.3</td>
<td>61.5</td>
<td>58.3</td>
<td>116.850</td>
<td>97.300</td>
<td>4.194</td>
<td>.10</td>
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<td>110.3</td>
<td>51.8</td>
<td>48.8</td>
<td>435.917</td>
<td>419.374</td>
<td>.828</td>
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<td>Attitudes</td>
<td>Nature of Science</td>
<td>76 &amp; Over</td>
<td>13</td>
<td>106.8</td>
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<td>110.3</td>
<td>10.8</td>
<td>9.9</td>
<td>77.876</td>
<td>76.536</td>
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</table>

$k^* = \text{Number of classes in each subgroup.}$  
$\bar{X}_1 = \text{Subgroup mean on Gamma I. Q.}$  
$\bar{X}_2 = \text{Subgroup mean on pre-test.}$  
$\bar{Y} = \text{Subgroup mean on post-test.}$
Teacher-Pupil Relationships

Teacher-pupil relationships have been stressed as an important factor in the learning situation. To determine the relationship between teacher-pupil relationships and the selected learning outcomes, two subgroups were formed. Sixteen teachers with ratings of 22 or above on the Teacher Rating Scale were placed in one group; 17 with ratings of 18 or below were placed in a second group.

The analysis of covariance was conducted on the pooled class means. Table XXXVI lists data and statistics from the comparisons of the two groups. To be significant at the .05 level, a F-value with 1 and 29 degrees of freedom must be 4.18 (117, p. 421) or larger.

The subgroup of teachers with high scores on teacher-pupil relationships was significantly related to the development of desirable attitudes by students. A F-value of 29.254 was calculated which was significant at the .001 level (117, p. 418). Adjusted criterion means were 8.731 for the high group and 11.438 for the low group.

The t test on pooled class means of general scholastic ability and pre-test knowledge indicated significant differences at the .01 level. Wert (117, p. 136) and Cornell (27, p. 292) have indicated that unless extreme departure in homogeniety occurs, the F test will not be appreciably influenced.
**TABLE XXXVI**

RELATIONSHIP OF TEACHER-PUPIL RELATIONSHIPS TO STUDENT LEARNING OUTCOMES

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Subgroups</th>
<th>Ratings by Principals</th>
<th>k*</th>
<th>$\overline{X}_1^*$</th>
<th>$\overline{X}_2^*$</th>
<th>$\overline{Y}^*$</th>
<th>SS Adjusted for $X_1$ and $X_2$</th>
<th>$F$ (df:1, 29)</th>
<th>Level of Significance</th>
<th>Adjusted Criterion Means</th>
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<td></td>
<td></td>
<td>Total</td>
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<tr>
<td></td>
<td>Nelson</td>
<td>High Ranking</td>
<td>16</td>
<td>110.7</td>
<td>35.4</td>
<td>42.3</td>
<td>240.970</td>
<td>230.798</td>
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<td>Total</td>
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<td>105.2</td>
<td>31.8</td>
<td>35.9</td>
<td>126.567</td>
<td>125.653</td>
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<td>18.3</td>
<td>23.9</td>
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<td>105.2</td>
<td>16.5</td>
<td>20.6</td>
<td>121.259</td>
<td>110.151</td>
<td>29.254</td>
<td>8.731</td>
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<td>High Ranking</td>
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<td>110.7</td>
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<td>544.90</td>
<td>494.86</td>
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<td>48.6</td>
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*\(k^* = \) Number of classes in each subgroup.

\(\overline{X}_1^* = \) Subgroup mean Gamma I. Q.

\(\overline{X}_2^* = \) Subgroup mean on pre-test.

\(\overline{Y}^* = \) Subgroup mean on post-test.
A $F$-value of 3.157, significant at the .10 level, was obtained on student changes in attitudes toward science and scientific careers. Adjusted mean gains indicated the teachers ranking high in teacher-pupil relationships were related to classes developing positive attitudes.

This data revealed that student attitudinal changes were related to the teacher's teacher-pupil relationships. A positive relationship was previously noted between teacher-pupil relationships and students showing an interest in science-related vocations.

Teacher Personal Adjustment

A factor which has received considerable emphasis is the personal adjustment of the teacher. Ryans (102), Reed (97), and Van Allenstein (113) have indicated the personality and adjustment of the teacher are important to classroom success.

Subgroups for this analysis were comprised of teachers receiving ratings of 22 and over in one group and teachers receiving ratings of 19 or lower in a second group.

Table XXXVII presents data and statistics used in the analysis of covariance to determine differences between classes taught by teachers ranking high in personal adjustment and those taught by teachers ranking low.

To be significant at the .05 level, a $F$-value with 1 and 29
TABLE XXXVII

RELATIONSHIP OF TEACHER PERSONAL ADJUSTMENT TO STUDENT LEARNING OUTCOMES

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Subgroups</th>
<th>Ratings by Principals</th>
<th>k*</th>
<th>( \bar{X}_1^* )</th>
<th>( \bar{X}_2^* )</th>
<th>( \bar{Y}^* )</th>
<th>SS Adjusted for ( X_1 ) and ( X_2 ) Total</th>
<th>Within</th>
<th>( F ) (df1, 29)</th>
<th>Level of Significance</th>
<th>Adjusted Criterion Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nelson</td>
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<td>109.1</td>
<td>34.3</td>
<td>40.6</td>
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<td>37.27</td>
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<td>60.1</td>
<td>58.6</td>
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<td>139.905</td>
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<tr>
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<td>Low Ranking</td>
<td>17</td>
<td>105.9</td>
<td>57.9</td>
<td>55.5</td>
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<tr>
<td>Attitudes</td>
<td>High Ranking</td>
<td>16</td>
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<td>49.8</td>
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<td>2.924</td>
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<td>58.1</td>
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<tr>
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<td>Nature of Science</td>
<td>High Ranking</td>
<td>16</td>
<td>109.1</td>
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<td>10.270</td>
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<td>105.9</td>
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</tr>
</tbody>
</table>

\( k^* \) = Number of classes in each subgroup.

\( \bar{X}_1^* \) = Subgroup mean Gamma I. Q.

\( \bar{X}_2^* \) = Subgroup mean on pre-test.

\( \bar{Y}^* \) = Subgroup mean on post-test.
degrees of freedom must be 4.18 (117, p. 421) or larger. Significant differences at this level existed between the two groups on two outcomes and the total Nelson Test.

A F-value of 5.913 was obtained on Part A of the Nelson Biology Test which measured student gain in knowledge and understanding of facts, concepts, and principles. The adjusted class criterion mean of the high ranking teachers was 22.304, and that of the lower group was 21.710. This data indicated that classes taught by teachers ranked high in personal adjustment made greater gains.

The t-test was calculated to determine differences between subgroup Otis means and pre-test means. The t-test on the means of the Otis scores ($X_1$) and pre-test scores ($X_2$) were not significant.

Classes taught by teachers ranked high in personal adjustment realized a better adjusted gain in understanding science. The high ranking subgroup had an adjusted mean of 9.453, while the low ranking group had an adjusted mean of 10.270. The t-test (117, p. 136) was calculated to determine the differences between the subgroup means, $X_1$ and $X_2$. The t-value obtained on $X_1$ was not significant, while the t-test calculated on subgroup $X_2$ means indicated a significant difference existed at the .01 level.
Critical thinking achievement and positive changes in student attitudes toward science and scientific careers were related to high teacher adjustment at the .10 level.

Positive gains on four of the selected learning outcomes were related to the teacher's personal adjustment at the .10 or .05 levels of significance. These relationships reveal personal adjustment ratings on the Teacher Rating Scale identified a group of teachers whose classes realized greater achievement than a second group of teachers whose classes indicated a lower achievement level. While the levels of significance attained were not high, further research with the use of this instrument is warranted.

**Total Teaching Experience**

Teaching experience has usually been found to have low correlation with teacher efficiency.

In this investigation classes of teachers with ten years experience and over were compared to classes of teachers with three or fewer years experience. Table XXXVIII lists the data and statistics of the analysis of covariance.

To be significant at the .05 level, a F-value with 1 and 24 degrees of freedom must be 4.26 (117, p. 420) or larger. No values approached this requirement.
### Table XXXVIII

**Relationship of Total Teaching Experience to Student Learning Outcomes**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Subgroups</th>
<th>Years of Experience</th>
<th>k*</th>
<th>$\bar{X}_1^*$</th>
<th>$\bar{X}_2^*$</th>
<th>$\bar{Y}^*$</th>
<th>SS Adjusted for $X_1$ and $X_2$</th>
<th>F (df:1, 24)</th>
<th>Level of Significance</th>
<th>Adjusted Means</th>
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<td>17</td>
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<td>35.9</td>
<td>41.6</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
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<td>1-3</td>
<td>11</td>
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<td>665.439</td>
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<td>11</td>
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<td>1-3</td>
<td>11</td>
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<td>16.6</td>
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<td>17</td>
<td>11</td>
<td>110.4</td>
<td>17.2</td>
<td>17.7</td>
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<td></td>
<td></td>
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<td>11</td>
<td>108.1</td>
<td>16.1</td>
<td>16.6</td>
<td>48.437</td>
<td>48.297</td>
<td>0.069</td>
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<tr>
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<td>10 &amp; Over</td>
<td>17</td>
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<td>61.4</td>
<td>58.9</td>
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<td></td>
<td>Appraisal</td>
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<td>60.2</td>
<td>56.8</td>
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<td><strong>Attitudes</strong></td>
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<td>110.4</td>
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<td>48.4</td>
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<td></td>
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<td>11</td>
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<td><strong>Attitudes</strong></td>
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<td>10 &amp; Over</td>
<td>17</td>
<td>110.4</td>
<td>10.6</td>
<td>9.5</td>
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</table>

$k^* = \text{Number of classes in each subgroup.}$

$\bar{X}_1^* = \text{Subgroup mean Gamma I. Q.}$

$\bar{X}_2^* = \text{Subgroup mean on pre-test.}$

$\bar{Y}^* = \text{Subgroup mean on post-test.}$
An analysis of individual teachers revealed several teachers with 10-27 years experience whose classes made excellent gains. There were, however, several teachers with over ten years experience whose classes showed no gain or very little gain on any criterion. The same patterns were found among inexperienced teachers.

**Total Biology Teaching Experience**

Biology teaching experience was analyzed for relatedness to the five learning outcomes. Two subgroups were formed; one of 13 teachers with 10 or more years of biology teaching experience, and a second of 16 teachers with three years or less.

Table XXXIX lists data and statistics from the analysis of covariance used to analyze differences in learning outcomes achieved by the teacher subgroups.

To be significant at the .05 level, a F-value with 1 and 25 degrees of freedom must equal or exceed 4.24 (117, p. 420). No statistical tests approached this value.

From the statistical data, it can be interpreted that experience of ten or more years of teaching biology was not significantly related to any of the individual learning outcomes. Experience was also not directly related to increased vocational interest by students.
### TABLE XXXIX
RELATIONSHIP OF BIOLOGY TEACHING EXPERIENCE TO STUDENT LEARNING OUTCOMES

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Subgroups</th>
<th>Years of Experience</th>
<th>$k^*$</th>
<th>$\bar{X}_1^*$</th>
<th>$\bar{X}_2^*$</th>
<th>$\bar{Y}^*$</th>
<th>SS Adjusted for $X_1$ and $X_2$</th>
<th>Level of Significance</th>
<th>Adjusted Means</th>
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<td>32.8</td>
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<td>10</td>
<td>110.4</td>
<td>35.8</td>
<td>41.5</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Part B, Nelson</td>
<td>10 &amp; Over</td>
<td>13</td>
<td>110.4</td>
<td>35.8</td>
<td>41.5</td>
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<tr>
<td></td>
<td>W. G. Critical Thinking</td>
<td>10 &amp; Over</td>
<td>10</td>
<td>110.4</td>
<td>61.5</td>
<td>59.2</td>
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<td></td>
<td></td>
</tr>
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<td></td>
<td>Appraisal</td>
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<td>56.8</td>
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<td>111.659</td>
<td>.147</td>
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<td>Attitudes</td>
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<td>110.4</td>
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<td>50.4</td>
<td>345.526</td>
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<td>Attitudes</td>
<td>Nature of Science</td>
<td>10 &amp; Over</td>
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<td></td>
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<td>10.0</td>
<td>41.569</td>
<td>41.521</td>
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</table>

$k^*$ = Number of classes in each subgroup.

$\bar{X}_1^*$ = Subgroup mean on pre-test.

$\bar{X}_2^*$ = Subgroup mean on post-test.

$\bar{Y}^*$ = Subgroup mean on post-test.
It would appear to this researcher at least two selective factors should favor experienced teacher subgroups: (1) knowledge and application of teaching processes and (2) loss of teachers who are not interested in teaching.

Evidence from this and other investigations in this area indicate that factors are operating which eliminate the advantage of the selectivity suggested above.

These findings concerning the relationship of teacher experience to a variety of outcomes raise serious questions concerning in-service education, classroom supervision, classroom evaluation, and salary schedules.

Teacher Salary

A previous investigation (53) by the BSCS reported a significance between teacher salary and learning outcomes. Teachers, administrators, and teacher educators in Oregon requested an investigation of teacher salary be included in this study.

Two subgroups were formed; one comprised teachers earning $7,000 or more and a second of those earning under $5,000. Table XL presents data and statistics from the analysis of covariance used to compare learning outcomes attained by classes of the two subgroups.
### TABLE XL

RELATIONSHIP OF TEACHER SALARY TO STUDENT LEARNING OUTCOMES

<table>
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<tr>
<th>Criteria</th>
<th>Subgroups</th>
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<th>$\bar{X}_2^*$</th>
<th>$\bar{Y}^*$</th>
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<th>F (df:1, 16)</th>
<th>Level of Significance</th>
<th>Adjusted Criterion Means</th>
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<td></td>
<td>Total</td>
<td>Within</td>
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<td>111.9</td>
<td>36.5</td>
<td>43.0</td>
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<td>106.8</td>
<td>17.2</td>
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<td>10</td>
<td>106.8</td>
<td>16.8</td>
<td>15.8</td>
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<tr>
<td>W. G. Critical</td>
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<td>111.9</td>
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<td>60.4</td>
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<td>59.2</td>
<td>56.4</td>
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</tbody>
</table>

$k^*$ = Number of classes in each subgroup.

$\bar{X}_1^*$ = Subgroup mean Gamma I. Q.

$\bar{X}_2^*$ = Subgroup mean on pre-test.

$\bar{Y}^*$ = Subgroup mean on post-test.
To be significant at the .05 level, the F-value with 1 and 16 degrees of freedom must equal or exceed 4.49 (117, p. 420). Inspection of the calculations clearly indicated a high teacher salary factor was not significantly related to individual selected learning outcomes. The analyses on composite success, however, indicated a relationship between high salary and total student gain.

Teacher salary is a factor complicated by many variables. Teachers with highest salaries in this study included teachers with ten or more years experience, coaches, and counselors. Thus, at least in this study, the higher salary often reflected additional duties which required extra teacher time.

The results obtained for teacher salary differ from those of the BSCS investigation. The two studies are not, however, directly comparable. The BSCS study involved primarily schools with large enrollments. In this study, 50 percent of the schools had enrollments under 250 students. This investigator also could not determine evidence of a pre-test to control relevant knowledge in the BSCS investigation. Bloom has stated (47, p. 385) that relevant pre-test knowledge should be controlled.

Number of Assigned Biology Classes

School enrollments in many communities in Oregon are not sufficient to provide the assignment of a teacher to a single subject
area. In larger schools, teachers often are assigned to a specific area related to their specialty. Considerable concern has focused on this situation. Are there significant differences in the learning outcomes realized by students of teachers teaching primarily in one area compared to students taught by a teacher with a multiple assignment?

The learning outcomes of classes taught by teachers with four or more assigned biology classes were compared to those of teachers teaching two or fewer classes. Table XLI presents data and statistics from the analysis of covariance.

To be significant at the .05 level, a F-value with 1 and 27 degrees of freedom must equal or exceed 4.21 (117, p. 421).

Inspection of the data and statistics revealed students with teachers having fewer biology classes obtained a higher adjusted gain on Part B of the Nelson Test. The t-test (117, p. 136) was conducted to determine if there were significant differences between the Otis means ($X_1$) or the pre-test means ($X_2$) of the two groups. Significant differences existed between the two subgroups on both means at the .02 level. Therefore, since this objective was not realized by most classes regardless of scholastic ability and pre-test knowledge, the adjusted gain was primarily due to these differences.
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<th>$\bar{X}_1^*$</th>
<th>$\bar{X}_2^*$</th>
<th>$\bar{Y}^*$</th>
<th>SS Adjusted for $X_1$ and $X_2$</th>
<th>$F$ (df:1, 27)</th>
<th>Level of Significance</th>
<th>Adjusted Criterion Means</th>
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<td>56.3</td>
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<td>54.8</td>
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<td>113.1</td>
<td>10.4</td>
<td>9.4</td>
<td>112 056</td>
<td>107.524</td>
<td>1.138</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Two or Fewer</td>
<td>18</td>
<td>105.3</td>
<td>11.1</td>
<td>10.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$k$ = Number of classes in each subgroup.

$\bar{X}_1$ = Subgroup mean Gamma I. Q.

$\bar{X}_2$ = Subgroup mean on pre-test.

$\bar{Y}$ = Subgroup mean on post-test.
Relationship of Teacher Factors to Composite Success in Teaching Biology

Science education should stress the realization of broad objectives if it is to fulfill its purposes to society (79, p. 209). The five learning outcomes selected for analysis in this study provided an evaluation of important areas of biological science education.

Teacher factors have been compared for significance to single outcomes in the first part of this section. Classes of successful teachers in biology, however, should succeed in more than one learning area.

To determine if there were differences between successful and less successful teachers on composite outcomes, two subgroups of teachers were established. A teacher whose class had mean gains in the upper 25-33 percent of the classes on three or more outcomes was classified as achieving composite success. Eleven teachers were judged to have achieved composite success. A second subgroup was formed of ten teachers with classes in the lowest 25-33 percent of the classes on three or more learning outcomes. Differences in teacher factors were analyzed to test the null hypothesis that there were no differences between teachers of classes attaining broad objectives compared to those who did not.

Table XLII lists the percentage of teachers in each subgroup who were in the categories listed for each characteristic.
TABLE XLII

RELATIONSHIP OF TEACHER FACTORS TO COMPOSITE SUCCESS IN TEACHING BIOLOGY*

<table>
<thead>
<tr>
<th>Teacher Factor</th>
<th>Number of Teachers in Each Subgroup</th>
<th>Percent of Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 35</td>
<td>45</td>
<td>30</td>
</tr>
<tr>
<td>Under 35</td>
<td>55</td>
<td>70</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Teaching Experience</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 10 Years</td>
<td>55</td>
<td>20</td>
</tr>
<tr>
<td>Under 10 Years</td>
<td>45</td>
<td>80</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Experience Teaching Biology</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 10 Years</td>
<td>45</td>
<td>20</td>
</tr>
<tr>
<td>Under 10 Years</td>
<td>55</td>
<td>80</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Salary</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Over $7,000</td>
<td>55</td>
<td>10</td>
</tr>
<tr>
<td>Under $5,000</td>
<td>9</td>
<td>50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Preparation in All Sciences</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 100 Hours</td>
<td>27</td>
<td>30</td>
</tr>
<tr>
<td>Under 50 Hours</td>
<td>18</td>
<td>30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Breadth and Depth in Science Preparation</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wide</td>
<td>55</td>
<td>30</td>
</tr>
<tr>
<td>Limited</td>
<td>27</td>
<td>60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Preparation in Biology</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 60 Hours</td>
<td>55</td>
<td>20</td>
</tr>
<tr>
<td>Under 40 Hours</td>
<td>27</td>
<td>50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Assigned Biology Classes</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Four or More</td>
<td>55</td>
<td>10</td>
</tr>
<tr>
<td>Two or Fewer</td>
<td>27</td>
<td>40</td>
</tr>
</tbody>
</table>

*The table should be read, 45 percent of the 11 more successful teachers were over 35, while 55 percent were under 35.
TABLE XLII (continued)

<table>
<thead>
<tr>
<th>Teacher Factor</th>
<th>Number of Teachers in Each Subgroup</th>
<th>Percent of Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11</td>
<td>More</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Successful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Successful</td>
</tr>
<tr>
<td>Number of Teachers in Each Subgroup</td>
<td>11</td>
<td>More</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Successful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Successful</td>
</tr>
<tr>
<td>Attitudes Toward Science and Scientific Careers</td>
<td>11</td>
<td>More</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Successful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Successful</td>
</tr>
<tr>
<td>Attitudes Toward Science Teaching</td>
<td>11</td>
<td>More</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Successful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Successful</td>
</tr>
<tr>
<td>Critical Thinking Skills</td>
<td>11</td>
<td>More</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Successful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Successful</td>
</tr>
<tr>
<td>Teacher-Pupil Relationships</td>
<td>11</td>
<td>More</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Successful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Successful</td>
</tr>
<tr>
<td>Personal Adjustment</td>
<td>11</td>
<td>More</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Successful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Successful</td>
</tr>
</tbody>
</table>
A comparison of teacher age on Table XLII reveals a slight difference in the ages of the teachers of the two groups. The more successful teachers were older than the less successful.

Analysis of teaching experience, Table XLII, discloses the more successful teachers had more total teaching experience and had also been teaching biology longer. Eighty percent of the teachers whose classes had low gains had been teaching biology for less than ten years.

A difference in salary, Table XLII, also was noted between the two groups. Fifty-five percent of the more successful teachers received salaries of $7,000 or over, while only ten percent of the teachers in the low group received salaries in this range. These percentages are closely related to the percentage of teachers who had been teaching for ten years or more.

An analysis of the preparation in science of these two groups reveals important differences.

Nearly equal percentages of the teachers in each group, Table XLII, had over 100 quarter hours of preparation in all sciences. Fewer of the more successful teachers had limited preparation. The median preparation in all sciences was 60 quarter hours for the upper group and 45 for the lower group.

Broad science preparation, Table XLII, was evident in
teachers with composite success; a majority of the teachers with limited success lacked breadth and depth of preparation.

A comparison of preparation in biology, Table XLII, presents nearly the same differences as those in broad preparation. The more successful teachers had greater preparation in biology. The median for the upper subgroup was 50 quarter hours, while the median for the lower group was 31 quarter hours. Four of the six teachers in the study who had earned less than 25 quarter hours were in the lower group. None of the teachers in the upper group had earned fewer than 36 quarter hours of credit. It may be concluded from this sample that composite success is related to depth and breadth of preparation.

A greater percentage of the teachers in the upper group were assigned four or more classes, Table XLII. These percentages suggest that composite success is achieved to a greater extent by teachers who are assigned primarily in one subject when this is their area of preparation.

An analysis of the teacher's critical thinking skills, Table XLII, reveals little difference between the two groups. A slightly greater percentage of the lower teachers were low in critical thinking abilities.

Favorable attitudes toward science and scientific careers were
related to composite success, Table XLII. The percentage of
teachers with less favorable attitudes was about equal in each
group. Twenty-seven percent of the teachers who achieved com-
posite success were in the high teacher subgroup on attitudes. No
teacher in the low group possessed more favorable attitudes.

The items related to attitudes toward science teaching,
Table XLII, on the teacher Reaction Inventory did not discrimi-
ate between the two groups. None of the teachers in either sub-
group were included among sample teachers with attitudes clos-
est to those of the panel. The mean of the higher group, however,
indicated their attitudes were closer to the scientists than were the
teachers in the low subgroup.

Principals' ratings of teacher-pupil relationships and per-
sonal adjustment discriminated between successful and unsuccess-
ful teachers. Comparisons of percentages obtained on teacher-pupil
relationships, Table XLII, indicated 36 percent of the teachers in
the more successful group ranked high in teacher-pupil relation-
ships, while 27 percent ranked low. Fifty percent of the less
successful teachers ranked low in teacher-pupil relationships
while only 20 percent ranked high.

Differences between the subgroups were more extreme on
personal adjustment ratings, Table XLII. Forty-five percent of
the teachers in the upper group ranked high in personal adjustment, while 27 percent ranked low. Only ten percent of the low group ranked high in adjustment, while 60 percent of the low group ranked low in adjustment.

Data obtained on these two teacher factors, teacher-pupil relationships and personal adjustment, suggest that principals are aware of teachers who are not effective due to specific problems.

Summary

Single teacher factors were analyzed by the analysis of covariance for significant relationship to specific learning outcomes. Teacher factors were also analyzed by comparative procedures for relatedness to composite success.

The following teacher factors were found by the analysis of covariance to be positively related to the learning outcomes.

1. Gain in knowledge and understanding of facts, concepts, and principles.
   a. Teachers rated high in personal adjustment by principals (.05).
   b. Teachers with 50 quarter hours or less in all sciences (.05).
2. Gain in skills to apply the methods of science.
   a. Two or fewer biology classes (.01).
   b. Teachers with 60 or more hours of biology (.10).

3. Gain in critical thinking skills.
   a. High teacher score on the CTA (.10).
   b. High rating in personal adjustment (.10).

4. Development of favorable attitudes toward science and scientific careers. Five factors were significant at the .10 level. No factor was significant at the .05 level or above. The discussion on teaching methods presents important findings related to this outcome.

5. Development of an understanding of the nature of science.
   a. High rating in teacher-pupil relationships (.001).
   b. High rating in personal adjustment (.05).
   c. Low teacher attitudes toward science teaching and the scientific enterprise (.05 and .10 respectively).

Modern science teaching emphasizes the accomplishment of several broad objectives. Therefore, a teacher whose classes realized a greater number of these objectives was considered a more successful teacher than one who did not. It is the opinion of this investigator that the relationship of teacher factors to teaching success, when viewed in this manner, provides a general framework
for teacher preparation and school administration.

Teachers whose classes were in high extreme subgroups on three or more learning outcomes were compared to teachers whose classes were in low extreme groups on three or more outcomes.

The following factors were related to composite success: (1) total teaching experience; (2) total biology experience; (3) salary of over $7,000 compared to a salary of under $5,000; (4) breadth and depth in science preparation; (5) over 60 quarter hours preparation in biology; (6) favorable teacher attitudes toward science and scientific careers; (7) high rating on teacher-pupil relationships; and (8) high rating on teacher personal adjustment.

Table XLIII summarizes the teacher factors related to specific learning outcomes and to composite success.
### TABLE XLIII

**RELATIONSHIP OF LEARNING OUTCOMES TO TEACHER AND SCHOOL FACTORS**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Knowledge and Understanding of Facts, Concepts, and Principles</th>
<th>Application of the Method of Science</th>
<th>Critical Thinking Skills</th>
<th>Attitudes Toward Science and Scientific Careers</th>
<th>Understanding of the Nature of Science</th>
<th>Total Nelson</th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prepar. in Biology</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prepar. in All Sciences</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breadth and Depth in Science</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attitudes Toward Science and Scientific Careers</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attitudes Toward Science Teaching</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical Thinking Skills</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher-Pupil Relationships</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher Personal Adjustment</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Teaching Experience</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experience Teaching Biology</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*H = High subgroup.  
L = Low subgroup.  
.10 = This level of significance suggests areas for further research.  
C = Positively related to composite success.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Knowledge and Understanding of Facts, Concepts, and Principles</th>
<th>Application of the Methods of Science</th>
<th>Critical Thinking Skills</th>
<th>Attitudes Toward Science</th>
<th>Attitudes Toward Scientific Careers</th>
<th>Understanding of the Nature of Science</th>
<th>Total Nelson</th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Salary</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Assigned</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Biology Classes</td>
<td><strong>.01</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School Size</td>
<td>H</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.10</td>
</tr>
</tbody>
</table>

*H = High subgroup.*  
*L = Low subgroup.*  
**.01** = This level of significance suggests areas for further research.  
*C = Positively related to composite success.*
METHODS OF TEACHING

Previous research investigations have suggested there is no one best method of teaching biology. Investigators and reviewers have stated methods should vary with the desired objective to be attained and the students involved.

This study investigated three factors related to methods of teaching biology. The following null hypotheses guided the study:

1. Selected learning outcomes are not realized more effectively by planned, direct teaching.

2. Specific methods or combinations of methods of teaching are not related to the realization of the selected learning outcomes.

3. There is no statistical difference in the realization of the selected learning outcomes in classes which follow a basic text as compared to other types of course organization.

The investigation of hypotheses one and two are discussed together, followed by a presentation of the data related to hypothesis three.

Data for investigating the relatedness of planned teaching and methods of teaching to the realization of the selected outcomes were
obtained from responses to the Teacher Inventory, student class mean gains on the evaluation instruments, and conferences and correspondence with teachers.

In part 14 of the Teacher Inventory, the five selected learning objectives of biology education were listed. These were:

1. The student can demonstrate increased knowledge and understanding of basic biological facts, concepts, and principles.
2. The student is able to apply the methods of science.
3. The student can show evidence of improving his ability to think critically.
4. The student can demonstrate attitudes which indicate an understanding of the nature of science.
5. The student can demonstrate a desirable improvement in his concept of the scientist and of scientific careers.

Under each listed objective the teacher indicated if he planned and taught to accomplish the stated objective. If the teacher checked yes, a second statement requested the method or methods he utilized to teach for the objective. Methods listed were:

1. Recitations from textbook assignments.
2. Free discussion based on topical assignments.
3. Lecture-demonstration combination.
4. Demonstration-discussion combination.
5. Lecture.
6. Laboratory.
7. Laboratory-discussion combination.
8. Project.
9. (Space for others).

The teachers were also asked to indicate which methods they believed to be most successful in realizing the objective and to describe what the students actually did when the selected methods were being used.

Responses to these statements and questions were tabulated for each teacher. Two teacher subgroups were formed to investigate each objective by selecting teachers with classes with the highest mean class gains and those with the lowest mean class gains. If a teacher were in one of the selected subgroups and his responses to the inventory did not clearly indicate methods utilized, the teacher was contacted by the researcher to obtain further information.

Objective One - The Student Can Demonstrate Increased Knowledge and Understanding of Basic Biological Facts, Concepts, and Principles

Two teacher subgroups were formed on the basis of class mean gains to Part A of the Nelson Biology Test. One group was composed of 14 teachers with classes achieving mean gains of
seven or more points. A second group of 17 teachers was established on the basis of classes which attained class mean gains of four points or less. Only three classes of the total 51 did not show a net gain during the school year.

The mean Gamma I. Q. of classes in the upper subgroup was 111, while the mean Gamma I. Q. of classes in the lower subgroup was 105.

Data for both subgroups were analyzed for differences in teacher planning, teaching methods, and student activities.

Table XLIV lists the number of teachers for each subgroup who did or did not plan to accomplish the stated objective.

TABLE XLIV

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>Did Teach</th>
<th>Did Not Teach</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>High group</td>
<td>11</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Low group</td>
<td>12</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

The data in Table XLIV indicates nearly all teachers in both subgroups taught for this goal. Only two of the total 45 responding teachers indicated they did not. Positive gains were realized by all but three of the total sample classes. Differences in achievement
cannot be ascertained from those who did teach and those who did not teach for this objective.

Teachers who did teach for this objective indicated the methods they utilized by checking methods listed on the Teacher Inventory or adding others. Table XLV presents the methods which the teachers used. The number of methods used is greater than the number of teachers because most teachers indicated more than one method was utilized.

An analysis of the data presented in Table XLV reveals several important differences between methods utilized by the teachers in the two subgroups. Teachers of classes who achieved low gains reported greater use of the following methods: textbook recitations, free discussion, lecture-demonstration combination, demonstration-discussion, and lecture. Teachers in the high gain subgroup utilized the laboratory-discussion method more extensively than the low group. Three teachers also reported out-of-class reading assignments as a method used to realize this objective.

The data in Table XLV and teacher descriptions of student activities indicate a greater emphasis by teachers in the high group on procedures which provide for student involvement. Observing and handling a variety of biological materials and organizing, relating, and discussing results of experimentations were characteristic student behaviors.
### TABLE XLV

METHODS UTILIZED TO TEACH FOR KNOWLEDGE AND UNDERSTANDING OF BIOLOGICAL FACTS, CONCEPTS, AND PRINCIPLES

<table>
<thead>
<tr>
<th>Method</th>
<th>Teachers Who Taught For This Objective</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High Subgroup</td>
<td>Low Subgroup</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number</td>
<td>Percent</td>
<td>Number</td>
<td>Percent</td>
<td></td>
</tr>
<tr>
<td>Recitations from textbook assignments</td>
<td>2</td>
<td>18</td>
<td>5</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Free discussion based on topical assignments</td>
<td>4</td>
<td>36</td>
<td>6</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Lecture-demonstration combination</td>
<td>4</td>
<td>36</td>
<td>7</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>Demonstration-discussion combination</td>
<td>3</td>
<td>27</td>
<td>7</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>Lecture</td>
<td>3</td>
<td>27</td>
<td>8</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>Laboratory</td>
<td>3</td>
<td>27</td>
<td>4</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Laboratory-discussion combination</td>
<td>9</td>
<td>82</td>
<td>5</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Project</td>
<td>4</td>
<td>36</td>
<td>5</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Assigned out-of-class reading</td>
<td>3</td>
<td>27</td>
<td>0</td>
<td>--</td>
<td></td>
</tr>
</tbody>
</table>

**Objective Two - The Student Is Able to Apply the Methods of Science**

Two teacher subgroups were established on the basis of class mean gains to Part B of the *Nelson Biology Test*. Fourteen teachers
of classes which achieved mean gains of two or more points composed the high subgroup. Eighteen teachers of classes with mean gains of minus one point or lower formed the low subgroup.

The mean Gamma I. Q. of classes in the upper subgroup was 109 while the mean Gamma I. Q. of classes in the lower group was 106.

Data for the subgroups were analyzed for differences in teacher planning, teaching methods, and student activities.

Table XLVI lists the number of teachers for each group who did or did not teach to realize the objective.

### TABLE XLVI

**TEACHERS WHO DID AND DID NOT PLAN AND TEACH FOR THE APPLICATION OF THE METHODS OF SCIENCE**

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>Did Teach</th>
<th>Did Not Teach</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>High group</td>
<td>10</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Low group</td>
<td>12</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

The majority of the teachers in both subgroups taught for this objective. Of 45 teachers who responded to this question, eight indicated they did not plan and teach to accomplish this objective. Half of the teachers who did not teach for the objective were in the lower group; however, calculated percentage differences do not warrant comparative generalizations.
The teachers indicated the methods they utilized to teach for this objective by checking the listed methods or adding others. Table XLVII lists the methods which the teachers indicated they used. The number of methods reported is greater than the number of teachers because several teachers reported utilizing more than one method.

Data in Table XLVII reveal that more teachers in the low group used the lecture and demonstration-discussion methods than did teachers in the high group. More teachers of high gain classes, on the other hand, used the laboratory and projects to teach for the application of the methods of science.

The student activities of the two groups also indicated a decided difference. Seven teachers in the high subgroup indicated extensive use of problem-solving activities in laboratory work. Emphasis was given to planning experiments, recording and analyzing data, drawing conclusions, and discussing various aspects of the investigations.

Only one teacher in the lower group reported problem-solving activities. Observing teacher demonstrations, dissecting, preparing slides, and observing various animals and plants were most frequently listed student activities which teachers in the lower subgroup employed to achieve this objective.
### TABLE XLVII

**METHODS UTILIZED TO TEACH FOR THE APPLICATION OF THE METHODS OF SCIENCE**

<table>
<thead>
<tr>
<th>Method</th>
<th>Teachers Who Taught For This Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High Subgroup</td>
</tr>
<tr>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Recitations from textbook assignments</td>
<td>1</td>
</tr>
<tr>
<td>Free discussion based on topical assignments</td>
<td>6</td>
</tr>
<tr>
<td>Lecture-demonstration combination</td>
<td>3</td>
</tr>
<tr>
<td>Demonstration-discussion combination</td>
<td>2</td>
</tr>
<tr>
<td>Lecture</td>
<td>1</td>
</tr>
<tr>
<td>Laboratory</td>
<td>9</td>
</tr>
<tr>
<td>Laboratory-discussion combination</td>
<td>4</td>
</tr>
<tr>
<td>Project</td>
<td>6</td>
</tr>
<tr>
<td>Field Trips</td>
<td>2</td>
</tr>
</tbody>
</table>

While class gains in this area were low for a majority of the schools involved in the study, many classrooms which were organized on a problem-solving basis indicated positive gains. Five BSCS classes participating in this study all made positive gains.
Objective Three - The Student Can Show Evidence of Improving His Ability to Think Critically

Subgroups were formed on the basis of class mean gains on the Watson-Glaser Critical Thinking Appraisal. Seventeen teachers with adjusted class mean gains of five points and over composed the high group. Thirteen teachers of classes with adjusted mean gains of two points or less formed the lower group.

The mean Gamma I. Q. for the upper group was 106 and for the lower group 108.

Data for the subgroups were analyzed for differences in teacher planning, teaching methods, and student activities.

Table XLVIII lists the number of teachers for each subgroup who did or did not teach to improve student critical thinking abilities.

<table>
<thead>
<tr>
<th>TABLE XLVIII</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEACHERS WHO DID AND DID NOT PLAN AND TEACH TO IMPROVE CRITICAL THINKING SKILLS</td>
</tr>
<tr>
<td>High group</td>
</tr>
<tr>
<td>Low group</td>
</tr>
</tbody>
</table>

A greater percentage of teachers who did not teach for the objective were in the low group than in the high group. The difference,
however, does not warrant comparative generalizations.

Table XLIX lists the methods which were utilized by teachers of high and low subgroups to realize this objective.

**TABLE XLIX**

METHODS UTILIZED TO TEACH TO IMPROVE CRITICAL THINKING SKILLS

<table>
<thead>
<tr>
<th>Method</th>
<th>Teachers Who Taught For This Objective</th>
<th>High Subgroup</th>
<th>Low Subgroup</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Number</td>
<td>Percent</td>
</tr>
<tr>
<td>Recitations from textbook assignments</td>
<td></td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Free discussion based on topical assignments</td>
<td></td>
<td>8</td>
<td>61</td>
</tr>
<tr>
<td>Lecture-demonstration combination</td>
<td></td>
<td>3</td>
<td>23</td>
</tr>
<tr>
<td>Demonstration-discussion combination</td>
<td></td>
<td>4</td>
<td>31</td>
</tr>
<tr>
<td>Lecture</td>
<td></td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Laboratory</td>
<td></td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Laboratory-discussion combination</td>
<td></td>
<td>7</td>
<td>54</td>
</tr>
<tr>
<td>Project</td>
<td></td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Reflective thinking procedures</td>
<td></td>
<td>5</td>
<td>38</td>
</tr>
<tr>
<td>Field trip problems</td>
<td></td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Written problem assignments</td>
<td></td>
<td>1</td>
<td>8</td>
</tr>
</tbody>
</table>
Teaching methods utilized by the teachers in the two subgroups showed two definite differences. A greater percentage of teachers in the low group reported using the demonstration-discussion and lecture methods. Reflective thinking procedures were reportedly used by 38 percent of the high teachers; no teacher in the lower group indicated using this method.

Methods reported and teacher descriptions of student activities utilized to achieve this objective, disclosed a definite relationship existed between the outcomes of the class and the general pattern of classroom activities. Six of the teachers in the high subgroup on this outcome were also in the high group formed to analyze the application of the methods of science. Classes in biology which were organized on a problem-solving basis, and which continually stressed this aspect of science education, produced better gains in the application of the methods of science and critical thinking skills than classes which occasionally practiced these procedures.

Objective Four - The Student Can Demonstrate Attitudes Which Indicate an Understanding of the Nature of Science

Teacher subgroups were established on the basis of student gains in understanding the nature of science. Class mean gains were determined from selected questions on the Reaction Inventory, Attitudes Toward Science and Scientific Careers. The distribution of
the mean class gains grouped 34 classes within a two point band. To improve discrimination, only extreme groups were analyzed.

One group was composed of nine teachers whose classes gained two or more points in the direction of the attitudes of the scientists. A second group was formed of eight teachers whose classes indicated a mean class change of one point or more away from the attitudes of the scientists.

The Mean Gamma I.Q. for the high group was 107 and for the low group 108.

Data for the subgroups were analyzed for differences in teacher planning, teaching methods, and student activities.

Table L lists the number of teachers for each subgroup who did or did not plan and teach to accomplish the objective.

**TABLE L**

**TEACHERS WHO DID AND DID NOT PLAN AND TEACH TO DEVELOP AN UNDERSTANDING OF THE NATURE OF SCIENCE**

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>Did Teach</th>
<th>Did Not Teach</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>High group</td>
<td>8</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Low group</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

Observation of Table L indicates that a greater percentage of the teachers in the low group did not teach for this objective. A further analysis of the teaching reports indicated six of the upper
group taught for both the understanding of science and improvement in attitudes toward scientists and scientific careers. Only one teacher in the low subgroup taught for both objectives.

Table LI lists the methods used to teach for the understanding of the nature of science as reported by the teachers.

**TABLE LI**

**METHODS UTILIZED TO TEACH FOR THE UNDERSTANDING OF THE NATURE OF SCIENCE**

<table>
<thead>
<tr>
<th>Method</th>
<th>Teachers Who Taught For This Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High Subgroup</td>
</tr>
<tr>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Recitations from textbook assignments</td>
<td>2</td>
</tr>
<tr>
<td>Free discussion based on topical assignments</td>
<td>3</td>
</tr>
<tr>
<td>Lecture-demonstration combination</td>
<td>3</td>
</tr>
<tr>
<td>Demonstration-discussion combination</td>
<td>6</td>
</tr>
<tr>
<td>Lecture</td>
<td>3</td>
</tr>
<tr>
<td>Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>Laboratory-discussion combination</td>
<td>3</td>
</tr>
<tr>
<td>Project</td>
<td>5</td>
</tr>
<tr>
<td>Field trips</td>
<td>1</td>
</tr>
<tr>
<td>Written reports</td>
<td>1</td>
</tr>
</tbody>
</table>
Improvement in understanding the nature of science was not realized by most classes. Nine, of a total sample of 45 responding teachers, indicated they did not teach for this objective. Eight others reported they did teach for the objective but were not satisfied with the resulting learning.

The data in Table LI is limited and inconclusive. Demonstration-discussion techniques were used by a greater percentage of the high group than of the low group. Projects involving research by the student were believed, by a majority of the teachers in the upper group, to be the most valuable method utilized.

Descriptions of student activities did not reveal definite differences between the two groups.

It appeared that a majority of the teachers did not have clear concepts in this area of the curriculum, or had not developed effective procedures for developing student understanding of the nature of science.

Objective Five - The Student Can Demonstrate a Desirable Improvement in His Concept of the Scientist and of Scientific Careers

Two subgroups of teachers were established on the basis of mean class gains obtained from responses to 91 items on the Reaction Inventory, Attitudes Toward Science and Scientific Careers.

Fifteen teachers with mean class gains of five or more points in
the direction of the attitudes of the scientists comprised the high
group. Eleven teachers with mean class gains indicating no change
or more negative attitudes were placed in the lower group.

The mean Gamma I. Q. for classes in the upper group was
106, while the mean Gamma I. Q. of classes in the lower group
was 108.

Data for the subgroups were analyzed for differences in
teacher planning, teaching methods, and student activities.

Table LII lists the number of teachers for each subgroup
who did and did not plan and teach to accomplish the objective.

**TABLE LII**

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>Did Teach</th>
<th>Did Not Teach</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>High group</td>
<td>11</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Low group</td>
<td>3</td>
<td>7</td>
<td>1</td>
</tr>
</tbody>
</table>

An analysis of Table LII clearly indicates that most teachers
in the lower subgroup did not teach for this objective. Thirteen of
45 teachers who responded to this question indicated they did not
teach for this objective; over half of these 13 were in the lower
group.
The data permits the inference that development of desirable attitudes toward scientists and scientific careers is not likely to occur as a concomitant outcome. Analyses of teacher factor relationships and data of these two subgroups, strongly suggest that the attitudes of the teacher toward scientists and scientific careers are not as important for achieving this outcome as planning and teaching specifically for this objective. Data cited by Klopfer in a previous study (65) revealed a similar finding.

Methods utilized by the teachers of the two subgroups who taught to achieve this objective are listed in Table LIII. The number of methods listed is greater than the number of teachers because many teachers checked more than one method.

A variety of methods were utilized by the teachers who achieved the higher gains. Field trips, films, reading case histories of scientific work, and/or laboratory work followed by class discussion were characteristic patterns of the upper group. Discussions usually focused on advances which were occurring in the biological and other sciences, opportunities in various phases and levels of scientific work, and personal and academic requirements for various positions.

An analysis of the teachers in these two subgroups also indicated planned teaching for the objective was as important as
TABLE LIII

METHODS UTILIZED TO TEACH TO DEVELOP DESIRABLE ATTITUDES TOWARD SCIENTISTS AND SCIENTIFIC CAREERS

<table>
<thead>
<tr>
<th>Method</th>
<th>Teachers Who Taught For This Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High Subgroup</td>
</tr>
<tr>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Recitations from textbook assignments</td>
<td>2</td>
</tr>
<tr>
<td>Free discussion based on topical assignments</td>
<td>6</td>
</tr>
<tr>
<td>Lecture-demonstration combination</td>
<td>2</td>
</tr>
<tr>
<td>Demonstration-discussion combination</td>
<td>2</td>
</tr>
<tr>
<td>Lecture</td>
<td>3</td>
</tr>
<tr>
<td>Laboratory</td>
<td>2</td>
</tr>
<tr>
<td>Laboratory-discussion combination</td>
<td>1</td>
</tr>
<tr>
<td>Project</td>
<td>0</td>
</tr>
<tr>
<td>Films</td>
<td>2</td>
</tr>
<tr>
<td>Field trips</td>
<td>2</td>
</tr>
<tr>
<td>Guest lecturers</td>
<td>2</td>
</tr>
<tr>
<td>Reading biographies of scientists</td>
<td>3</td>
</tr>
</tbody>
</table>
desirable teacher attitudes toward scientists and scientific careers. Only one teacher in the highest teacher subgroup on both his attitude score and his class mean gain score did not teach for this objective. Other teachers in the high teacher subgroup on the basis of their attitudes toward scientists and scientific careers did not have classes with high mean gains unless they taught for the objective.

Course Organization - Relationship of Biology Classes Using a Basic Text Compared to Other Types of Course Organization

The utilization of a single textbook as the basis for a biology course has been the subject of controversy. Multi-texts, local courses of study, and problem-solving approaches utilizing no course of study have been advocated as plans to supplant the basic text.

Forty teachers indicated the plan of course organization which they used for their classes. Table LIV lists the plans of course organization.
TABLE LIV

PLAN OF COURSE ORGANIZATION REPORTED
BY SAMPLE TEACHERS

<table>
<thead>
<tr>
<th>Course Organization</th>
<th>Number of Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Followed a basic text</td>
<td>20</td>
</tr>
<tr>
<td>Adapted to local environment using a variety of printed materials</td>
<td>9</td>
</tr>
<tr>
<td>Followed materials developed by BSCS</td>
<td>5</td>
</tr>
<tr>
<td>Followed locally prepared course of study</td>
<td>3</td>
</tr>
<tr>
<td>Followed no course of study, but used local problems: a problem-solving approach</td>
<td>3</td>
</tr>
<tr>
<td>utilizing local resources</td>
<td></td>
</tr>
</tbody>
</table>

Two subgroups were formed to determine differences in learning outcomes of classes using a basic text plan of course organization compared to classes with other types of organization. Each subgroup contained 20 classes.

Differences in learning outcomes were analyzed by the analysis of covariance adjusting for general scholastic ability and relevant pre-test knowledge. Table LV presents data and statistics comparing the basic text plan of course organization to other plans.
### Table LV

**Relationship of Textbook Form of Class Organization to Student Learning Outcomes**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Subgroups Plan of Organization</th>
<th>k*</th>
<th>$\bar{X}_1*$</th>
<th>$\bar{X}_2*$</th>
<th>$\bar{Y}$*</th>
<th>SS Adjusted for $X_1$ and $X_2$</th>
<th>F (df:1, 36)</th>
<th>Level of Significance</th>
<th>Adjusted Criterion Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nelson</td>
<td>Textbook Plan</td>
<td>20</td>
<td>106.1</td>
<td>31.7</td>
<td>37.2</td>
<td>230.745</td>
<td>221.192</td>
<td>1.555</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other Plans</td>
<td>20</td>
<td>110.1</td>
<td>35.3</td>
<td>40.7</td>
<td>230.745</td>
<td>221.192</td>
<td>1.555</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td><strong>106.1</strong></td>
<td><strong>31.7</strong></td>
<td><strong>37.2</strong></td>
<td><strong>230.745</strong></td>
<td><strong>221.192</strong></td>
<td><strong>1.555</strong></td>
<td></td>
</tr>
<tr>
<td>Part A,</td>
<td>Textbook Plan</td>
<td>20</td>
<td>106.1</td>
<td>16.5</td>
<td>21.6</td>
<td>134.069</td>
<td>131.573</td>
<td>.683</td>
<td></td>
</tr>
<tr>
<td>Nelson</td>
<td>Other Plans</td>
<td>20</td>
<td>110.1</td>
<td>18.3</td>
<td>23.5</td>
<td>134.069</td>
<td>131.573</td>
<td>.683</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td><strong>106.1</strong></td>
<td><strong>16.5</strong></td>
<td><strong>21.6</strong></td>
<td><strong>134.069</strong></td>
<td><strong>131.573</strong></td>
<td><strong>.683</strong></td>
<td></td>
</tr>
<tr>
<td>Part B,</td>
<td>Textbook Plan</td>
<td>20</td>
<td>106.1</td>
<td>15.2</td>
<td>15.6</td>
<td>68.147</td>
<td>67.632</td>
<td>.274</td>
<td></td>
</tr>
<tr>
<td>Nelson</td>
<td>Other Plans</td>
<td>20</td>
<td>110.1</td>
<td>16.9</td>
<td>17.3</td>
<td>68.147</td>
<td>67.632</td>
<td>.274</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td><strong>106.1</strong></td>
<td><strong>15.2</strong></td>
<td><strong>15.6</strong></td>
<td><strong>68.147</strong></td>
<td><strong>67.632</strong></td>
<td><strong>.274</strong></td>
<td></td>
</tr>
<tr>
<td>W. G. Critical Thinking</td>
<td>Textbook Plan</td>
<td>20</td>
<td>106.1</td>
<td>57.9</td>
<td>56.7</td>
<td>163.310</td>
<td>159.070</td>
<td>.959</td>
<td></td>
</tr>
<tr>
<td>Appraisal</td>
<td>Other Plans</td>
<td>20</td>
<td>110.1</td>
<td>61.4</td>
<td>58.7</td>
<td>163.310</td>
<td>159.070</td>
<td>.959</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td><strong>106.1</strong></td>
<td><strong>57.9</strong></td>
<td><strong>56.7</strong></td>
<td><strong>163.310</strong></td>
<td><strong>159.070</strong></td>
<td><strong>.959</strong></td>
<td></td>
</tr>
<tr>
<td>Attitudes</td>
<td>Textbook Plan</td>
<td>20</td>
<td>106.1</td>
<td>52.9</td>
<td>50.4</td>
<td>3,313.639</td>
<td>3,144.920</td>
<td>1.931</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Other Plans</td>
<td>20</td>
<td>110.1</td>
<td>52.0</td>
<td>49.6</td>
<td>3,313.639</td>
<td>3,144.920</td>
<td>1.931</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td><strong>106.1</strong></td>
<td><strong>52.9</strong></td>
<td><strong>50.4</strong></td>
<td><strong>3,313.639</strong></td>
<td><strong>3,144.920</strong></td>
<td><strong>1.931</strong></td>
<td></td>
</tr>
<tr>
<td>Attitudes</td>
<td>Nature of Science</td>
<td>20</td>
<td>106.1</td>
<td>11.0</td>
<td>10.4</td>
<td>104.055</td>
<td>103.816</td>
<td>.082</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other Plans</td>
<td>20</td>
<td>110.1</td>
<td>10.6</td>
<td>9.7</td>
<td>104.055</td>
<td>103.816</td>
<td>.082</td>
<td></td>
</tr>
</tbody>
</table>

* $k^*$ = Number of classes in each subgroup.
* $\bar{X}_1^*$ = Subgroup mean Gamma I. Q.
* $\bar{X}_2^*$ = Subgroup mean on pre-test.
* $\bar{Y}$ = Subgroup mean on post-test.
To be significant at the .05 level, the F-value with 1 and 36 degrees of freedom must equal or exceed 4.11 (117, p. 421). Inspection of Table LV indicated no significant differences between the two subgroups. It can be concluded that learning outcomes evaluated in this study did not differ significantly in classes using the textbook as a plan of organization compared to other types of class organization.

Observation and conferences with several participating teachers, however, indicated extreme differences in the use of the textbook as a plan of organization. Plans based on a basic text varied from a read-recite activity to a problem-solving experience using a basic text as a point of departure and as a major reference. While there are weaknesses in biology textbooks, the analyses of this study indicated other plans did not produce significantly higher gains.

Summary

The analyses of teacher reports relating to teaching methods and pupil behavior utilized to achieve selected learning outcomes revealed important findings which support and extend previous research.

Analyses of data indicated that objectives are most effectively obtained when teaching is planned for a specific purpose. The
relationship of planned teaching to the realization of the objective was particularly evident in teaching for attitudinal changes. It was concluded that while knowledge and attitudes which a teacher possesses will influence his students, planned teaching is of considerable importance.

A comparison of teachers with classes achieving high gains to teachers with classes achieving low gains on each of the five selected outcomes indicated successful methods and patterns of student activity were related to student learning outcomes. Teachers with high class means on several learning outcomes: (1) emphasized pupil-centric methods as opposed to teacher-centric methods; (2) utilized the laboratory for solving and analyzing problems as opposed to strictly observing, drawing, and dissecting; and (3) planned to accomplish specific objectives.
CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

This study was designed to reveal the relationship of learning outcomes to selected teacher factors and teaching methods in tenth grade biology classes in Oregon during the 1962-1963 school year.

A stratified random sample of 51 public high schools was selected to participate in this study. One class and one teacher from each school were involved in the evaluation.

Students were pre-tested in the fall to control scholastic ability and relevant knowledge. Tests utilized were: the Otis Mental Ability Test, Gamma: Form Em; the Nelson Biology Test, Form Am; the Watson-Glaser Critical Thinking Appraisal, Form Ym; and the Reaction Inventory, Attitudes Toward Science and Scientific Careers.

Post-testing was conducted in the spring to determine student gains. Evaluation instruments used were: the Nelson Biology Test, Form Bm; the Watson-Glaser Critical Thinking Appraisal, Form Zm; and the Reaction Inventory, Attitudes Toward Science and Scientific Careers. Changes in student interest in science-related careers were determined by the Student Inventory which
was completed in both the fall and the spring. The student sample which completed the entire testing program numbered 1191.

Data concerning teacher factors and teaching methods were obtained from tests and an inventory completed by each teacher, principal ratings, and data from the State Department of Public Instruction. Tests utilized were: the Watson-Glaser Critical Thinking Appraisal, Form Zm, and the Reaction Inventory, Attitudes Toward Science, Scientific Careers, and Science Teaching. Each principal rated his teacher on teacher-pupil relationships and personal adjustment by use of the Teacher Rating Scale.

Teacher factors were analyzed for significance by the analysis of covariance on extreme subgroups. Comparative analyses of percentage differences were also used to determine the relationship of teacher factors to composite success.

Teaching methods and student activities were investigated for their relationship to learning outcomes by comparing methods and activities utilized in classes with the highest mean gains to classes with the lowest mean gains.

Gain in knowledge and understanding of biological facts, concepts, and principles as measured by Part A of the Nelson Biology Test was attained by 48 of 51 classes. This objective was stressed by all but two of the responding teachers. Factors which were significantly related with learning in this area were: (1) school
enrollment under 250 students (.10 level), (2) teachers possessing less than 50 quarter hours in all science fields (.05 level), and (3) teachers ranking high in personal adjustment (.05 level). Pupil-centric teaching methods providing involvement of the learner in a variety of experiences were related to the outcome.

Twenty-seven of the classes did not obtain positive gains in the application of the methods of science as measured by Part B of the Nelson Test. Eight teachers did not teach for this objective, and several others indicated no definite planning. Factors significantly related to gain in learning were: (1) teachers teaching two or fewer biology classes (.01 level) and (2) 60 or more quarter hours of preparation in biology (.10 level). Classes which were organized on a problem-solving basis generally realized greater gains. An analysis of questions which were incorrect on the post-test indicated that many students lacked an understanding of the methods and techniques of science.

The Watson-Glaser Critical Thinking Appraisal sampled the student's critical thinking skills. The analysis indicated that 44 classes obtained positive gains. Teacher responses revealed that seven did not teach for this objective. Two factors were significantly related to student growth: (1) teachers scoring high on the Watson-Glaser CTA (.10 level) and (2) teachers with high personal adjustment ratings (.10 level). Most of the high gains were associated
with classes utilizing problem-solving techniques with direct instruction and practice in critical thinking.

Student attitudes toward science and scientific careers became more favorable to the scientific enterprise during the school year. This change was significant at the .10 level. The attitudes of the students also changed in the direction of attitudes which their teachers possessed. It appeared the development of favorable attitudes was related to a number of teacher factors: (1) under 35 years of age (.10 level), (2) under 40 quarter hours of preparation in biology (.10 level), (3) 100 or more hours in all sciences (.10 level), (4) high teacher rating of teacher-pupil relationships (.10 level), and (5) high rating of personal adjustment (.10 level). Teachers who planned and directly taught for the objective were closely related to classes with high gains. A number of teachers with extensive preparation and positive personal attitudes did not teach for this goal.

Improvement of student attitudes related to understanding the nature of science was small. Data indicated that classes made positive gains, but most of these gains were not large. A number of factors were found to be related to gains in this area: (1) high rating of teacher-pupil relationships (.001 level), (2) high rating of personal adjustment (.05 level), (3) teachers with attitudes which
were less positive toward science and scientific careers (.10 level), and (4) teachers whose attitudes toward science teaching were less positive (.05 level). The analysis of teaching methods used by extreme groups revealed a direct relationship between low gains and those who did not teach for the objective. Methods utilized by more high classes than low classes involved observing various aspects of the scientific endeavor followed by discussions pertinent to career decisions.

Data revealed classes of certain teachers achieved high gains on three or more learning outcomes, while classes of other teachers had low gains or no gains on three or more outcomes. Differences in the characteristics of these teachers were believed to be important for designing teacher preparation programs and administering school staff. Comparisons indicated composite success was positively related to the following factors: (1) total teaching experience, (2) total biology experience, (3) salary over $7,000 compared to a salary of under $5,000, (4) breadth and depth in science preparation, (5) over 60 quarter hours of preparation in biology, (6) favorable teacher attitudes toward science and scientific careers, (7) high rating of teacher-pupil relationships, and (8) high rating of personal adjustment.

Student interests in science-related vocations were analyzed
for changes during the school year. A positive gain was determined for the total student sample. Characteristics of teachers whose classes showed the most increase were: (1) young teachers with high personal adjustment and (2) experienced teachers with broad preparation and high ratings of personal adjustment.

CONCLUSIONS

The following conclusions are drawn from the data presented in this investigation:

1. Certain teacher factors were significantly related to each of the five learning outcomes at the .10 level or above.

2. The principals were able to discriminate between teachers with high and those with low personal adjustment. This factor was significantly related to four of the five outcomes and was the most important teacher factor related to composite teaching success.

3. During the school year students developed more favorable attitudes toward science and scientific careers. They also became more interested in science-related careers as possible vocations.

4. Evidence was obtained which indicated that student attitudes tended to change in the direction of those held by their teacher.
5. Data were analyzed which indicated that teaching which was planned to achieve a specific objective was more efficient. This was particularly evident in teaching to change attitudes.

6. Teaching methods and patterns of teaching were related to high gains on the selected learning outcomes. Pupil-centric methods emphasizing problem-solving laboratory procedures with analyses of experimentation were characteristic of a majority of the classes with high composite success.

7. A subgroup of teachers with classes realizing high gains on three or more outcomes were identified. Teacher factors of this subgroup distinguished them from a subgroup of teachers whose classes were low in gains on three or more outcomes. While all of these factors were not related significantly to a specific outcome, they represented factors which separated successful from unsuccessful teachers.

8. A number of teachers possessed attitudes which indicated lack of information concerning the scientific endeavor and the status of science. These teachers could not be distinguished by age, experience, preparation, or
assignment.

9. Teachers with less than 40 quarter hours of preparation in all science areas and less than 30 quarter hours in biology, with one exception, did not teach classes with positive gains among the highest third on any of the objectives.

10. Methods courses in biology and other subject areas need to provide prospective teachers with a clearer understanding of important objectives and how they may be realized. Data obtained in this study indicated several teachers were not previously cognizant of broad objectives or were not including them in their teaching.

11. Teaching and learning in biological science education can be improved by evaluating a broad range of student outcomes. Data from the evaluation of learning outcomes in this study indicated that several classes were realizing gains in only one of the learning areas. Knowledge of these deficiencies would provide a basis for improving the educational program.
RECOMMENDATIONS

On the basis of data contained in this study it is recommended:

1. Public school administrators and local boards of education should:
   a. Require personal interviews for selection of staff members.
   b. Cooperatively establish objectives for local science courses and evaluate to determine if outcomes correspond to desired goals.
   c. Provide funds and leadership to support needed in-service education.
   d. Encourage science teachers to gain needed training through institutes and regularly offered courses.
   e. Assign teachers to areas where they have sufficient preparation and interest.

2. Biology teachers should:
   a. Obtain depth and breadth of preparation in science as suggested by the AAAS and the new Oregon norms.
   b. Establish objectives, considering the role of science education, for the course which they are teaching.

They should carefully plan for specific objectives
and evaluate to determine the success of the procedures utilized.

3. Science educators in teacher education institutions should:
   a. Evaluate the personal adjustment of applicants for teacher education.
   b. Develop preparation programs for biology teachers emphasizing modern concepts in biology and including chemistry and physics.
   c. Provide instruction and practice for prospective teachers in teaching for specific learning objectives.
   d. Provide instruction and practice for prospective teachers in the evaluation of varied learning outcomes.
   e. Include courses in their programs related to the history and sociology of science.

4. Consideration should be given to the completion of the following studies:
   a. A study to determine student gain on standardized science tests due to environmental factors and not to specific classroom instruction.
   b. A longitudinal study to determine if teacher factors
associated with composite success consistently identify successful teachers.

c. A follow-up study to determine attitude changes toward science and the scientific enterprise of students in this study who continue in science courses through high school, and of those who do not.

d. A longitudinal follow-up study to determine the career decisions and related factors of scientifically oriented students in this investigation.

e. A study should be conducted using the Teacher Rating Scale with other teacher samples to further evaluate and to refine the instrument.
BIBLIOGRAPHY


APPENDICES
ATTITUDES TOWARD SCIENCE AND SCIENTIFIC CAREERS

Reaction Inventory*

Name ____________________________________ School ________________________________

First Last

Instructions: Please give your reactions to the following list of statements regarding science, scientists, and scientific careers. Work rapidly. Record your first impressions—the feeling that comes to mind as you read the item.

Draw a circle around AA if you completely agree with the item.
Draw a circle around A if you are in partial agreement.
Draw a circle around N if you are neutral.
Draw a circle around D if you partially disagree.
Draw a circle around DD if you totally disagree. 

Example:
AA A N D D 100. In the springtime Paris is more beautiful than New York. (Since A is circled, this indicates that you are in slight agreement.)

AA A N D D 1. Science is not sufficiently appreciated by most people.

AA A N D D 2. Science is a systematic way of thinking.

AA A N D D 3. Scientists are seldom concerned with their working conditions.

AA A N D D 4. The development of new ideas is the scientist’s greatest source of satisfaction.

AA A N D D 5. Friends often discourage girls from taking high school science courses.

AA A N D D 6. Science and technology are essential to the development of present-day cultures.

AA A N D D 7. Increased radiation resulting from bomb tests is a threat to civilization.

AA A N D D 8. Scientists are too narrow in their views.

AA A N D D 9. Industries use research as a means to improve their economic position.

AA A N D D 10. The application of scientific knowledge to the development of new industries enriches society.

AA A N D D 11. The President’s cabinet should be enlarged to include a Secretary of Science.

AA A N D D 12. The scientist will make his maximum contribution to society when he has freedom to work on problems which interest him.

Reaction Inventory (continued)

13. A scientist might aptly be described as a nonconformist.

14. Scientists should be looked upon as "subjects for suspicion."

15. Scientific investigations are undertaken as a means of achieving economic gains.

16. To become a scientist requires superior ability.

17. Science requires creative activity.

18. Scientists are willing to change their ideas and beliefs when confronted by new evidence.

19. Scientists have unusually intelligent mothers.

20. Scientists are "longhairs."

21. The complexity of science hides its cultural values.

22. Modern science is too complicated for the average citizen to understand and appreciate.

23. Scientists possess too much power in our society.

24. Decisive economic, political, and social processes are greatly influenced by science.

25. It is undemocratic to favor exceptional scientific talent.

26. The monetary compensation of a Nobel Prize winner in Physics should be at least equal to that given popular entertainers.

27. Hazards created by the increased use of radioactive materials make scientific work less attractive than previously.

28. Scientists are shy, lonely individuals.

29. Loyalty checks and security clearances have seriously interfered with the work of scientists.

30. For me, training for a career in science is not worth the time and effort required.

31. Science is primarily a method for inventing new devices.

32. Scientists are more emotional than other people.
Reaction Inventory (continued)

33. Girls have very little mechanical aptitude, and therefore should not consider scientific careers.

34. Scientists are honored persons who stand very high in popular prestige.

35. To appreciate modern society fully, a person must understand the importance of science.

36. Scientists are an "odd" lot.

37. Science without mathematics is impossible.

38. Science is the greatest unifying force among nations.

39. Maintenance of scientific work is essential to national survival.

40. The use of scientific achievement is often hampered by selfish individuals.

41. Scientific work is boring.

42. Scientific activity is greatly influenced by culture.

43. The free flow of scientific information among scientists is essential to scientific progress.

44. I don't have the intelligence for a successful scientific career.

45. The winning of the esteem of his associates is one of the main incentives for the scientist.

46. Scientific findings always lead to final truths.

47. Scientists are as concerned as are other groups with the policies of the company for which they work.

48. Industrial developments are based more on practical experience than on laboratory research,

49. The scientist can expect to accumulate little wealth as compensation for his work.

50. Science is a man's world; there is little room in it for women.

51. Science is primarily responsible for the frequent changes which occur in our manner of living.

52. Scientists are "eggheads."

53. Scientific work requires long years of labor and self-discipline.
 Reaction Inventory (continued)

AA A N D DD  54. A great research scientist is little concerned with the practical applications of his work.
AA A N D DD  55. Scientists are communistic.
AA A N D DD  56. Science is an attitude towards life and environment.
AA A N D DD  57. Our foremost scientists are primarily concerned with their own thoughts and ideas.
AA A N D DD  58. Science has done little for the average citizen.
AA A N D DD  59. Scientific truths are usually found by persons seeking economic gain.
AA A N D DD  60. The neglect of basic scientific research would be the equivalent of "killing the goose that laid the golden eggs."
AA A N D DD  61. Science receives too little serious attention in the mass media.
AA A N D DD  62. Scientists today are subject to too many governmental restrictions.
AA A N D DD  63. The engineer serves a more practical purpose in society than does the research scientist.
AA A N D DD  64. There is much self-satisfaction to be received from work as a scientist.
AA A N D DD  65. A scientist's life is full of adventure.
AA A N D DD  66. The average American home discourages girls from scientific careers.
AA A N D DD  67. Universities do little scientific research that is of immediate practical value.
AA A N D DD  68. Scientists do not need the physical stamina necessary for most other work.
AA A N D DD  69. Science helps us to understand our environment.
AA A N D DD  70. Scientific concepts and discoveries often bring about new sociological problems.
AA A N D DD  71. Scientists are against formal religion.
AA A N D DD  72. "Practical" politicians and business men disregard the advice of scientists.
AA A N D DD  73. Scientists often have physical deformities which render them unfit for other work.
AA A N D DD  74. Science and its inventions have caused more harm than good.
75. The social environment of the United States is hostile to the development of scientific talent.

76. One cannot have a normal family life and be a scientist.

77. The bulk of scientific research is carried on by devoted men and women without regard for their personal living or social relations.

78. Public interest in science is essential to the maintenance of scientific research.

79. Most of the basic scientific research done in our country is carried on by industry.

80. Many specific findings in science contradict the laws of God.

81. American scientists are largely responsible for our country's status among nations.

82. Scientists are essentially magicians, making two blades of grass where one grew before.

83. Industrial research is often carried on by teams of scientific workers.

84. Scientific work is monotonous.

85. The working scientist believes that nature is orderly rather than disorderly.

86. The modern world is dominated by science.

87. Scientists as a group are often condemned for the unpopular ideas and activities of a few fellow workers.

88. Scientists are often willing to sacrifice the welfare of others to further their own interests.

89. Scientists are usually unsociable.

90. Curiosity motivates scientists to make their discoveries.

91. The chief reward in scientific work is the thrill of discovery.

92. In high school, boys receive more encouragement to take science courses than do girls.

93. Americans place greater value on the practical applications of scientific discoveries than on the discoveries themselves.
ATTITUDES TOWARD SCIENCE, SCIENTIFIC CAREERS, AND SCIENCE TEACHING

Reaction Inventory*

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42. Scientific activity is greatly influenced by culture.

43. The free flow of scientific information among scientists is essential to scientific progress.

44. Pure science rather than technology has had the primary role in determining recent human progress.

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Reaction Inventory (continued)

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AA A N D DD 92. In high school, boys receive more encouragement to take science courses than do girls.

AA A N D DD 93. Americans place greater value on the practical applications of scientific discoveries than on the discoveries themselves.

AA A N D DD 94. Moral issues should be introduced in the teaching of science.
Reaction Inventory (continued)

AA A N D DD  95. High school teachers should have the time and facilities to carry on research related to their educational activities.
AA A N D DD  96. The reading of science fiction no matter how good will distort the students outlook on science.
AA A N D DD  97. Science can raise moral standards just as it has already raised material standards of living.
AA A N D DD  98. It is undemocratic to make special educational provisions for those with exceptional scientific talent.
AA A N D DD  99. The pronouncements of science are tentative without any guarantee of absolute certainty.
AA A N D DD  100. To become a superior scientist requires superior intelligence.
AA A N D DD  101. A teacher who rejects evolutionary theory is not qualified to teach biology.
STUDENT INVENTORY*

Instructions: This inventory is requesting information which will be used by the investigator for analyses. Fill in the requested information as completely and accurately as possible.

1. Name ________________________________ 2. Age ________________________________
   First                          Last

3. Grade in School (Circle) 9, 10, 11, 12 4. Sex (Check)  □ Boy  □ Girl

5. Name of School ________________________________ 6. Name of Teacher ________________________________

7. In what quarter of your class did you stand last semester on the basis of your school grades? (Check one)
   □ In the highest quarter of my class.
   □ In the upper middle quarter.
   □ In the lower middle quarter.
   □ In the lowest quarter.

8. What science courses have you taken (or are you taking) in high school?
   □ General Science  □ Biology  □ Chemistry  □ Physics
   □ Physical Science  □ Other (specify) ________________________________

9. Check your reason or reasons for taking biology.
   □ It is required for high school graduation.
   □ I like science.
   □ I need science for college entrance.
   □ I plan a career in which science is necessary.
   □ I think every good citizen should know science.
   □ Other reason (specify) ________________________________

10. What kind of occupation do you want to go into as an adult? (What is your first choice?) ________________________________

11. Would you be interested in becoming a scientist? (For example: a chemist, a psychologist, a pathologist, or an astronomer.) (Check one)
   □ Yes  □ No  □ Undecided

12. Would you be interested in becoming an engineer? (For example: electrical, mechanical, civil, or chemical engineer.) (Check one)
   □ Yes  □ No  □ Undecided

13. Would you be interested in becoming a science teacher? (For example: general science teacher, biology teacher, chemistry teacher, physics teacher.) (Check one)

☐ Yes  ☐ No  ☐ Undecided

14. If you have checked "yes" to question 11, 12, or 13 indicate at what age you experienced your first interest in science.

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<thead>
<tr>
<th>Age</th>
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15. If you have checked "yes" to question 11, 12, or 13 indicate the person who has been most influential in developing your interest in science.

☐ Brother  ☐ Friend  ☐ Self  ☐ Counselor

☐ Mother  ☐ Sister  ☐ Father  ☐ Relative

☐ Teacher  ☐ Other (specify) ____________________________

16. If you are not thinking about a career in science or engineering, which of the following have something to do with it? Check all statements that explain your feelings.

☐ I am more interested in another career.
☐ Science is too difficult for me.
☐ Mathematics is too difficult for me.
☐ Scientists are peculiar people, and I don’t want to be like them.
☐ You can’t make much money as a scientist or engineer.
☐ Other reason (please state) ____________________________
☐ Other reason (please state) ____________________________
TEACHER INVENTORY

Directions:

Please complete the Inventory by placing a √ in the appropriate box or supplying the requested information in the space provided.

1. Name Mr. Mrs. Miss ____________________________
   (Circle one) Last, ____________________________
   First

2. □ Single □ Married

3. Age
   □ Under 25 □ 45-54
   □ 25-34 □ 55 or over
   □ 35-44

4. Total years of teaching experience. (Any subject, any grade, count this year.)
   □ 1 □ 10-15
   □ 2-3 □ 16-25
   □ 4-9 □ 26 or more

5. Total years of experience teaching biology. (Count this year)
   □ 1 □ 10-15
   □ 2-3 □ 16-25
   □ 4-9 □ 26 or more

6. Number of years in present district. (Count this year)
   □ 1 □ 4-9
   □ 2-3 □ 10 or more

   □ $4,000 to 4,999 □ $7,000 to 7,999
   □ $5,000 to 5,999 □ $8,000 to 8,999
   □ $6,000 to 6,999
Teacher Inventory (continued)

8. Undergraduate education

A. Institutions

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B. Undergraduate teaching areas

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9. Graduate education

A. Institutions

<table>
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<th>Institutions</th>
<th>Degree (M.S., M.A., etc.)</th>
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B. Graduate areas of concentration

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<th>Second area</th>
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10. Academic preparation (Undergraduate and graduate)

A. Science

<table>
<thead>
<tr>
<th>Subject</th>
<th>Total number of quarter hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td></td>
</tr>
<tr>
<td>Chemistry</td>
<td></td>
</tr>
<tr>
<td>Physics</td>
<td></td>
</tr>
<tr>
<td>Geology</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
</tbody>
</table>

TOTAL HOURS

B. Mathematics

<table>
<thead>
<tr>
<th>Total number of quarter hours</th>
</tr>
</thead>
</table>
Teacher Inventory (continued)

C. Professional education

Total number of quarter hours of professional education

D. Indicate the number of quarter hours you have completed in each of the following areas.

<table>
<thead>
<tr>
<th>Quarter Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. General Biology</td>
</tr>
<tr>
<td>2. General Zoology</td>
</tr>
<tr>
<td>3. General Botany</td>
</tr>
<tr>
<td>4. Anatomy (Include plant and animal)</td>
</tr>
<tr>
<td>5. Physiology (Include plant and animal)</td>
</tr>
<tr>
<td>6. Embryology and Comparative Anatomy</td>
</tr>
<tr>
<td>7. Genetics</td>
</tr>
<tr>
<td>8. Evolution</td>
</tr>
<tr>
<td>9. Ecology (Include plant and animal)</td>
</tr>
<tr>
<td>10. Microbiology</td>
</tr>
<tr>
<td>11. Other (Please state)</td>
</tr>
<tr>
<td>12. Methods of Teaching Biological Science</td>
</tr>
</tbody>
</table>

11. Have you participated in a NSF Institute? [ ] Yes [ ] No

<table>
<thead>
<tr>
<th>Institution</th>
<th>Type of Institute</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Summer</td>
<td>AYI</td>
</tr>
<tr>
<td></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
Teacher Inventory (continued)

12. Indicate the professional and scientific organizations of which you are a member.

☐ National Science Teachers Association
☐ National Association of Biology Teachers
☐ American Association for the Advancement of Science
☐ National Education Association
☐ American Institute of Biological Sciences
☐ Others (Please specify)

13. Plan of course organization

Indicate the type of organization which most accurately describes your course. Place a check in the appropriate space.

☐ Follows a basic text.
☐ Follows a locally prepared course of study.
☐ Follows no course of study, but uses local problems; a problem-solving approach with local resources.
☐ Follows materials developed by BSCS.
☐ Other (Please specify)

14. Methods of teaching

Select the method or methods of teaching which best describe the practice you used to teach for each specific objective.

A. Objective:

The student can demonstrate increased knowledge of basic biological facts, principles, and concepts.

(1) Did you plan and teach to accomplish this objective?

☐ Yes    ☐ No
Teacher Inventory (continued)

(2) If you checked yes to (1) check the method or methods utilized to teach for this objective.

☐ Recitations from textbook assignments
☐ Free discussion based on topical assignments
☐ Lecture–demonstration combination
☐ Demonstration–discussion combination
☐ Lecture
☐ Laboratory
☐ Laboratory–discussion combination
☐ Project
☐ Other (Please specify) ________________________________

(3) a. From the methods checked above, select not more than two which you think were most effective in achieving the objective. Write the name of the method or methods in the space provided.

b. Please state what the students actually did when the methods listed in (a) were used.

B. Objective:

The student is able to apply the methods of science.

(1) Did you plan and teach to accomplish this objective?

☐ Yes ☐ No
Teacher Inventory (continued)

(2) If you checked yes to (1) check the method or methods utilized to teach for this objective.

☐ Recitations from textbook assignments

☐ Free discussion based on topical assignments

☐ lecture-demonstration combination

☐ Demonstration-discussion combination

☐ lecture

☐ laboratory

☐ laboratory-discussion combination

☐ Project

☐ Other (Please specify) ______________________________________

(3) a. From the methods checked above, select not more than two which you think were most effective in achieving the objective. Write the name of the method or methods in the space provided.

b. Please state what the students actually did when the methods listed in (a) were used.

C. Objective:

The student can show evidence of improving his ability to think critically.

(1) Did you plan and teach to accomplish this objective?

☐ Yes ☐ No
Teacher Inventory (continued)

(2) If you checked yes to (1) check the method or methods utilized to teach for this objective.

☐ Recitations from textbook assignments
☐ Free discussion based on topical assignments
☐ Lecture-demonstration combination
☐ Demonstration-discussion combination
☐ Lecture
☐ Laboratory
☐ Laboratory-discussion combination
☐ Project
☐ Other (Please specify)

(3) a. From the methods checked above, select not more than two which you think were most effective in achieving the objective. Write the name of the method or methods in the space provided.

b. Please state what the students actually did when the methods listed in (a) were used.

D. Objective:

The student can demonstrate attitudes which indicate an understanding of the nature of science.

(1) Did you plan and teach to accomplish this objective?

☐ Yes ☐ No
Teacher Inventory (continued)

(2) If you checked yes to (1) check the method or methods utilized to teach for this objective.

☐ Recitations from textbook assignments
☐ Free discussion based on topical assignments
☐ Lecture-demonstration combination
☐ Demonstration-discussion combination
☐ Lecture
☐ Laboratory
☐ Laboratory-discussion combination
☐ Project
☐ Other (Please specify) ____________________________________________

(3) a. From the methods checked above, select not more than two which you think were most effective in achieving the objective. Write the name of the method or methods in the space provided.

b. Please state what the students actually did when the methods listed in (a) were used.

E. Objective:

The student can demonstrate a desirable improvement in his concept of the scientist and of scientific careers.

(1) Did you plan and teach to accomplish this objective?

☐ Yes ☐ No
Teacher Inventory (continued)

(2) If you checked yes to (1) check the method or methods utilized to teach for this objective.

☐ Recitations from textbook assignments
☐ Free discussion based on topical assignments
☐ Lecture-demonstration combination
☐ Demonstration-discussion combination
☐ Lecture
☐ Laboratory
☐ Laboratory-discussion combination
☐ Project
☐ Other (Please specify) ____________________________

(3) a. From the methods checked above, select not more than two which you think were most effective in achieving the objective. Write the name of the method or methods in the space provided.

b. Please state what the students actually did when the methods listed in (a) were used.

15. What was the average enrollment of the biology class participating in this study during the 1962-1963 school year? ______________

16. How many classes do you teach per day? ______________

17. How many biology classes do you teach per day? ______________

18. How many preparations do you have per day? ______________

19. Were you employed outside the school during the 1962-1963 school year?

☐ Yes   ☐ No
TEACHER RATING SCALE

School ____________________________________________Principal ____________________________________________

Directions: Please place a cross (X) on the line opposite the response which most accurately indicates your frank and objective evaluation of the behavior of the teacher being rated. Mark only one response under each question. You possibly will find that each phrase in a particular response is not applicable to the subject being rated. The closest approximation is what is wanted.

A. TEACHER-PUPIL RELATIONSHIPS

1. What is the status of this teacher's disciplinary ability?

_______ a. Pupils actively interested and busy with school work; atmosphere of room free and natural; usually no question of misconduct even when teacher not present; pupils able to govern themselves.

_______ b. Pupils usually attentive to task at hand; teacher usually not on "lookout" for misconduct; work proceeds with little or no interruption.

_______ c. Room fairly quiet; some whispering and inattention, but teacher restores "order" with occasional reprimand or warning look; teacher usually sensitive to minor lapses of conduct.

_______ d. Pupils in classroom appear restless; considerable inattention and noisy behavior; indication of lack of respect for teacher; teacher appears nervous and distraught, unable to control.

_______ e. Classroom exceptionally quiet; pupils hardly dare move; atmosphere of tenseness; pupils fear teacher who "rules with an iron hand."

2. Does this teacher have a "student" or "subject-matter" point of view?

_______ a. Interested in the personality development of child; sensitive to individual differences in children's needs, abilities, and interests; as sensitive to emotional, social, and physical needs of child as to his intellectual needs; actually does something to help meet these needs.

_______ b. Sensitive to various needs of child, but does little to meet them, except for intellectual needs; quite willing to vary intellectual standards of achievement.

_______ c. Apparently aware of various needs of child, but believes teacher's responsibility limited to intellectual needs; quite conversant on individual differences in mental ability, but does little about such differences.

_______ d.Insensitive to any needs of child other than intellectual; pays little attention to individual differences in mental ability, does try to make material meaningful to child, and seeks to encourage independent thinking.
Teacher Rating Scale (continued)

______ e. Almost ignores child as individual; thinks in terms of subject-matter mastery only; every pupil must meet same requirements of achievement; emphasis on drill even though meaningless to pupil; seldom deviates from text.

3. What is the nature of this teacher's attitude toward children?

______ a. Regards child objectively for what he is, --an active, immature organism; uses friendly, sympathetic approach; loves children; enjoys having them around; sees child's point of view.

______ b. Intellectually appreciates child's potentialities for development; friendly, with understanding adult point of view; does not seem particularly desirous of associating with children.

______ c. Frequently does not sympathize with child's point of view; child "just needs to grow up"; usually engrossed in child's success or failure in measuring up to adult's demands.

______ d. Children regarded as "miniature adults"; tendency to expect too much or too little of children; child's greatest virtue is to obey.

______ e. A child "should be seen and not heard"; children are naturally "bad", --imps of Satan; children naturally stubborn, mean, deceitful; often ill at ease in presence of children.

4. What is this teacher's understanding of pupil behavior problems?

______ a. Not as concerned with aggressive forms of "misconduct" as with the withdrawing forms of behavior; actively seeks to determine the cause-and-effect relationships in each child's behavior and to promote a more adequate adjustment.

______ b. Conscious of pupil's personality needs; often seeks for underlying causes of misbehavior; desire for "order" in classroom; however, often limits treatment to minor forms of punishment.

______ c. Usually oblivious to pupil's underlying personality needs; aware of advisability of becoming acquainted with pupil's home background, etc., but usually relies upon direct punishment.

______ d. Understands difference between conduct and behavior; overconcerned with conduct; treatment usually the same for all cases, --punishment.

______ e. Regards aggressive transgressions against authority as most serious of behavior problems; considers shy, meditative child as "model pupil"; wholly concerned with outward symptoms of misbehavior; no awareness of necessity of getting at underlying maladjustment.
Teacher Rating Scale (continued)

5. What is the attitude of the pupils toward this teacher?

______a. Regarded as one of most popular teachers in building; looked upon by pupils as a real friend to whom they can go to share their experiences.

______b. Attitude of respect and admiration rather than fondness; teacher not as approachable in a person-to-person relationship.

______c. Attitude of deference and obedience which most teachers expect of pupils; usually willing to conform to teacher's wishes, but no heart-felt attraction.

______d. Considerable dislike for teacher; pupils show little respect for teacher.

______e. Pronounced ill will toward teacher; teacher looked upon as enemy who is feared, avoided, or antagonized.

B. TEACHER'S PERSONAL ADJUSTMENT

From your experience in working with this teacher how would you rate him (her) in the following problem areas?

6. Is the teacher capable of analytical thinking?

______a. Intellectually independent; approaches problems analytically; capable of theorizing; enjoys solving problems; work is carefully planned and detailed; is persistent and serious.

______b. Generally persistent and serious and able to analyze and solve the more pressing problems; attempts to organize and plan work, but sometimes lacking in details.

______c. Average in analytical thinking; at times accepts ideas of others rather than do independent thinking; avoids activities that involve careful planning and detailed work unless asked to do so; uses habitual procedures.

______d. Appears to be casual rather than serious; is likely to attend to duties as the "spirit" moves him; willing to go along with the "crowd."

______e. Accepts uncritically the ideas of others; may not be able to do critical thinking; is willing to avoid planning and thinking; has a dislike for intellectual or creative activities.

7. What are the social attitudes of the teacher?

______a. Is more interested in people than things; converses readily and freely and makes friends easily; participates in and enjoys social mixing, frequently assuming some leadership; participates in various community social organizations.
Teacher Rating Scale (continued)

b. Usually appreciates the opportunity to work with people and seems to enjoy social organizations; sometimes assumes leadership in community activities; appears to be at ease in social groups and attempts to analyze and improve social relationships.

c. Quite friendly, but reserved; will participate in social events only to the extent demanded by his position and will assume leadership only when asked to do so.

d. Does not like to assume leadership in social functions; tends to be more interested in things than people; does not feel free or secure in social organizations, and dislikes affiliating with social groups.

e. Very self-conscious, shy, and socially timid; small number of friends; gives evidence of lacking common social skills and seeks background on social occasions; does not participate in community social organizations; prefers to be alone.

8. What emotional attitudes are shown by teacher?

a. Spirits are stable and uniform; not subject to apprehensive fears or worries; not easily upset or frustrated; avoids tension through relaxation; sees life in reality; is optimistic.

b. Usually demonstrates good emotional control; takes things in stride; most minor problems settled without undue tension or frustration; appears to be well adjusted and has good physical vigor.

c. Moody and sometimes emotionally unstable; frequently appears rushed or disrupted by minor problems; attempts to be calm in most situations; poised, but with considerable effort.

d. Usually serious, reserved and exacting; indecisive, uncertain, distracted, appears to be torn between several demands; frequently embarrassed.

e. Easily disrupted by minor problems and events; readily and easily embarrassed; often appears tired and listless, impulsive and jittery; frequently feels thwarted and suffers from tension, worry and uneasiness; frustrated and impatient.

9. To what extent does teacher demonstrate confidence in self?

a. Makes decisions readily; feels sure of own judgment and makes correct decisions; makes easy adjustment to new or difficult situations; enjoys the approval and favor of his associates; is optimistic about the present and future; not dissatisfied with his physique or appearance.

b. Usually equal to varying demands; does not hesitate to make decisions, even though they are not always approved by others; attempts to adjust to new situations generally through some effort.
Teacher Rating Scale (continued)

_____c. Sometimes feels inferior; is often pessimistic about the past and future; makes decisions but does not always feel secure in judgments made.

_____d. Avoids new or difficult situations, preferring to follow habitual routines; feels sorry for self much of the time; makes decisions only after consulting with many friends and associates; generally dissatisfied with personal appearance and ability.

_____e. Displays the traditional "inferiority feeling"; cannot make decisions satisfactorily or with ease; distrusts his own judgment and ability.

10. To what extent does the teacher develop satisfactory personal relations?

_____a. Does not lose patience readily and is not angered too frequently or too easily; does not feel slighted or misunderstood by others; is not too critical of friends and associates.

_____b. Conversational, friendly and with a good sense of humor; usually has an understanding point of view; reasonably good control of temper; sometimes critical of others.

_____c. Attempts to work satisfactorily with others when the occasion demands; inclined to lose patience when the "chips" are down; has a tendency to be more critical of friends and associates than is justified.

_____d. Tends to lose patience easily and becomes angered frequently when working with friends and associates; makes little or no attempt to understand people and feels misunderstood by them.

_____e. Easily irked by other people; usually touchy, suspicious, and inconsiderate in working with associates; demands own way--his ideas are better than all others.

11. How effective do you consider this teacher?

_____a. Outstanding in effectiveness

_____b. Quite effective

_____c. Effectiveness questionable

_____d. Somewhat ineffective

_____e. Very ineffective

Explanatory comments


Teacher Rating Scale (continued)

12. Disregarding this teacher's relationship with pupils, do you consider him (her) an effective teacher?

______a. Yes

______b. No

______c. Uncertain

Explanatory comments

__________________________________________________________________________

__________________________________________________________________________
APPENDIX B
May 29, 1962

Dear Principal:

Much money and effort have been expended during the last five years in the improvement of the teaching of biology. The National Science Foundation has sponsored numerous institutes to provide teachers with improved subject matter background. The Biological Sciences Curriculum Study has developed new materials and methods for teaching high school biology. Many local school districts and county units have held in-service workshops concerning the teaching of biology. All these activities have been organized for the purpose of aiding the teacher in improving the quality of teaching and learning in his classroom.

A doctoral study has been proposed to determine the relationship of pupil learning outcomes and selected teacher factors and teaching methods in tenth grade biology classes in Oregon. The study is to be conducted during the 1962-1963 school year. Teachers will be selected from schools interested in participating in the study by random selection techniques based on school size-ratio of high schools in Oregon. One class of pupils from each teacher selected will be pre-tested and post-tested in areas of basic biological understandings, science attitudes, and critical thinking skills. An attitude inventory and a questionnaire will be completed by each teacher.

This study should provide significant information concerning several aspects of biology teaching which will be of interest to administrators, teachers, and science educators. Would your school be interested in having a teacher (or teachers) participate in this important study? Basic information concerning participation of selected teachers and the students in one of their classes is presented on the attached page. The instruments to be used for evaluation and the times for administration are also listed. Space is provided for you to indicate your interest on the sample survey questionnaire.

Secondly, to treat the data by statistical methods, it is necessary to obtain the information included on the accompanying sample survey questionnaire. Would you kindly complete the sample survey questionnaire and return it in the enclosed stamped envelope at your earliest convenience?

Thank you for your cooperation in completing this questionnaire. I sincerely hope your school will participate in this study.

Sincerely yours,

/s/ Robert W. Howe

Robert W. Howe, Instructor
Department of Science Education

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Dr. S. E. Williamson, Chairman
Department of Science Education
Oregon State University

Enclosures: Letter of Explanation
Field Study Plan
Questionnaire
Stamped Envelope
FIELD STUDY PLAN

A brief description of the field study is presented to provide information for teachers and administrators concerning teacher and student participation, school visitations by the researcher, and material costs.

I. Teacher Participation

Classroom teachers who are participating in the study will administer the evaluation instruments in the fall and in the spring of the school year. The evaluation instruments will be mailed to the researcher in Corvallis for scoring and further study. An attitude inventory concerned with science and science teaching and a general questionnaire will also be completed by the classroom teacher during the latter part of the 1962-1963 school year.

II. Student Participation

The study will involve evaluation of students in the fall and in the spring of the school year, 1962-1963. The evaluation instruments will be distributed to the schools, administered by the biology teacher, and mailed to Corvallis. The evaluation instruments to be employed in the study are listed below with required times for administration.

III. Evaluation Instruments

A. Fall (projected testing date is the third week in September)

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Time for Administration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Otis Quick Scoring Mental Ability Test, Gamma Test, Form EM</td>
<td>30 minutes</td>
</tr>
<tr>
<td>2. Nelson Biology Test</td>
<td>50 minutes</td>
</tr>
<tr>
<td>3. Watson-Glaser Critical Thinking Appraisal</td>
<td>40-50 minutes</td>
</tr>
<tr>
<td>4. Student Attitude Survey</td>
<td>25-30 minutes</td>
</tr>
</tbody>
</table>

B. Spring (projected testing date is the second week in May)

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Time for Administration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Nelson Biology Test</td>
<td>50 minutes</td>
</tr>
<tr>
<td>2. Watson-Glaser Critical Thinking Appraisal</td>
<td>40-50 minutes</td>
</tr>
<tr>
<td>3. Student Attitude Survey</td>
<td>25-30 minutes</td>
</tr>
</tbody>
</table>

IV. School Visitation

During the school year the researcher has planned to confer with the teachers participating in the study. These visitations would be scheduled with the approval of the teachers concerned to discuss various aspects of the study.

V. Material Costs

All materials will be supplied by the researcher. Mailing expenses incurred through the return of the materials will also be paid by the researcher.
Field Study Plan (continued)

The above information provides essential data which will be of interest to both administrators and teachers. The names of individual teachers, students, and schools will not be used in this study. All information obtained will be treated in a professional manner.
APPENDIX D
SAMPLE SURVEY QUESTIONNAIRE

Directions: Please fill in the provided spaces with the requested information or check mark.

1. High School: ____________________________ Street Address ____________________________ City ____________________________

2. School Enrollment: Place a (√) in the provided space to indicate the total number of students enrolled in your school spring semester, 1962.

<table>
<thead>
<tr>
<th>Under 100</th>
<th>501-700</th>
<th>1,501-2,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-300</td>
<td>701-1,000</td>
<td>Over 2,001</td>
</tr>
<tr>
<td>301-500</td>
<td>1,001-1,500</td>
<td></td>
</tr>
</tbody>
</table>

3. Class Enrollments: Indicate the number of students enrolled in each class this semester.

<table>
<thead>
<tr>
<th>Grade Nine</th>
<th>Grade Ten</th>
<th>Grade Eleven</th>
<th>Grade Twelve</th>
</tr>
</thead>
</table>


   Number of Full-Time Biology Teachers
   Please check the types of classes which will be taught by these teachers.

<table>
<thead>
<tr>
<th>General Biology</th>
<th>BSCS Biology</th>
<th>Other</th>
</tr>
</thead>
</table>

   Number of Part-Time Biology Teachers
   Please check the types of classes which will be taught by these teachers.

<table>
<thead>
<tr>
<th>General Biology</th>
<th>BSCS Biology</th>
<th>Other</th>
</tr>
</thead>
</table>

5. This study should provide information of significance to both school administrators and teachers. Would you indicate below whether or not members of your science staff would be interested in taking part in this study?

   Yes ___ No ___

6. Principal ____________________________

Return to: Robert W. Howe
Physics-Chemistry, Room 249
Oregon State University
Corvallis, Oregon
### TABLE 1VI

**CLASS MEANS ON EVALUATION INSTRUMENTS***

<table>
<thead>
<tr>
<th>School</th>
<th>Otis</th>
<th>Nelson Total F</th>
<th>S</th>
<th>Nelson Part A F</th>
<th>S</th>
<th>Nelson Part B F</th>
<th>S</th>
<th>W-G CTA F</th>
<th>S</th>
<th>Reaction Inventory F</th>
<th>S</th>
<th>Understanding Science F</th>
<th>S</th>
<th>Vocational Interest Change</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>124</td>
<td>45 56</td>
<td></td>
<td>24 32</td>
<td></td>
<td>21 24</td>
<td></td>
<td>73 77</td>
<td></td>
<td>36 33</td>
<td></td>
<td>6.5 5.8</td>
<td></td>
<td>- 4</td>
</tr>
<tr>
<td>2</td>
<td>122</td>
<td>43 51</td>
<td></td>
<td>21 29</td>
<td></td>
<td>22 22</td>
<td></td>
<td>69 73</td>
<td></td>
<td>37 32</td>
<td></td>
<td>7.4 5.3</td>
<td></td>
<td>+ 8</td>
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<tr>
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<td>120</td>
<td>40 48</td>
<td></td>
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<td>67 71</td>
<td></td>
<td>42 41</td>
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<td>6.5 7.5</td>
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<td>68 66</td>
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<td>40 39</td>
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<td></td>
<td>+ 1</td>
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<tr>
<td>5</td>
<td>116</td>
<td>41 46</td>
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<td>21 26</td>
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<td>19 20</td>
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<td>9.3 8.9</td>
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<tr>
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<td>8.4 7.0</td>
<td></td>
<td>+ 6</td>
</tr>
<tr>
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*Raw scores for each instrument utilized in the student evaluation were listed for fall (F) and spring (S).

Spring scores on the Watson-Glaser Critical Thinking Appraisal were adjusted for differences in difficulty between the two forms used.

A lower score in the spring on the Reaction Inventory and on understanding science indicated a favorable change in attitudes.
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