AN EVALUATION OF NINTH-GRADE SCIENCE FOR THE ACADEMICALLY TALENTED

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PREFACE

A significant trend in public school curriculum development in the United States, is characterized by the formation of national committees with the involvement of nationally known personalities, prestige institutions of higher learning, and much federal money. This trend is particularly obvious in the area of secondary school science. The investigation reported herein originated from the premise that curriculum research in secondary school science programs is still necessary at the local level and that significant contributions toward the realization of national objectives can be made by individual initiative.

The principal objective of this study was to evaluate the various ninth-grade science programs being utilized by the Wichita schools in 1961-1962. At the time of the study (April 1965) students involved were seniors, who, as ninth-grade students ranked in the top ability quartile and participated on one of the groups under investigation.

Grateful acknowledgement of his contributions to this study is made to Dr. Victor O. Hornbostel, chairman of the writer's advisory committee. Other members of the committee to whom gratitude is expressed include Mrs. Helen Jones, Drs. Bernard R. Belden, James E. Webster, and Kenneth Wiggins. Special recognition is also due many people in the Wichita schools for their unfailing cooperation. The division of pupil services, the curriculum division, the high school principals and the senior counselors contributed to the data collection.

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CHAPTER I

THE NATURE OF THE PROBLEM

Introduction

The basic assumption underlying this study is that the curriculum of the junior high school has a lasting motivational effect upon the plans and interests of students subject to the influence of such curriculum. Justification of such an assumption results from the realization that anything less would be tantamount to questioning the influence of the entire curriculum and hence the influence of the school itself. Implicit to this assumption is the axiomatic conclusion that the total influence is the sum of the smaller influences.

A secondary assumption impinging upon this study is that the attrition of academically talented students from the science field of endeavor constitutes a loss to the field, to the welfare and defense efforts of the nation, and at least in some degree, to the individual involved.

It is the purpose of this chapter to introduce the dissertation in terms of the problems which impinge upon it. Starting with broad and general observations which present problems of universal scope, the chapter concludes with the presentation of the specific problem under investigation and the specific questions to which answers were sought. The primary purpose of the study is to analyze the content of some prevalent ninth-grade science courses for academically talented students in terms of lasting interest, science achievement and future plans.

The Broad Problem

There is an abundance of confusion and a dearth of agreement today among teachers, administrators, and curriculum planners, concerning the subject matter of the ninth-grade science course. This confusion is easily aggravated by the consideration of such important matters as individual differences, motivation, creative thinking, goals and the "unique" philosophy of the junior high school. Some of the uncertainty results from a change in our thinking in regard to the objectives of high school science, in that chemistry, physics, and biology are undergoing radical changes. This, along with an increased emphasis on the importance of the elementary science program and a more science conscious public, has contributed to focus public opinion, and administrative and teacher concern on the entire science program.

Most teachers, administrators, and curriculum planners agree that the ninth-grade program should fit into the total science picture from kindergarten through twelfth grade. Furthermore, if junior high school science is to have any meaning, it should not only be coordinated with, and prepare for, senior high school science, but the program itself should be so structured as to form a self-contained unit in the seventh, eighth, and ninth grades, with a specific objective centered around a high school level of student activity. At the present time, however, a vacuum has been created in the ninth-grade science course, leaving it literally without profitable subject matter. The strengthened program in the seventh and eighth grades has virtually "used up" the traditional subject matter, leaving for the ninth grade, a "review" of previously presented material.

Closely associated with the problem created by the dearth of subject matter, is another associated with the concern for a laboratory experience for ninth graders. Here again, there is more agreement than difference in opinion, that the junior high school science program should be more than a part of the reading program; that ninth graders should learn science, rather than learn about science; that science is what scientists do.

In attempting to design a ninth-grade program, curriculum planners have followed several choices. Many science teachers and administrators have found themselves developing a curriculum for the first time, and very often they have found themselves somewhat short of adequate training for their new role. The easiest thing for educators to do under these circumstances, and probably the most reasonable, is to borrow a well established course from the senior high school. The expediency of such procedure is obvious; the content is well-described, as are the supplies and equipment, and personnel within the system is available to initiate such an endeavor.

There are many examples of this kind of curriculum revision. Earth science has been introduced in many systems for ninth graders, on the theory that since the traditional general science lacks depth and unity of course content, a single unified science built around a central theme would make up for these lacks. Another significant argument has been that since senior high school science usually included biology, chemistry and physics, earth science would really not rob the senior high school of any of its present science curriculum. Also significant, relative to earth science, is that it represents a return to the fold, earth science having once been the traditional ninth-grade subject only then called geography.

Biology has been the most popular of the single unified courses to be introduced in the junior high school. Curriculum planners have argued that since biology was usually considered a sophomore subject, it was the most logical subject to move down into the ninth grade. This practice, along with the trend of first trying the new course on the ninth-grade academically talented, has been considered legitimate. However, many professionals in the field of curriculum have disagreed. Blanc (4) considers this fragmentation completely antithetical to the growing recognition of the interdisciplinary nature of the sciences and the level of sophistication of the modern junior high school student. Mallinson (24) concurs with Blanc's viewpoint.

As a result of experimental research in which a comparison of the performance of ninth grade and college students in an earth science laboratory activity was made, Romey & Merril (41) concluded: Ninth-grade students of average ability grasped the material presented in an earth science class as well as did the college undergraduate group of similar ability. They add the implication that ninth-grade science students should be taught at a high level of sophistication with the use of inductive reasoning to develop concepts.

Several professional groups in different parts of the country have been examining general science programs. Although their recommendations are tentative and no group is willing at this time to suggest a program in science for the junior high school, agreements on general guide lines are beginning to appear. The following is a summary of Blanc's (4) general guide lines:

1. Fragmentation of science into junior high school science, has been increasing in scope for many years.

2. Many science educators are beginning to feel that the multiplicity of topics in many general science courses is getting out of hand. As our scientific knowledge broadens, more and more areas of study are being added to the general science program and nothing is being left out. This is resulting in unworkable courses to which neither the student nor the teacher can do justice. Many of the educators and curriculum designers are therefore beginning to feel that a study in depth of several major areas of science is preferable to an attempt at giving students an overview of everything that is known in science.

3. Many curriculum designers have not clearly differentiated in their minds the difference between a science course based on accepted concepts and understandings in science and a course that is merely an introduction to the varied technology of our times.

4. Thoughtful science teachers have long felt that a good many general science classes have evolved mainly into "reading about science" interspersed with a few sporadic "experiments" performed by the teacher.

5. Reading skills, vocabulary building, applications of science concepts, and many other desirable outcomes can be achieved only by means of a conscious and concentrated effort on the part of teachers. The science curriculum that guides teachers, needs to be designed with these purposes in mind.

6. It is the feeling of many people interested in science education that the junior high school level has been a neglected area. The significance of a strong general science course taught on a full five-day-a-week schedule with facilities and equipment for students to really learn the meaning of the search for truth, has seemingly escaped the curriculum planners in many schools.

In reporting the status of science teaching at the junior high school level to the American Association for the Advancement of Science and the National Science Foundation, by which his study had been jointly sponsored, Mallinson (29) concluded that all the studies point to several salient facts:

1. The shortage of teachers of science has been particularly destructive of the junior high school program.

2. It is difficult to find agreement concerning the desirable content of general science at the junior high school level.

3. An evaluation of many of the textbooks available for junior high school science, particularly those designed as series for seventh, eighth, and ninth grades, provides ample evidence of the

redundancy and naivete of much of the material. On the other hand, many misguided enthusiasts mistake sophistication for vigor. Their views suggest that junior high school science should be little more than an introduction to the specialized sciences taught in the high school.

4. The junior high school science program is plagued by the zealous who are desperately trying to identify students with scientific aptitude, a trait, if it is a trait, which to this date has not been identified or measured.

Weisbruch, (61) prominent Catholic science coordinator, says the answer to the ninth-grade science problem lies not in changes of subject matter, but a change in method. He submits that neither biology nor earth science belong in the junior high school, because they are still basically descriptive in nature, much like the old traditional general science. The ninth-grade science must be a laboratory science with a high order of student activity; not another descriptive course of the kind to which they have been overexposed.

Renner (40) in an analysis of the revolution of science education concludes:

> We have found that there is basically only one reason why the revolution in science education has occured. The secondary school science curriculum was in need of repair because those responsible for it considered that observing and classifying facts constituted a proper scientific experience. In other words, the process side of science was missing. To have a proper experience with science, not only must the process side of science be present, but the content must be up to date and of such a nature that problem solving, not problem doing, is encouraged.

In the heart of his analysis, Renner submits that extravagantly equipped laboratories, in which students spend many hours, does not by itself take us anywhere. One does not have to look far today to see elaborately equipped laboratories collecting dust while the teacher continues his lecture-recitation method of instruction in a so-called new approach to science teaching.

Junior high school science has certainly had its share of experimentation in regard to individual difference. As Mallinson (29) stated, a scientific aptitude has not as yet been identified, but scientific motivation is another thing most experts consider very real. In discussing creativity in the sciences, Abelson (1) notes that mental capacity and judgment are largely genetically controlled, but motivation is the factor most subject to change by one's surroundings. With motivation comes the self-control necessary for tapping one's resources. The inner resources which permit the creative person to continue after repeated failure, he concludes, can stem only from deep motivation.

Wiesner, (62) a former science advisor to the president, addressing himself to the problem of national policy said:

> Initially our most important source of new creativeness will be the large proportion of our youth which is now, for one reason or another, either denied the opportunity for the necessary education or is not motivated sufficiently by our society to seek it.

Since, as Abelson notes, motivation is the factor most subject to change by one's surroundings, educators have concerned themselves with this factor by giving special consideration to the matter of individual differences. Boredom, they agree, would probably contribute to the aversion of a creative person from science studies and careers. Klausmeier and Wiersma (25) have made a comprehensive study of the prevalent activities being pursued in the United States, to allow academically talented students to proceed at a rate commensurate with their ability. On the basis of the results from an experimental study they conducted in the Milwaukee Public Schools, this system has incorporated the condensation of three years of mathematics and science into grades seven and eight, for students of high learning ability.

Fischler (17) considers the new focus of the sixties in the area of curriculum development will be on the development of a science program from kindergarten through grade nine. The groups which he thinks are making some great strides include the Educational Services Incorporated (ESI) located in Watertown, Massachusetts; Elementary School Science Project (ESSP) at the University of California, Berkley; and the University of Illinois Science Project located at Urbana, Illinois.

Cohen (10) reports that the central theme of recent science education research has pertained to the crisis in the supply of scientific manpower and to seeking some easing of this critical situation. Efforts have included national and state surveys of the status of science education and of science teacher demand and supply, determination of student reactions to teachers, courses and scientific careers, predictions of science achievement of students, and attempts to up-grade science courses.

The few reports from recent literature indicate that the controversy over ninth-grade subject matter content has not been solved. On the contrary it has extended itself to include the entire science program, from kindergarten through twelfth grade. Those who really know the complexities of curriculum development stated years ago that curriculum could not be developed in a vacuum; that the concentration of emphasis at the ninth-grade level for example, without due consideration for the students' previous experiences and their future possibilities is likely to create more problems than such isolated emphasis can hope to solve. Perhaps the only defense for such procedure is that often the only way to arrive at the solution of a problem is to create or delineate new problems.

The More Limited Problem

In the fall of 1959, shortly after the first National Defense Education Act provided money on a matching basis for the construction of science laboratories, a laboratory science program was initiated in the Wichita junior high schools. One room in each of the fourteen buildings was equipped to give academically talented pupils individual experiences in order to challenge and motivate them and at the same time satisfy the state laboratory science requirement. Nine junior high schools offered biology, traditionally taught to sophomores, and the other five junior high schools offered a course consisting of (approximately nine weeks each) chemistry, physics, biology, and earth science. In the Wichita system, this course just described was referred to as "Lab Science".

Whether a particular school offered biology or the combination of science was influenced by the thinking of science teachers and administrators. Briefly, the opinion of the staffs of most schools was that the combination of courses was more in keeping with the junior high school philosophy of exploration, that the pupils' training gained in the "Lab Science" arrangement could be better utilized in the existing high school program, and that the pupils' experiences better correlated with their previous science background in the elementary and seventh and eighth grades. However, the greater number of teachers better prepared in biology than in the physical sciences was a more influential factor in the ultimate decision of nine schools to teach biology.

Because the junior high schools were split five to nine on their laboratory course offering, much continuity was lost in the overall city program. Many pupils transferring from one junior high school to another were in trouble because they could not find the same course in the new school. The high schools were receiving students with a greater variation of background, and the problem of a program with continuity of content was growing. The high school biology teachers were particularly disturbed because those junior high schools teaching biology were sending only lower level pupils to the high school biology program. The better students having taken biology in the ninth grade chose courses other than biology or took no science at all.

Also, in the fall of 1959, the new program in high school physics, Physical Science Study Committee (PSSC), was introduced in the Wichita high schools. The following fall the new program in high school biology, Biological Science Curriculum Study (BSCS) green version, was initiated in four Wichita high schools. Those additions contributed more confusion to the direction of the science program, and so, the first vertical science committee was formed. This committee was composed of science teachers from the elementary school, junior high school and senior high school levels, the curriculum directors of the elementary schools, the assistant superintendent in charge of curriculum and the investigator, a junior high school principal who served as the chairman.

In January of 1962, the vertical science committee submitted its proposal for curriculum change in both structure and content, the major change being in the junior high school. The idea behind the proposal was that all junior high school pupils should have laboratory experiences and that the average and below average pupil would likely benefit as much or perhaps more from such a class than the academically superior student.

The Board of Education accepted this philosophy and provided the funds to equip all science rooms in all the junior high schools for such a program. It must be said that the proposal was not accepted in its entirety at every junior high school. The heart of the change was the placement of the "Lab Science" throughout the ninth grade and some schools were reluctant to abandon teaching biology to their academically talented pupils. These schools were claiming excellent results in achievement and high motivation on the basis of their subjective observations. No extensive follow-up was made.

Other schools, during the early days of the junior high school laboratory program, had fewer sections of the honor program than they needed to accommodate all of their academically talented. As a result, some of these high caliber students enrolled in traditional general science. Also during this embryonic period, there were in nearly every school, a few students who for some reason or another, preferred the traditional general science to the highly competitive honors program though their ability was as high as many of those who did qualify.

Furthermore, because science need not be taken at the ninth-grade level, there were a large number of academically talented students who took no science at all in the ninth grade.

The implications of the Science Motivation Project by Mallinson (29) would tend to suggest that the influences of the junior high school experiences are likely to be reflected not only in the high school but also in the college years.

It would appear therefore, that the opportunity presents itself to examine this heterogeneous group of academically talented seniors in an attempt to see if the qualities of the junior high school experiences in science are transient and have little effect on the students' later contacts with science, or if these experiences as Mallinson suggests, reflect a part of a much larger picture.

The Specific Problem

Does the nature and kind of ninth-grade science experience of these academically talented students, appear to influence the extent to which they pursued science in senior high school?

Does the nature and kind of ninth-grade science experience of academically talented students, and the units of science credits they have received in high school, manifest itself among the academically talented seniors in any of the following ways?

1. Achievement in the broad field of science
2. Interest in science
3. Plans for taking science in college
4. Plans for a career in science

CHAPTER II

RELATED ASPECTS OF THE STUDY

Introduction

As suggested in the title of the study and delineated in Chapter I, there is more involved in this investigation than the isolated consideration of ninth-grade science subject matter content. Empathy for those involved in such curriculum development could result only after one has reflected upon the historical significance which abounds.

For example, placing general science in the ninth-grade curriculum was preceeded by a hotly debated and most interesting struggle. Some of this struggle is presented in this chapter.

As technology introduces changes in practices and procedures and as findings of experimental research impinge more upon the conceptualization process of curriculum development, and as more money via government channels becomes available, new curricula and scientific methods of curricular development are appearing. This chapter will consider some supportive theory and discussion of recent developmental practices.

Lastly the chapter will be concerned with the additional problem of curriculum development necessitated by meeting the needs of academically talented students. What are the characteristics of these students? What are the problems they present to curriculum planners? Is there evidence of neglect in this area? What does recent research indicate relative to this kind of problem?

Historical Development

The lay observer could easily conclude that general science has always been a part of the American high school, and that it was introduced into the high school curriculum with little fanfare because everyone felt that it should be so included to introduce the other high school science subjects. The opposite could never be more true. The road to this goal in curriculum development was as rough and stony as any ever traveled.

The first real text in general science was Clark's General Science, published in 1912, by the American Book Company (9). It contained 363 pages with illustrations and cost eighty cents. It had an accompanying laboratory manual which cost forty cents. Later came a flood of material which has never abated.

At the time the book was published, there were twelve different sciences being taught in the high schools. They included physics, chemistry, botany, zoology, physiology, anatomy, geology, geography and meteorology. The National Education Association appointed a committee of twelve (one for each science being taught in high school) to investigate the possibility of a general science course. The chairman was William Orr, Deputy State Commissioner of Education, Boston, Mass. Dr. Otis Caldwell was chairman of a similar committee of the Central Association of Science & Mathematics Teachers. Webb (59) gives some interesting selections from their published comments to show the nature of the controversy.

From Dr. Caldwell's committee: "As the various sciences have become differentiated and developed, most of them have been introduced with the high school curriculum in one or more parts of the country. Each science has its merit, else it would not stand as a science. .... Often eight different science subjects, and sometimes even twelve are found in the high schools of a single state. These numerous sciences are contending with one another for a place in the high school, instead of presenting a demonstration of the efficiency of a unified science. This is a need apparent to anyone who has studied the schools first hand.

What should science do for high school pupils? It should give knowledge of the world of nature, more purposeful activity, future occupations, solving own problems, enjoyment of life. The truths of science are the truths of life.

First year science in the high school should be organized upon a broad basis, including the fundamental principles of the various sciences, and using materials from all. Physiology and hygiene should be combined with physical education.

In the second year, emphasis should be on the biological sciences and their applications. The third and fourth year need diverging interests such as physical and chemical science, domestic science, agricultural science, and electives."

Commissioner Orr's committee also recommended an "introductory science" for the first year of high school, rather than any special science or physical geography. The committee further recommended that this introductory science be followed by physics in the second year, chemistry in the third, geography and/or biology in the fourth year.

As the argument continued as to which science was the most important, the introduction of a general science began to appear as the only solution to the dilemma. Those who were arguing that chemistry, for example, should be maintained in the high school would much rather see an introductory course required than to have one of the other established sciences move into the coveted position. A parallel debate was going on at the same time as to what should be required and what should be elective. Those supporters of a particular science did not really feel that their own speciality should be required but rather that none of the other sciences should be required either. At the same time, all interest groups realized that no single science could thrive in a vacuum. General science not only appeared to be the way out, but a desirable promotion of each science.

Since the consensus was at least reasonably general that this introductory science should be offered in the first year of high school, it was natural and logical that it should replace the science that was being taught in the first year of high school. By far the most popular scientific course being taught in the ninth grade was some kind of geography. Sometimes it was simply called geography but usually a somewhat more sophisticated title was used to distinguish it from the elementary course. "Physical Geography" was most usual, but also used was "High School Geography", and "Industrial Geography". Later it was called "Physiography" and still later "Earth Science".

The physical geography proponents went conscientiously to work to save their pet interest. The arguments they used appear at best humorous to us today. Certainly we wonder how our logic will seem to those involved in curriculum change a half century from now.

An early reply to the trend to replace physical geography with general science was given by Fairbanks (16) of the University of California in 1910.

> After a long and careful analysis of the situation from all standpoints, it seems to me that the proposed course in general science for the first year of the high school is fundamentally bad and a decidedly backward step. If generally introduced, it will displace physical geography which I hope to be able to show you is, when properly interpreted, the only science study which is fully adapted to this stage in the school course. ... . It is with the hope of discouraging this movement, and saving the high schools years of groping in the darkness of this general science notion, that I wish to plead the advantages from every standpoint of this old but too often unappreciated subject of physical geography. Because of wrong ideas as to what physical geography should be for first

> year high school pupils, because of the wrong attitude of most of the texts, because of the wrong conceptions of most of the laboratory work and the too formal demands of college entrance requirements, and finally because of the still widely held view that anybody can teach physical geography whether he has any preparation or not, the matter has reached such a stage that we have got to defend one of the most practical as well as broadly cultural subjects of the whole high school curriculum.

Fairbank's article was not only well written, but it was packed with emotion. He predicted that general science was sure to be poorly taught. He stated that no one man in the University of California was capable of giving such an all-round science course and asked if they could expect to find such men in high school.

Like so many situations of this kind, it would be most interesting to have a reaction from Fairbanks if he were around today, with his beloved physical geography making the come back that it has under the title of earth science. Some of the arguments Fairbanks used, such as "Physical geography is more adapted to immature minds...requires outdoor observations ... all phenomena are primarily geographic, i.e., they take place somewhere ... geography is vitalized, personal and warm", are being used today, in only slightly different context, by those who believe that earth science is the course that should be offered to ninth-grade students.

Though there is much similarity, it is really doubtful that Fairbanks would recognize the course if for no other reason than because of the prevalence of the laboratory, and problem solving techniques. Fairbanks raised serious questions about the value of the laboratory.

> The laboratory method in physical geography is in danger of becoming formal and lifeless. The importance of acquiring a rational knowledge of the interaction of the phenomena about us has often been lost sight of in weeks devoted to the study of contour map, the prolonged analysis of weather maps, and the mechanical recording of physical observations. The ability to

> handle all sorts of meteorological instruments will for most pupils be of little value in practical life, but an understanding of the meaning of weather signs as illustrated in the phenomena of the air will not be forgotten and will be of perpetual use.

The highly emotional and presumptous comments of Fairbanks did not remain unanswered for long. Mann (31), another involved professor at the University of Chicago wrote: "Fairbank's paper proves, if it proves anything, that physical geography is as ill-fitted as it could possibly be for the purpose, and that only general science can ever satisfactorily meet the present demand."

Perhaps the most significant part of the criticism is the "present demand" aspect. "Present demands" for styles in clothes go through cycles for example. For a time a certain style may be in demand but when something new comes along, the old style must be discarded. It is true that a style may return, but it is really never quite the same. The material is different, or the weave or the color may not be suitable. Few people ever put an article of clothing in the trunk and bring it out years later with much measure of satisfaction in wearing the article. Does the return of the stick shift on new automobiles imply that the old and proven manual clutch has after all proven superior? Or does superiority have anything to do with it? Certainly the sticks on the new models only faintly resemble those of an earlier existence.

Those involved in curriculum planning need only take one look at its historical development to be convinced of the naivete in thinking that they are motivated solely by function. The "demands" of the situation, both of which planners are aware and those of which they have no consciousness of existence, are probably the real villains or heroes.

Perhaps curriculum writers and curious investigators would exhibit genuine wisdom in the matter if they would refuse to laugh and ridicule the arguments of their predecessors, and for that matter criticize themselves too severely if they seem to be doing the same thing years later with the only difference being in the fabric or weave.

A truly significant fact is that change does make an indelible mark. The writer is acquainted with an outstanding high school physics teacher who resisted at first, the change to PSSC physics. Yet very soon after the first booklet had been released, he was caught utilizing some of the PSSC ideas in his laboratory sessions, and only to friends would he admit his theft. If the so-called PSSC physics were suddenly to disappear, traditional physics would never be the same.

We need not present a great mass of arguments supporting the change to general science. It should suffice to say that those who did support the general science idea were the victors, if there were victors. With the possibility that the presentation of more arguments designed to save physical geography appear anticlimactic, a few, however, are most interesting. Coulter (12) of the University of Chicago again, wrote:

> I can not agree with the method of general science. It is a substitute of the enclyclopedic for the educative. As an analogy, almost all the living languages are represented in the populations of Chicago, yet it would hardly seem rational to teach a child all the foreign languages at once, by picking out the commonest words and phrases of each.

In concise rebuttal, Caldwell (8) of the same university wrote: "The accusation that general science is encyclopedic is true in the sense that it attempts to include a measure of the scientific information which seem to be appealing and worthwhile to young learners."

Ten years later the controversy still persisted, but with a new wrinkle. In 1924, Martin (33) of the Arsenal Technical High School, Indianapolis, reported:

> The course in civics is regarded as more profitable than general science since it gives a broad view of life, including the relation of science to it, and therefore is more valuable to the student than the limited phase showing the relation of science alone to life as presented by general science.

As Webb (59) observed, "Truly this was the first time, perhaps the only time, that general science was criticized because it was too narrow."

The development of subject matter materials in general science was not accomplished without the assistance of national committees and specialists in the related fields. One such specialized scientist was Millikan (34) whose work in establishing the mass of the electron achieveed for him international fame. Millikan was not particularly proud of his contribution to the general science movement.

> I was intimately associated with the initiation of the general science movement - for which I hope God may sometime forgive me - so that I have had to look quite carefully into the teaching of all the secondary school sciences. The elements of science instruction are simple and definite and the mere statement of these elements at once points the way at least to the next step in the solution. The successful technique of teaching high school physics at least, and I think also of other high school sciences, is now pretty well known. For the last fifty years those who have been actually teaching secondary school physics have been working out by trial and error, a successful technique of that teaching, and there is now large agreement upon it.

The article by Millikan was answered the next year by Downing (14).

> But that the elements in the problem of secondary school science are simple and definite and that the mere statement of these elements at once point the way at least to the next step in their solution seems to me an optimism born of ignorance. His statement that the successful techniques of teaching high school physics and also other high school sciences is now pretty well known, a technique which he claims has been worked out by trial and error is far from the truth. If one had made 50 years ago a similar statement in regard to medicine, that the technique of treating diseases had been thoroughly determined by the preceding centuries of the trial and error method, he certainly, in the light of the advances made in the last 50 years by the scientific method could justly have been accused of rashness. The scientific study of the efficiency of the various types of pro-

> cedure in the teaching of physics and other sciences has just begun. The curious thing is that men who are supposed to be saturated with the scientific attitude of mind fail to see that the problem of teaching must be attacked in the same scientific way as the problems of the physical and biological sciences. Surely the trial and error method would not go far in settling the problem on which the present day physicist is at work. Nor can we expect them to be more successful in settling the problem of teaching.

These two philosophies of Downing's and Millikan's have persisted in conflict from the time of their introduction to the present. During most of this period the philosophy, as represented by Downing, has prevailed. Now it seems that the philosophy, as represented by Millikan, is growing and gaining the ascendancy.

Because biology has made its way into the ninth grade and because there are significant elements of society which feel that biology is the best subject to teach in a ninth-grade science class, some of its historical development will be considered here. Furthermore, one of the experimental groups of this study consists of students who had biology in the ninth grade.

The subject of biology is truly a contribution of the American high school, not having been first a college subject watered down to high school level. As such, it marks the first successful revolt by high school teachers against the course content and methods of college professors. General biology came into vogue about ten years after general science, or about 1922. It was accepted more readily, however, inasmuch as the general science controversy had paved the way for the practice of going from the specific to the general in curriculum development. The specialized courses of botany, zoology, and physiology, really had to give way if any portion of their content was to be a part of the average high school student's experience. It was a wise move, for today, general biology is elected by more students at the senior high school level, than any other science.

At first the tendency was simply to teach botany for one semester and zoology for the other. Though this description implied recognition of the standard specialized courses, it did not conform to the objectives toward an all-inclusive title. The New York State Board of Education published a general biology syllabus in 1910 (35). Four major aims were stated:

1. To give boys and girls a first hand knowledge of some common plants and animals

2. To lead pupils to some understanding of the essential functions carried on by all living things

3. To teach them something about the economic importance to man of plant and animal products and the necessity of preserving the biological resources of the country

4. To emphasize especially the essential conditions of individual and public health in city and state

As Rosen (42) observed: "In many ways, the introduction of general biology was a reaffirmation of high school teachers of Pestalozzi's ideology, now welded to the pragmatism of John Dewey."

General biology was readily accepted in nearly all areas but New England. In 1916, Walter (56) of Brown University wrote as follows:

> At the present time, it is frequently true that the biological course of the average high school has strong resemblance to hash. To speak plainly, it too often consists of warmed up left overs, e.g., a little nature study from the grades, some large indigestible chunks of college zoology, a dash of elementary physics and chemistry, a little botany and hygiene, and in certain states where required by law, an intemperate dose of temperance.

The general rule was for biology to be placed in the tenth grade or the first year of the three-year high school course. As Rosen(42) observes:

For small high schools general biology provided greater economy of time and teaching staff. The scope of general biology was broader, less technical and more practical. In short, the new course was far better adapted to the American high school than botany and zoology courses.

Despite a widespread opinion that general biology was a poorly organized, incomplete, snap course in the hands of incompetent teachers, the new experiment in high school science teaching attracted students. In the smaller school, general biology was replacing botany, zoology, and physiology; in the larger, it was being added to the curriculum as an elective--but one whose popularity increased alarmingly at the expense of the specialized courses.

By 1936, it appeared that in biology, at least, a panacea for the ills of high school science had been found.

Recent Proposals For Ninth-Grade Science

As pointed out in Chapter I, biology has been the most popular substitute or replacement for general science. A recent survey conducted by the United States Office of Education revealed that among the schools sampled, 13.5 per cent were offering general biology as an elective at the ninth-grade level. (55) There are other indications that an increasing number of schools are offering the first year biology course at this level in preference to the more traditional tenth year placement.

Yager (64) and the University School in Iowa City analyzed this trend in their school.

For the past six years it had been possible for both ninth and tenth grade students to enroll in general biology in the university schools. During the past four years approximately 50 per cent of the students have elected the course during their ninth year. The students were not segregated according to grade level and the same teachers, laboratories, and course schedules were involved for both ninth and tenth grade groups.

A comparison free from influences of differences in general ability indicated the difference in achievement between adjusted means of the ninth and tenth grade students was not statistically significant.

Queries directed to the course instructors yielded contrasting opinions in several respects. There was agreement on a number of important points however. The majority of instructors felt that there was little evidence of difference between ninth and tenth grade student's attitude or classroom performance. Several instructors felt that ninth grade students exhibited a more inquiring approach to the course. The number of outside projects completed by the ninth grade group was considerably greater than that for the tenth grade students. Very little difference was noted in the over-all performances of students in the laboratory and on teacher constructed examinations. There was some indication that tenth grade students performed better on test items involving abstract concepts. It seems safe to assume that tenth grade students would be able to achieve a greater depth of understanding by virtue of their greater motivity than degree of difficulty.

There are several implications associated with this study. First of all, it is apparently possible to organize a good ninth year biology course that may have many characteristics of the typical tenth year general course. With most teachers and most objective measures available, there is little difference in performance between ninth and tenth grade students. Certain teachers can affect the achievement of either group positively or negatively. Certainly school organizations as to number or periods, laboratory facilities, and teacher assignments will affect performance by students in the two grades. However, when the variables are largely controlled, there is little difference in achievement between groups for the typical general biology course.

These findings tend to support the often quoted statement that maturity probably has little to do with the level of the concept, only the level of presentation.

Another implication involves the suggestion that considerable reorganization of the science curriculum--kindergarten throughout twelfth grade--is possible and possibly desirable. Certainly the void in the typical junior high school could be altered by a good general biology course. Most of the information concerning health, hygiene, conservation, safety, etc., which was commonly a part of the junior high science is now found in the elementary school. This is also true for areas concerning more basic science. This suggests the need for expanding junior high science where thoroughly trained specialists in science education are available.

Before leaving biology as a strong contender for the coveted role of ninth-grade science, it would be well at this time to summarize the pros and cons of biology being granted this esteemed position. Sharkan (44) goes into detail on a few of the pros clearly revealing his bias. First the pros:

1. A considerable portion of the material covered in the ninth-grade general science course has been introduced in the elementary school science programs and completed in the strengthened seventh and eighth grade science programs. Therefore when this is done, one will gain a year in the science program. All subjects are moved down a year and an advanced program is set up.

2. Since biology is usually taught in the tenth grade, it is the logical subject to move downward into the junior high school. Chemistry and physics are more specialized sciences which require more elaborate equipment and changes in the physical environment of the school. Likewise they require more of a mathematical background than biology.

3. More teachers are trained to teach biology and hence express by their training their interest and motivation. Certification requirements are clearly defined by most states as to what constitutes adequate preparation for biology teachers. Though an earth science course is available, teachers with training and interest are not.

4. Biology is a course with prestige while connotations of an earth science course imply that it is just right for the science-shy student. Likewise, an introduction of biology in the ninth grade will

satisfy the demands of the critics of American public education by raising the standards of scientific education so that students start to motivate themselves toward a college education earlier, and will help eliminate the supposedly "snap" courses they are taking.

5. The introduction of ninth-grade biology will allow the academically talented students to gain one year through school and will allow them to enter college with advanced standing. This is becoming extremely more important in our professional world when more years are spent obtaining advanced degrees.

6. Ninth-grade biology could easily be the most functional course in the ninth grade or in junior high school. During the ninth grade one finds dynamic changes taking place in the growing boy or girl. The pubescent spurt and the onset of adolescence focuses one's thinking on oneself as a biological mechanism and supports the teaching of a functional ninth-grade biology as the opportune subject at the appropriate time.

Many of these pro arguments are considered by some to really say more against ninth-grade biology than they say for it. Therefore, in the list of cons the only change is sometimes in the frame of reference.

1. The greatest disputation against ninth-grade biology is that of the maturation factors in children relative to the placement of biology. Critics have said that the maturity of one year is exceptionally significant in the teaching of biology. They go on to say that ninth-grade students have not matured enough to assimilate the subtle and complex relationships that are taught in the study of heredity, evolution and reproduction.

2. A specialized course such as biology in the ninth grade is

antithetical to the philosophy of the junior high school. The role of the junior high school should be that of exploration; it should concern itself with many areas of science.

3. Biology does not lend itself to the laboratory centered approach which is so badly needed in the junior high school, particularly at the ninth-grade level. The change which is needed in the junior high school is one of method, not content. The biology as now taught in most tenth grades will not produce this necessary change in method.

4. High school teachers do not relish the idea of going to a junior high school to teach. Even though they should not need to move, they do not like for the junior high schools to literally capture their most popular subject. They often claim that they are faced with either transferring to the junior high schools or teaching something else in the senior high schools for which they have less training and less interest.

5. Finally, ninth-grade biology will result in a "watering down" of tenth grade biology material to the extent that biology will loose its great appeal that it now enjoys as a high school science, and will end up as a glorified nature study course.

Thelen (53) identified a total of 511 facts and concepts of chemistry which in his opinion were necessary for the understanding of the biological phenomena considered in certain selected typical biology curriculum materials. He concludes, as a result, that the high school biology topics have been treated superficially because most schools teach biology before chemistry. He only implies that any consideration of placing such a course even lower in the curriculum hierarchy would only compound the problem.

There seems to be little question of the fate of the old traditional general science. Elementary science has taken most of the factual material and distributed it with varying degrees of success from the first to the eighth grade in the present elementary science curriculum. As a consequence of this, the ninth-grade general science course has become dull and repetitious. Furthermore, the new laboratory approaches of biology, chemistry and physics would certainly call for something entirely different if the ninth-grade science is to be considered to any degree, as a preparation course for senior high school science. There are many who seriously object to even an inference that anything taken in the junior high school be designed to prepare for the senior high school. Weisbruch (60) dismissed the argument with these remarks:

> Whether general science is considered in the light of preparation for senior high school science or as a terminal course, certain fundamental objectives should be clearly understood and agreed upon before a change is made. Whatever the content of the course it should first of all be part of a developing program that utilizes what has gone before in the elementary science program and at the same time prepares for what is to come after.
>
> Secondly, some of the history of the great ideas in science should be taught as part of an understanding of how science develops. I am not advocating teaching the history of science in place of science.
>
> Finally the ninth-grade science course should fill a need for an understanding of the tremendous impact of science upon the individual and upon society. I believe that a science course containing these three elements would fill a need in the science curriculum and at the same time, be feasible for both the student who wishes to continue in science and for the student for whom ninth-grade science is a terminal course.

Regarding the problem of whether to place biology or earth science in the ninth grade, Weisbruch (60) had this to offer:

> I do not believe that either of these will be the final answer to the question of what to do with ninth-grade science, because both solutions deal with the subject matter of the course. The answer lies not in a change in the content of the course but rather a change in the method. As long as the ninth-grade course is primarily teacher centered with the accent on the lecture period, with its necessary factual presentation

> and memorization of scientific data, it cannot qualify as a science. Now both of these new approaches are science and therefore cannot rely for its conclusions upon experimental data. Biology even with scheduled laboratory periods has conventionally been taught as a descriptive science, not as a laboratory science. Substituting earth science or biology for the present general science which already deals mostly with descriptive subject matter such as technology, health, safety, and conservation, will not meet the objectives which a ninth-grade science course should have. Science at this level should make use of all that has gone before and serve as a gateway to further experiences in science. In view of our present science program, a purely descriptive science would not do this.

Weisbruch (60) agrees that the ninth-grade science course must certainly teach the student how to perform experiments as a scientist would perform them and for the same reason. A student cannot understand the method of science nor can he develop an adequate appreciation for science, unless he acts as a scientist. Weisbruch listed some objectives which he proposed would help students discover the method of science.

1. The course must be laboratory centered. The student must gather useful data, record the data, study it, analyze it and interpret it.

2. Heavy stress must be placed on quantitative measurements, on deductive and inductive reasoning, and on the relationship between science and mathematics, so that the student may come to see the logic in science.

3. The course must be so structured as to develop an understanding of the method of science. This means that the main emphasis of the course must be placed on the role of experiment in the process of discovery.

4. The course must emphasize problem solving in the laboratory in order to foster the habit of initiative in the use of the imagination and to develop habits of questioning and critical thinking.

5. The course should stress the contributions made by great men of science.

We cannot discuss the pros and cons of what should be contained in ninth-grade science for long without considering the changing interests of our students. It has been indicated in studies such as one by Crumrine (13) that the interests of students change considerably throughout the junior high grades. Such research findings indicate that in the majority of cases, students at the sixth grade level tend to elect general science as their first choice of preference. A similar study by Mallinson (30) indicates that during the intervening years of junior high and high school, science as a subject is accorded the least enthusiasm. Thus, the preceeding years have failed to keep the inherent interest alive for many. In speaking of this situation Norton (37) had this to say:

> Obviously, it is possible that the teachers and the curriculum may not be entirely at fault. Many students will shy away from advance science courses due to their increased difficulty which tends to frighten many students away. Actually, science is not more difficult as a subject than English or history--the writer is convinced that the teachers of science themselves are largely responsible for this unfortunate connotation. Then again many find that science is a subject that does require considerable work and application and many find that it lacks some of the romantic aspects that they had originally expected when they were younger. However, we can still place much of the fault for this apparent shift of interest to the lack of a well-organized junior high science and laboratory program.

Norton goes on to point out that the major weakness of the junior high science program lies not in its content but in its approach. With this viewpoint he is concurring with all but those who particularly advocate biology or an earth science subject.

> Although we do not have to be reminded of the energy and enthusiasm of the teenager, many science teachers at this level insist on dissipating youthful interest and energies, by using the worn out lecture recitation approach. Who can blame the student for his distaste for science taught in this manner? The lecture-recitation method may be adequate for advanced college preparatory science work, but the junior high student learns best by doing. A mistake committed by many science teachers, who do use an activity centered program, is their attempt to rush projects and student activities and on occasion they actually do the activities for the student to save time and eliminate the blunder and probable mistakes which the student generally commits. We still fail to realize that the student learns by his mistakes.

Poll (39) agrees with the activity centered approach relative to his contention that the student who is given the opportunity to assume responsibility is in a position to learn how to act responsibly. Not all students are responsive to the same learning experiences. Each student knows himself and his needs better than does his teacher. He should be provided with a sufficient variety of learning experiences so that he can select modes of learning that are most productive for him. Each student must be given a certain latitude of choice-making opportunities. He should be able to make wrong choices without being additionally penalized by the teacher.

Showalter (46) describes a unified science program now in full operation at the Ohio State University High School. The program was introduced gradually. In 1959-69, general science was replaced by Unified Science I; the next year Unified Science II replaced biology, and so on. Comprehensive evaluation of the program has not been made but opinions on the change are not hard to find, nor are legitimate problems. Most objections come from those who did not want to give up the old science and to some degree, they simply miss the old title.

Lerner (28) discusses a course based on the integration of chemistry and physics into a single course. Such a course was first offered in 1960 in Barringea High School, Newark, N.J. He found many problems with overlapping of concepts, textbooks and teachers, but he concluded that they were on the right track trying to capitalize on the strengths of Chemical Bond Approach, Chemistry Educational Materials Study and PSSC.

One of the most recently formed groups for curriculum development is the Harvard Project Physics group which hopes to check the continuing drop in the proportion of students who take physics, by developing a lively science closely related to achievement in other fields. (37) The group was formulated much after the fashion of the PSSC; however, they are somewhat short of the resources of PSSC. The Harvard group feels that even with all the efforts that have been directed at physics as a high school subject, PSSC is not the last word, a feeling supported by the fact that physics has decreased in relative popularity.

There are a few arguments or proposals for a ninth-grade earth science course in the literature. Mathews (32) presents one of the most complete pictures of the growth of earth science. He discusses the actual statistics of the increase in the interest of earth science, the problem of teacher training, at what grade level it is being taught and the course content.

Shroud (45) presents several reasons why earth science should be taught in the junior high before the interested science student gets into the senior high with its highly appealing courses. His best point, however, is that the junior high age is when the interest in earth science and its associated "awes" is at a maximum. He does not present a vigorous argument that it should be taught at any particular grade within the junior high school, though he mildly supports its location in the eighth grade.

Skinner & Davis (48) found that earth science was offered in at least three different patterns to ninth graders in Ohio. They found most teachers in agreement that it should be taught in the ninth grade though high school geology teachers said otherwise. In nearly every case in which the class had been organized recently, the class had been launched by an interested teacher. The trend seemed to indicate an increase of earth science for ninth grade students.

Caldwell (7) made a rather rigorous study to determine the content of an earth science course for ninth grade, having in mind the following specific objectives:

1. To determine the amount of earth science presently offered and the grade offered

2. To determine the purpose of the ninth-grade earth science as it was being taught

3. To determine the degree of emphasis on earth science topics

4. To determine the future emphasis in ninth-grade science

5. To analyze the content of ninth-grade earth science

6. To point out promising trends in ninth-grade earth science

Eighty-three questionnaires were analyzed from as many different centers in the United States. Thirty-five came from Illinois, four from schools in Pennsylvania, four from Michigan, and less than four from twelve other states. The investigation indicated the following:

1. There is an increasing interest in the teaching of a one-year earth science course at the ninth-grade level.

2. Many schools are anticipating the introduction of an earth science course in their secondary science program.

3. Those schools who have recently started earth science have done so at the ninth-grade level.

4. Most science teachers of earth science courses have had very little to no special training in the areas of the earth science fields. One conclusion was that it was apparent that curriculum studies were needed on a national basis, pertaining to the growth and development of effective earth science courses in the secondary school science programs.

Stephenson (50) describes the Earth Science Curriculum Project, (ESCP) undertaken by the American Geological Institute with grant support from the National Science Foundation. Its general objectives are the development of up-to-date teaching resource materials for use in secondary school earth science courses and the acceleration and improvement of college programs for the preparation of earth science teachers.

The project is an interdisciplinary effort of astronomers, geologists, geophysicists, meterologists, oceanographers and physical geographers working with science teachers and science educators to produce text materials, teaching guides, laboratory and classroom demonstration and experimental materials, monographs and visual aids.

Implications for Curriculum Development

A previous section of this chapter considered the historical significance of ninth-grade science, but did not introduce patterns of curriculum development procedures, relative to the past. The earliest method of curriculum revision and development probably consisted of legislation to determine which subjects to teach. Textbook writers exercised a free hand and as self-appointed experts determined to a great extent much of the curriculum content. In the 1890's, there began what has been called the development of curricula by national committees, and though the practice moved away from this procedure, the trend is again in this direction as evidenced by curricula being developed by such nationally known groups as the Physical Science Study Committee (PSSC) of Massachusetts Institute of Technology and the Biological Science Curriculum Study (BSCS). Today we are witnessing another beginning of the cycle. Again a feeling is being expressed that school programs are too diverse and chaotic; that their content is inadequate; that national effort is needed to establish the main outlines and main patterns and that therefore a national curriculum commission is needed. (21) (54)

The committees, whether functioning in 1890 or in 1960, were initiated to bring order and uniformity into rather meaningless and shallow programs which led nowhere. The chief role of the early committees was to make recommendations regarding the content and the organization of the secondary and the elementary school curriculum. The responsibility tended to be in the hands of college professors who attempted to determine what elementary and secondary schools should be doing in spite of the fact that they had no first-hand information. Another outstanding characteristic of the curriculum during this period was the sharp distinction between subject matter and method.

Following the First World War, the responsibility for curriculum development gradually shifted to local school systems, a trend which has continued to the present day. As Taba (51) notes:

> This change in the concept of curriculum and the shift in the responsibility for curriculum development also produced changes in the method of organizing and administering the process of curriculum development. Curriculum experts and teachers began to participate in curriculum production. To organize this participation, committee work became the chief vehicle. The earliest formula for work was "from the top down" or the "administrative approach" in which the committee structure was elaborated in the central office. It yielded many publications but did not always achieve a corresponding impact on the classrooms because the changes in curriculum were not always accompanied by changes in the skills and attitudes of teaching personnel. Gradually both the pattern of participation and the nature of responsibility were extended. The "grass roots" approach replaced the "from the top down" administrative approach and included as much of the schools personnel as possible, on the assumption that the functioning curriculum would be improved only as the professional competence of teachers improved. Under this approach, change began with teacher concerns.

The present curriculum reform in science is unique in the history of American Education. For the first time, complete textbooks have been written to be experimentally tested in the classroom for two or three years before final publication. The same procedure is being used in developing learning aids to complement each course in the curriculum.

The laboratory is more intimately a part of the total learning activity than has been characteristic of previous studies. Research such as the study being conducted by the writer is attempting to evaluate the effect and worth of this laboratory experience.

The involvement of the scientific community in curriculum improvement has been extensive. At times in the past scientists have contributed to the context of high school courses but not by developing organizational criteria, formulating methods of teaching, or creating learning aids.

Previously the science curriculum has been outlined primarily as a body of subject matter to be learned. One has only to examine course guides to find examples. How the material should be learned and the structure of science were not considered as curriculum dimensions. These are the factors, however, that are likely to bring about maximum learning.

Major efforts are being made to develop a science curriculum that presents a unified picture of the discipline. The fragmented samplings reflected in the units and chapters of most older courses are no longer evident. Integrated theories, unifying theories, and learning cycles are replacing them. The new science courses are attracting international interest. Several are being translated into foreign languages, although they are still in an experimental form.

Much of the success of the new courses is due to the financial support given them, which made it possible to enlist the best talent available. The American people have never before invested in curriculum development, nor have many attempts been made to attack the problem on a national scale. There are many achievements that seem likely to loom large in the years to come. The most hopeful of these is the renewal of interest in human learning. Regarding the "learning of science" as the most promising achievement, Hurd (22) offered the following:

> Those who developed the new science courses, sought to raise the quality of learning. Quality is defined as knowing the characteristics of a discipline, its methods of investigation and the nature of its data. It is recognized in the student's ability to pattern the conclusions, processes, and theories of science. This means he understands the "structure of science" and has developed a capacity for logical thinking.
>
> The learning of science has dimensions both in the nature of the discipline and the individual. The essential cognitive skills are primary objectives of teaching. These are not unlike the methods by which the scientists acquire new knowledge and insight.

Bloom (5) considers the problems of developing curriculum and instruction in relation to four major types of questions:

1. What educational purposes or objectives should the school or course seek to attain?

2. What learning experiences can be provided that are likely to bring about the attainment of these purposes?

3. How can these learning experiences be effectively organized to help provide continuity and sequence for the learner and to help him in integrating what might otherwise appear an isolated learning experience?

4. How can the effectiveness of learning experiences be evaluated by the use of tests and other systematic evidence-gathering procedures?

Bloom (5) says that educational objectives mean the explicit formulations of the ways in which students are expected to be changed by the educative process--the ways in which they will change in their thinking, their feelings, and their actions.

Page (38) considers the changing objectives of science, the changing art of science teaching, and the building of a science curriculum, as problems which should be considered together. The goal of science teaching is twofold. It must first produce well-trained scientists to carry on scientific research and the multitudinous applications so necessary in our society today. Second, and this is of growing concern to both educators and scientists, science teaching must acquaint the general public with what the scientist is after, with what he has to offer, and with what he cannot provide.

Page expresses the most serious problem in science education today as that of shifting the emphasis of a million teachers of science from the mere facts and the often outdated conclusions of science to something more enlightening. Regarding the present approaches to the solution of this problem he adds:

> The programs of science curriculum reform that offer the greatest promise have been those supported by the NSF with the encouragement of the professional scientific societies. All these programs are coordinated efforts, involving the writing of new textbooks, teaching guides, laboratory manuals etc; the training of teachers and the support of schools instituting the change. In each the revised curriculum has been tested in representative high schools and modified as a result of this trial. Colleges are already feeling some of the results; freshmen with the PSSC training have a more mature view of physics than in the past. In many ways these new high school science curricula have provided the enlightenment we so badly need.

In discussing curriculum design in science, Watson (57) has found that in many instances this important task is approached within an overly limited framework that fails to consider many of the dimensions that must be met. Any group, whether local, state or national, that undertakes curricular reforms must assume responsibility for all aspects of such procedures. Watson lists five dimensions of planning of which he considers each necessary but not sufficient.

1. The large and small concepts which constitute the structure of a particular subject

2. The many procedures which give vitality, continuity, and commonality to the efforts of scientists

3. The peculiar characteristics of the learner such as his age, sex, and the cultural attributes of his community

4. The intellectual behaviors of classifying, transforming, and formalizing through which each individual appraises and organizes his experience into significant conceptions;

5. The appropriate tactics and strategy of teaching through which the teacher evokes in the learner, the particular responses desired from the instructional setting.

To set up an activity-centered program, of the kind to which much of the attention of this study has been directed, Norton (37) advised the following:

> The three most important aspects to keep in mind regarding any junior high science curriculum structure are as follows:
>
> 1. Avoid repetition of materials already presented at the elementary level.
>
> 2. Provide a good foundation for the advanced courses in the senior high school.
>
> 3. Develop a rounded science program which has continuity and sufficient information for the student who does not elect any further science work.

In thinking of what a school and its staff should do before it is committed to involvement in a new curriculum building program, Lee (27) suggests three stages in a preparatory program:

> 1. The school system with its teachers should take a good hard look at the suggested program and at its own situation and decide whether the program under consideration will do the job that needs to be done. These new materials are no panacea. They will enable one to do certain things under certain conditions and the teacher should be aware of what these conditions are. The programs involve considerable expense as well as a great deal of hard work. It is the obligation of the science department to see that the school board, the administration, and the community know what is expected of them and what they may expect from the program.
>
> 2. The teacher should be prepared. Many of the new programs utilize scientific concepts that are unfamiliar to the average classroom teacher. It is a mistake to assume that, just because a teacher can handle a science he now teaches, he will be able to handle the new materials. If possible the teacher should take advantage of the summer institutes or the in-service institutes related to these studies. Also teachers may make use of the consultant services which most of the study groups have available.

3. The individual school should devise a realistic evaluation schedule. This means that enough time should be allowed for the program to be evaluated on its own merit. It also means that one should know what to expect and what not to expect from these new programs. Enough time and enough depth should be designed into the program to ascertain whether the program will accomplish its projected aims.

Aspects Relative to the Academically Talented

The concern with the problem of providing better educational programs for academically talented pupils appears to be omnipresent. Teacher training institutions in many states have added new courses which deal specifically with the education of the gifted student. National organizations have provided leadership in this area and have devoted many pages in their respective periodicals and magazines to the topic of the rapid learner. Administrators have given serious attention to provisions for individual differences on the part of pupils in their schools in the form of curricular change and the initiation of new learning activities. Teachers have put forth considerable effort to improve learning opportunities for the superior pupils in their charge, regardless of the organizational pattern of their particular school. Parents in many communities have become actively interested in and concerned about the educational programs in schools in their area and are asking if the school program really is meeting the needs of all the pupils. The nation as a whole has been aware that providing adequately for gifted pupils is an important project for our nation. The Educational Policies Commission of the NEA (15) made their position quite clear:

> The maximum welfare for a group is achieved when each member contributes as much as he is able to. The democratic ideal can be most fully attained when every individual has opportunity for educational experience commensurate with his abilities and for vocation responsibility commensurate with his qualifications.

Most writers on the subject of educational objectives agree that we are now in a time when objectives are verbalized from an interrelated frame of reference. We have long been proud of the fact that our first concern is for the welfare of the individual but we also realize that the needs of individuals and the needs of our democratic society are hard to separate. Witty (63) expressed the need of society in this manner: "The future of our country and of democracy as a way of life depends to a considerable degree upon the widespread recognition and development of our greatest resource, gifted children and youth."

An effective enrichment program is concerned with enriching the pupil's entire learning process. Grossnickle (20) points out clearly four objectives of enrichment:

1. To encourage students to work independently and learn directly from appropriate books and periodicals.

2. To enable students to develop broader skills and to acquire more technical knowledge than the average student can assimilate.

3. To give the student the opportunity to explore, discover, and develop his interests and potentialities.

4. To challenge the student to work at the level of operation at which maximum growth is possible.

In speaking of the needs of our nation, Stalnaker (49) left no doubt as to his concern:

> As a nation, we must also recognize that we have been more concerned about helping the hopelessly retarded than the unusually able and have given much more money to this purpose. To be sure, it is the duty of society to take care of the defective children, but if we are interested in the improvement of our nation and in maintaining a position of world leadership, we had better earmark many dollars for the superior child every time we earmark one dollar for the defective. Only in this way will we in the long run, improve the lot of the deficient. There is nothing undemocratic in providing a superior education for any student able to profit by such education. Mass education must not come to mean reducing the best to the level of the average.

In a survey taken in one junior high school by Norton (37), talented students were asked to name the one teaching technique that they felt had helped them the most to learn new subject matter, maintain an interest in the classwork, challenge thinking, develop new ideas, and foster an atmosphere conducive to learning. Although many methods were mentioned, the majority of students named the use of the panel discussion as the most valuable for them. Norton concludes that such techniques can be of value in enriching the learning for capable students for such activities provide opportunities for the following:

1. They promote a goal directed activity.

2. They foster a sense of responsibility on the part of each individual.

3. They develop the abilities of pupils to work cooperatively with others.

4. They improve upon techniques of self expression.

5. They encourage the development of logical thinking on the part of each pupil.

Weaver (58) points out that many of the newer programs were at first conceived for the academically talented students. The question was soon asked of course, "Why isn't enrichment good for all students?". In the newer programs, students assume a high degree of responsibility for planning the areas of content, organization and procedures of the course. At first it was felt that only the very capable could do this kind of thing. In the newer programs, students are closer to the active center of the learning process and certainly all levels of abilities should learn more in this way. The suggestion here is that concern for the academically talented has blazed the way for curriculum reform in all levels of ability and that scientific abilities once considered desirable for the talented are now considered critical abilities for all students.

Bicak (2) developed a study as an outgrowth of the questions which were raised when the topic of homogeneous versus heterogeneous grouping was discussed. The study was undertaken as an attempt to provide answers to the following questions:

1. Do pupils in comparable ability sections taught in homogeneous classes differ in over-all achievement in eighth grade science?

2. Do pupils in comparable ability sections taught in homogeneous and heterogeneous classes differ in achievement as measured by an application test?

3. Do pupils react in a significatnly different manner, indicated by response to questionnaire items as a result of having been a member of a particular heterogeneous or homogeneous section?

In testing a series of null hypotheses, no significant differences at the one per cent level were found between the mean scores of comparable heterogeneous and homogeneous groups. Each group made significant mean gains but no group gained significantly more than its counterpart.

It was concluded that ability grouped classes with pupil selection based on a single selection measure achieved at the same mean level as heterogeneous classes provided the following conditions were met:

1. Classes must be taught the same general subject matter with added material of the enrichment type required of the high ability classes.

2. Adjustment must be made on methods and rate of instruction in terms of the abilities of the groups.

3. Both groups must be encouraged to work up to their capacities.

It might be assumed for University High School, that the findings are permissive rather than directive. A recommendation could be to accept either homogeneous or heterogeneous grouping at the eighth-grade level as long as present population characteristics, course content, curriculum and research knowledge pertain.

This section would not be complete without a clear understanding of our use of the term "academically talented". For purposes of this study, we are concerned with the top 25 per cent of the Wichita seniors, as indicated by their science score on the Iowa Tests of Educational development, taken when they were beginning ninth-grade students. This concept is in keeping with that held by most writers in the field. Conant (11), in an address to an NEA conference for the academically talented, considers the group slightly more exclusive:

> We are here considering only one of many important problems in American secondary education. We will be discussing the education of not more than a fifth of the secondary school population of the country. ... ... .What is needed, most of us feel, is a careful consideration of the secondary school education of all those boys and girls who have the ability to study effectively and rewardingly advance mathematics, foreign languages and tough courses in chemistry and physics. You will note that I have just ventured to give a definition of the academically talented youth--in the jargon of modern philosophy, it is an operational definition. ... . There are some of us here who are primarily interested in the really unusual pupil--not more than two per cent of the high school population often labeled as the "Gifted" and I, for one, think this is the proper use of the word.

From the conservative element of curriculum planners has come a particular problem relative to the academically talented. They have said that science teachers are attempting to enrich their program by presenting mature concepts to immature pupils. This is commonly known as the problem of grade placement and in more recent curriculum terminology, as the problem of sequence.

Another question for consideration with this group, is that of time to be alloted to the various fields of study and activity. Is our proposal for curriculum change for ninth-grade science going to demand a lion's share of the students' time? Even though the actual class time may be the same, will the associated activities be such that the total demand for time be extended?

The factor of time is more significant for the academically talented students than for any other group. By definition this group is not average. Their span of attention is greater and especially is their capacity for independent study superior to the average student's. Because a homogeneous group of this kind is so easy to motivate to pursue independent study, and because the value of such work is well established, teachers of academically talented groups have a tendency to "pile it on". The important aspect of the problem is that these students are likely already overwhelmed with demands for their time outside of class. They are the most active in all kinds of extra-curricular activities. They belong to the band which may require, at least to their way of thinking, private lessons and practice. They are likely to belong to several clubs and are usually interested in sports, if not as a participant, an active spectator. They pursue a vigorous reading program of newspapers, magazines and the current best sellers. (19)

What is the significance of talented students' characteristics to the curriculum planners? The suggestion here is that the factor of total time is highly important and that in curriculum revision one must weigh very carefully any change which might possibly include a built-in element of improper demand for this highly scarce resource.

CHAPTER III

DESIGN AND METHODOLOGY

Introduction

The primary objective of this study is to evaluate the various ninth-grade science programs used by the Wichita junior high schools in 1961-1962, for their academically talented students in terms of achievement, interest, plans for taking science in college and plans for using science in a career. The writer's interest in science curriculum is not limited to the ninth-grade, nor to that portion of the curriculum which applies only to the academically talented students, but for many reasons, limiting the study to these areas was necessary. In the first place, ninth-grade science is causing most of the controversy. Secondly, four distinct science groups who were in school in 1961-1962, were available for study in 1965. (These groups will be described in detail in the discussion of the population.) Thirdly, two of the science options were offered in 1961-1962, to only the top students, referred to in this study as the academically talented and defined as the upper 25 per cent. (Actually 30 per cent of the Wichita ninth grade in 1961-1962, ranked in the upper quartile by Iowa Tests of Educational Development (ITED) national norms and are included in this study.)

This chapter describes the whole population, how samples were drawn, instruments used, the statistical methods used and the hypotheses which were tested.

Population and Samples

The whole population included all students presently seniors in Wichita, who as beginning ninth graders ranked in the upper 25 per cent as determined by the national norms of the science scores of ITED. These seniors have come from fourteen junior high schools which had the following official enrollments on September 15, 1961:

TABLE I

NINTH-GRADE TOTAL ENROLLMENT AND UPPER SCIENCE QUARTILE IN EACH SCHOOL

School	Total Enrollment	Number in Upper Science Quartile	Per Cent Enrollment
Allison	264	72	27.3
Brooks	212	80	37.7
Curtis	453	161	35.5
Hadley	284	99	34.9
Hamilton	309	72	23.3
Horace Mann	274	32	11.7
Jardine	278	65	23.4
Marshall	278	107	38.5
Mathewson	196	18	9.2
Mayberry	277	71	25.6
Mead	331	139	39.5
Robinson	361	171	47.4
Roosevelt	351	128	36.5
Truesdell	381	100	26.2
Total	4,249	1,315	30.5

Obviously different schools had varying proportions of the Wichita total in the upper quartile. The city as a whole had 30.5 per cent of the total junior high school enrollment in the upper quartile according to national norms.

Groups Within the Population

Ninth-grade students in the Wichita junior high schools in 1961-1962, could possibly have been included in one of four different groups relative to science. They could have been in biology, laboratory science, general science or no science.

Biology

This tenth-grade science course was introduced to the Wichita junior high schools in the fall of 1959, as a result of one of the first National Defense Education Projects (NDEA). Those responsible for this curriculum change planned that biology in the ninth grade would be as nearly a carbon copy of the tenth-grade course as was possible to produce. The same text was used, the senior high school classrooms were used as patterns for the new junior high school biology rooms, the senior high school equipment lists were used to determine the ninth-grade biology orders and certainly the ninth-grade biology was to satisfy the state requirement for a laboratory science. On the basis of college training in the biological sciences there were staff members in these junior high schools with comparable preparation to that of many senior high school biology teachers. It was, in fact, the better preparation of the junior high school teachers in biology relative to their physical science preparation, which convinced these schools to move in the direction of biology.

Only one room was equipped in each school in which biology could be taught and the number of sections of biology to be taught was limited to six. No school however actually taught six sections because of the students' interest, preference and eligibility requirement. Students were eligible to enroll in biology if they had made a minimum of a "B" in their eighth grade science class. Schools therefore differed in the number of sections taught as shown in Table II.

TABLE II

DISTRIBUTION OF NINTH-GRADE SCIENCE SECTIONS
1961-1962

School	Biology	General Science	Laboratory Science
Allison	4	2	0
Brooks	0	3	2
Curtis	4	2	0
Hadley	0	0	2
Hamilton	3	3	0
Horace Mann	2	1	0
Jardine	0	2	2
Marshall	3	0	0
Mathewson	1	3	0
Mayberry	0	0	1
Mead	2	3	0
Robinson	5	5	0
Roosevelt	0	2	3
Truesdell	4	2	0
Total	28	28	10

Laboratory Science

Of the fourteen junior high schools, five decided to present a laboratory science course centered around the laboratory activity of four science areas. Approximately nine weeks each was spent in physics, chemistry, earth science and biology. This was a new program--there was nothing in the high school which could dictate the content of this course. It would require a teacher competent in four areas with equipment and facilities for four different science fields. This course also satisfied the state requirements for a laboratory science. (Though the better training of teachers in either the biological sciences or the physical sciences was a major factor in determining what science should be taught, had more schools decided in favor of laboratory science, the cost of implementing the program would have been considerably greater.)

General Science

All but two of the junior high schools continued to offer general science (Table III), with its traditional lecture-recitation approach. Experiments were done as teacher demonstrations and seldom, if ever, did the students perform. Talented students still continued to enroll in this course for several reasons. A few have confided with their teacher, counselor and the investigator that they harbored a fear of biology (or laboratory science if the school they attended offered laboratory science) as being too competitive or too difficult for them to make the "A" grade to which they were accustomed and upon which they placed high value. They often expressed a preference for taking biology in the senior high school and in some cases, even these top students did not qualify because of a low grade in eighth-grade science. Surprising as it may seem, there was no dearth of students who ranked in the upper quartile for this experimental group (Table III). General science did not meet the state requirement for a laboratory science.

TABLE III

DISTRIBUTION OF NINTH-GRADE SCIENCE POPULATION

School	Biology	General Science	Laboratory Science	No Science	Total
Allison	27	13	0	32	72
Brooks	0	15	31	34	80
Curtis	61	27	0	73	161
Hadley	0	7	30	62	99
Hamilton	31	19	0	22	72
Horace Mann	14	2	0	16	32
Jardine	0	23	24	18	65
Marshall	51	0	0	56	107
Mathewson	8	0	0	10	18
Mayberry	0	2	17	52	71
Mead	33	28	0	78	139
Robonson	98	23	0	50	171
Truesdell	57	8	0	35	100
Total	380	183	150	602	1,315

No Science

It must be remembered that though one unit of a laboratory science credit was required for graduation in Kansas, the science class did not need to be taken in the ninth grade. Talented ninth-grade students have such a wide range of interest and there are so many courses and activities competing for their time that they very often prefer to meet this requirement at a later date when the schedule does not seem to them, to be so tight. Their choice often became one of deciding between a science or a foreign language.

It is true of course that some schools gave more encouragement to their students to take science in the ninth grade than did others. In the main this encouragement was given through more inviting science programs or less inviting alternatives.

As indicated in Table III, it appears that the postponement of the science requirement is by far the most popular practice for the total of the Wichita students. Forty-six per cent of these top students apparently felt that some other course of action was more desirable at that time.

Biology appeared to have had more appeal than did laboratory science; however, comparison of the biology population and the laboratory science population must be made in terms of the total population of the schools which offered biology or laboratory science. Table IV makes such a comparison.

TABLE IV

SELECTIVITY OF BIOLOGY AND LABORATORY SCIENCE BETWEEN SCHOOLS TEACHING BIOLOGY AND THOSE TEACHING LABORATORY SCIENCE

Group	Enrollment	Number in the Upper Quartile	Per Cent in the Upper Quartile
Biology	380	872	43.6
Laboratory Science	150	443	33.9
Total	530	1,315	40.4

Procedures in the Identification of the Study Population

The office of pupil services in the central office building had the ITED results for the year 1961-1962, necessary for the identification of the population. The test scores had been printed from a computer and arranged by classes within fourteen junior high schools. The first task then, was one of compiling a list of students from the ninth grade of this year, who placed in the top quartile of the science section. The second step was to find these students' science scores which they registered in October, of their senior year, 1964-1965, to give a pretest and posttest for each student. A card was prepared for each senior and alphabetized according to high schools. Of the original 1,368 ninth-grade students who ranked in the upper quartile, 1,315 had an available score in the twelfth grade. This is indicated by school in Table V.

TABLE V

SENIOR POPULATION

School	Ninth-Grade Students in Upper Quartile Who Enrolled in Senior High Schools in 1964-1965	Seniors Still Enrolled April 1965
East	396	381
Heights	17	15
North	204	191
South	215	216
Southeast	321	312
West	215	200
Total	1,368	1,315

Since the ITED tests were taken early in October of 1964, the next step was to determine if the students with an available pretest and post-test science score, were still in the Wichita schools, and thereby still part of the population. A form was prepared for each subject with a pretest and posttest score, (Appendix A) alphabetized by high school, and taken to the registrar of each of the six high schools. The last column in Table V therefore represents the population of seniors who are presently enrolled in the Wichita high schools, (April 1965) who ranked in the upper quartile of their ninth-grade class and are still available for future testing.

In addition to confirming the enrollment of the seniors who met the conditions of the population, the high schools also indicated on the form (Appendix A) all the science courses the subjects had taken including their present enrollment. These 1,315 records were then arranged into the basic groups of this study as indicated by Table VI.

TABLE VI

TWELFTH-GRADE DISTRIBUTION OF SCIENCE GROUPS

School	Biology	General Science	Laboratory Science	No Science	Total
East	83	44	74	180	381
Heights	0	11	0	4	15
North	65	9	10	107	191
South	66	47	23	80	216
Southeast	126	56	5	125	312
West	40	16	38	106	200
Total	380	183	150	602	1,315

It should be pointed out that Heights High School was transferred into the Wichita system in the fall of 1963, and that the majority of the students came from junior high schools from outside the Wichita system. Those few students who did become a part of the study population took their ninth-grade science in a Wichita junior high school and moved into the Heights district on or about September of 1963.

Selection of Samples

A number was assigned to each subject in each of the four basic groups. Numbers ranged from one to 380 for the biology group, from one to 183 for the general science group, from one to 150 for the laboratory science group and from one to 602 for the no science group. Four random samples of fifty each were chosen from these groups using a table of random numbers. It was these 200 subjects then, for whom additional information was needed and from which inferences will be made to the population.

Instrumentation

Instruments were needed to indicate science achievement, science interest, the extent to which science has been pursued and the extent to which science is now included in students' plans for college and for a career.

Measurement of Science Achievement

The instrument used to measure the science achievement of the subjects is the science test of ITED. In October of 1961, both test number two, "Science Background", and test number six, "Reading of the Natural Sciences", were given in the test battery. In October of 1964, however, only test number six was included. This clearly limited the investigator to test number six but even had it not been for this obvious limitation there are good reasons to have selected this alternative for a pretest and posttest design. The Research and Testing Division of the Wichita Public Schools informed the investigator of its conviction that the test on the reading of natural science was as good a measure of achievement in science (in some cases a better measure) than the test on science background. It was for this reason, in fact, that the Wichita schools have ceased giving both tests and have decided in favor of "The Reading of Natural Sciences". Travers (52) rigorously supports this viewpoint:

> Just what such (reading) tests measure is not entirely clear. They may measure knowledge of the subject-matter field, since they require the examinee to call upon his background of general knowledge in interpreting the passages. It should be noted that, although this battery does give emphasis to the ability to interpret material in the various subject-matter fields, it also emphasizes the idea that tests of essential or basic knowledge have a place in the assessment of educational development... ... . There can be no doubt that, through reading tests, the measurement of thinking skill in a subject matter field has great potentiality as a technique of measurement.

Furthermore, the test attempts to measure one of the more recently stressed goals of science--that science should develop more on the part of the learner than a mass of facts. Students should learn a way to approach a new situation or problem. With academically talented students, the investigator was more desirous of this measure than perhaps any other.

Lastly, the objective qualities of the tests indicate the somewhat greater strength of the reading test. It has a reliability of .90 while that of the background test is .88. The correlation of the reading test to the composite score is .843, while that of the background test to the composite score is .762. (23)

Measurement of Science Interest

As a measure of science interest, the science section of the Kuder General Interest Survey, Form E, was utilized. An interest test was not given in 1961, nor in 1964, as a part of the school testing program, so this became part of the responsibility of the investigator. Permission was received from Science Research Associates (Appendix B) to lift the thirty-three triads which contained the science items from the context of the manual and administer them separately. The construction of the Kuder test is such that each area of interest is measured relative to its selection in the triad (26), and the condensation of the test, (Appendix C) to only those triads which contain the science items, does not harm the test as a measure of science interest.

Perhaps the greatest determinant of interest included within this study is the extent to which these students have actually taken science courses above and beyond their required one class. The significance of this implication will be discussed in the section on design.

Measurement of Number of Science Courses Taken

The form previously described (Appendix A) which constitutes a science transcript, was the instrument utilized to collect this data. With the exception of two high schools at which the investigator gathered the data, this information was produced by the registrar or another office staff member familiar with making transcripts.

Measurement of Plans Relative to Science

An investigator-constructed instrument was utilized to measure the students' plans for taking science in college and including science in a possible career. The instrument (Appendix D) contains items relative to science plans to which the subjects respond on a three point continuum. There is no intention to determine a score as a composite measure of "plans" and each item will be considered separately for each group under investigation.

Measurement of Students' Opinions

Several opinions of the students relative to their ninth-grade science experience were desired. These were contained on the investigators instrument. Again no composite score was intended and an analysis is made separately for each item.

Hypotheses

This study will test the following null hypotheses:

1. There is no significant difference in the extent to which science has been pursued in high school (number of science courses taken) among those groups which had, as ninth-grade students, biology, general science, laboratory science or no science.
2. There is no significant difference in the achievement scores of the present seniors who as ninth-grade students took either biology, general science, laboratory science or no science.
3. There is no significant difference in the achievement scores of the present seniors who have taken one, two, three or four science courses.
4. There is no significant difference in the science interest scores of the present seniors who as ninth-grade students took either biology, general science, laboratory science or no science.

5. There is no significant difference in the science interest scores of the present seniors who have taken one, two, three or four science courses.
6. There is no significant difference in the extent to which seniors express plans for taking science courses in college relative to their ninth-grade science experience.
7. There is no significant difference in the extent to which seniors express plans for taking science courses in college relative to the number of science courses they have taken.
8. There is no significant difference in the extent to which seniors express plans for considering a science experience.
9. There is no significant difference in the extent to which seniors express plans for considering a science-oriented career relative to the number of science courses they have taken.
10. There is no significant difference in the extent to which seniors express feelings of quality relative to their total science program and their ninth-grade science experience.
11. There is no significant difference in the extent to which seniors express feelings of quality relative to their total science program and the number of science courses they have taken.
12. There is no significant difference in the extent to which seniors express satisfaction with the quantity of science they have taken relative to their ninth-grade science experience.
13. There is no significant difference in the extent to which seniors express satisfaction with the quantity of science they have taken relative to the number of science credits

they have received.

14. There is no significant difference in the extent to which seniors feel their ninth-grade science was either too general or too specific in its content.

15. There is no significant difference in the extent to which seniors express the adequacy of their ninth-grade science experience in terms of the preparation they received for the laboratory activities of the senior high school science program.

Design

The primary objective of this study is to determine if the kind of experience students have in the ninth grade relative to science, makes any difference in their achievement in science, their interest in science, the extent to which they will take science in high school and their future plans regarding science. In the preceding section a description of four different experiences relative to science was given and it was stated that the students who have had these different experiences constitute the basic groups for the study. These four different experiences or treatments are therefore the major independent variables of the study. The experimental groups are composed of those students who took biology, general science and laboratory science in the ninth grade, and the control group is composed of those students who took no science in the ninth grade. This section will describe the statistical tests which were chosen to analyze the dependent variables in terms of these four treatments, and in terms of the extent to which students have taken science in high school.

The Number of Science Courses Taken

This analysis will be made to determine if different experiences in ninth-grade science has affected the total number of science courses taken during the high school tenure grades nine through twelve. The number of science credits are considered to be definite intervals of time spent in class. One full credit would represent two semesters in class, for example, and two credits would be as much greater than one credit as three credits would be greater than two credits. In other words, these credits represent interval measurement and an analysis of variance is appropriate to test the related hypothesis.

Achievement

Pretest and posttest scores are available to indicate achievement and since these scores represent measurement approaching that of an interval scale, the parametric statistic, analysis of covariance, will be employed. As Garrett (18) states, "Through covariance analysis one is able to effect adjustments in final or terminal scores which will allow for differences in some initial variable".

In one analysis with this statistic the effect of the ninth-grade science experience will be desired. The second analysis considers the effect of the extent to which science has been pursued in high school.

Interest

The Kruskal-Wallis One-Way Analysis of Variance by Ranks will be employed to analyze the Kuder interest scores because at best they probably represent ordinal measurement. The strength of this statistic is indicated by Seigel (47) as the notes: "The Kruskal-Wallis test seems to be the most efficient of the nonparametric test for "k" independent samples. It has the power-efficiency of 95.5 per cent when compared with the "f" test, the most powerful parametric test." Again both the ninth-grade science experience and the number of science courses will be considered for analysis.

Future Plans

The measurement level of this information is nominal and a chi-square test for "k" independent samples is appropriate. The contingency tables have a particular advantage in this analysis in that the data can be seen at a glance and each individual cell indicates vividly its contribution to the total chi square.

Experience

It was desirable to know how the students felt about their science background and total science experience. The measurement level of this information is similar to that for future plans and the chi-square test is again appropriate.

CHAPTER IV

FINDINGS

Introduction

The primary purpose of this study is to evaluate the various ninth-grade science programs previously described in terms of achievement, interest, extent to which science had been pursued in high school, extent to which students plan to pursue science in college or in a career, and the students' opinions of their science experiences. A secondary purpose is to evaluate the influence of time spent with science (number of science courses taken in high school) upon the students' achievement, interest, future plans and their opinions of their science experience.

This chapter will present the statistical tests for homogeneity of the groups and for the fifteen hypotheses listed in the preceding chapter. The limitations and recommendations pertaining to these findings will be presented in Chapter V.

Tests for Homogeneity

As described earlier, homogeneous grouping has been partially assured by selecting only those subjects who ranked in the upper quartile of achievement. Within this upper quartile, however, is a wide range of ability and should the selection process whereby students select the ninth-grade science class they desire, place more of the very top students in one particular kind of ninth-grade science, the groups for this study would not be homogeneous. Therefore a test for homogeneity was utilized. As Garrett states (18), "A simple check on the equality of sample variance is to calculate the sum of the squares for each group separately, divide by the appropriate df, and test the largest V against the smallest V using the F test." Such calculation follows in Table VII.

TABLE VII

GARRETT'S TEST FOR HOMOGENEITY OF VARIANCE
USING ITED PRETEST SCORES

Biology	General Science	Laboratory Science	No Science
$SS = X^2 - \frac{(\Sigma X)^2}{N}$	$SS = X^2 - \frac{(\Sigma X)^2}{N}$	$SS = X^2 - \frac{(\Sigma X)^2}{N}$	$SS = X^2 - \frac{(\Sigma X)^2}{N}$
= 18,019.00	= 14,472.00	= 20,551.00	= 15,413.00
- 17,409.78	- 14,044.88	- 19,880.18	- 15,033.78
609.22	427.12	670.82	379.22
V = SS/df	V = SS/df	V = SS/df	V = SS/df
= 609.22/49	= 427.12/49	= 670.82/49	= 379.22/49
= 12.4333	= 8.7167	= 13.7902	= 7.7391

F = Largest V/Smallest V = 13.6902/7.7391 = 1.7689

Alpha with 49 and 49 df, is 1.94 at the .05 level

Garrett's check of homogeneity from Table VI, indicates an insignigicant *F* value at the .05 level of confidence, and that the groups included in this study are homogeneous when they are arranged according to the ninth-grade science they have taken. It can be argued that this test is appropriately two-tailed. For this interpretation the probability associated with the critical value found for *F* (1.7689) is about .02 for a one-tailed test and .04 for a two-tailed test.

Since another objective of this study is to determine the influence of the extent to which science has been pursued in high school on achievement, interest, future plans, etc., it would appear necessary to make an additional check on the equality of sample variance when the groups are distributed according to the number of science courses they have taken. Such a check follows in Table VIII.

TABLE VIII

GARRETT'S TEST FOR HOMOGENEITY OF VARIANCE OF GROUPS RELATIVE TO THE NUMBER OF SCIENCE CREDITS USING ITED PRETEST SCORES

One Credit	Two Credits	Three Credits	Four Credits
$SS = X^2 - \frac{(\Sigma X)^2}{N}$	$SS = X^2 - \frac{(\Sigma X)^2}{N}$	$SS = X^2 - \frac{(\Sigma X)^2}{N}$	$SS = X^2 - \frac{(\Sigma X)^2}{N}$
= 16,321.00	= 17,991.00	= 19,398.00	= 14,745.00
- 15,917.67	- 17,344.98	- 18,741.41	- 14,206.08
393.33	646.02	656.59	538.92
V = SS/df	V = SS/df	V = SS/df	V = SS/df
= 393.33/50	= 646.02/57	= 656.59/53	= 538.92/36
= 7.8666	= 11.3336	= 12.3884	= 14.97

F = Largest V/Smallest V = 14 97/7.8666 = 1.9029

With 36 and 50 df, alpha = 2.04 at the .05 level

Again the insignificant F from Garrett's simple check, indicates that the groups are homogeneous at the .05 level of confidence, when the students are distributed according to the number of science credits they have received. Considering the appropriate two-tailed interpretation, the probability associated with the critical value found for F (1.9029) is about .08. For purposes of this study, the .08 point will be satisfactory and the statistical testing of hypothesis one, two and three may be conducted.

Hypothesis One

There is no significant difference in the extent to which science has been pursued in high school (number of science courses taken) between those groups which had as ninth-grade students, biology, general science, laboratory science or no science.

The analysis of variance is appropriate to test this null hypothesis and a significance level of at least .05 will be accepted for rejection.

In this analysis the number of science courses taken by each member of the sample is considered as an interval of time and therefore constitutes interval measurement. This measure in terms of science courses or science credits is given in Table XXXVI of Appendix E. The analysis of variance follows in Table IX.

TABLE IX

ANALYSIS OF VARIANCE OF TIME INTERVALS IN CLASS

Total Sum of Squares	Among Sum of Squares
$SS = X^2 - \frac{(\Sigma X)^2}{N}$	$SS = \frac{(\Sigma X_1)^2}{n_1} + \frac{(\Sigma X_2)^2}{n_2} + \frac{(\Sigma X_3)^2}{n_3} + \frac{(\Sigma X_4)^2}{n_4} - \frac{(\Sigma X)^2}{N}$
$= 1402.6 - \frac{(481)^2}{200}$	$= \frac{(115)^2 + (143)^2 + (147)^2 + (76)^2}{50} - \frac{(481)^2}{200}$
$= 1402.5 - 1156.805$	$= 1221.180 - 1156.805$
$= 250.695$	$= 64.375$

Source	df	SS	Mean Sq	SD
Total	199	250.695		
Among	3	64.375	21.458	
Within	196	186.320	.9506	.975

$\underline{F} = 21.458/.9506 = 22.5731$

With 3 and 199 df, alpha = 2.65 at the .05 level and 3.88 at the .01 level

The analysis of variance from Table IX indicates a highly significant $\underline{F}$ value. This is sufficient evidence to reject the null hypothesis and to confirm the alternate hypothesis that students' experience in the ninth grade relative to science does have an influence on the extent to which they will pursue science courses in high school.

As Garrett suggests (18), a significant F does not tell us which means differ significantly but that one is reliably different from some others. To determine the significance of the difference between any two selected means we must compute a t ratio by dividing the given mean difference by its standard error of the difference. Such computations are performed in Table X.

TABLE X

COMPUTATION OF T RATIOS BETWEEN MEANS OF NINTH-GRADE SCIENCE GROUPS FOR NUMBER OF SCIENCE COURSES

Standard Deviation from Table IX = .975

Standard Error of the Difference = $.975\sqrt{1/50+1/50}$ = .975(.2) = .195

With 49 df, t at the .05 level = 1.98 and at the .01 level = 2.63

Any difference of .386 (1.98 x .195) will be significant at the .05 level

Any difference of .513 (2.63 x .195) will be significant at the .01 level

Laboratory Science Mean = 2.94	Biology Mean = 2.30
General Science Mean = 2.86	No Science Mean = 1.52

Table X did not indicate a t for each mean difference but indicated instead the difference necessary to produce a significant t. Table XI indicates all the possible comparisons of the groups and a significant t at the .01 level in every comparison but the comparison between the laboratory science group and the general science group. Implications of the findings of this analysis and the remaining analyses will be discussed in Chapter V.

TABLE XI

COMPARISON OF MEAN DIFFERENCE BY USE OF THE T

Larger Mean	Smaller Mean	Difference	Significance Level
Laboratory Science	General Science	.08	Not Significant
Laboratory Science	Biology	.59	.01
Laboratory Science	No Science	1.37	.01
General Science	Biology	.56	.01
General Science	No Science	1.33	.01
Biology	No Science	.72	.01

Achievement

Hypothesis Two

There is no significant difference in the achievement scores of the present seniors who as ninth-grade students took either biology, general science, laboratory science or no science.

Analysis of covariance is appropriate to test this null hypothesis and a significance level of .05 will be accepted for rejection. Pretest and posttest scores of the ITED science section are given in Table XXVII of Appendix E. Table XXVIII presents the computations for the sums of squares which appear in Table XII. Also indicated in Table XII is the fact that insufficient evidence was found to reject the null hypothesis. However, the calculated F value of 2.589 was close to the table value of 2.65 for the .05 level of rejection; rejection of the null could have been accomplished at the .06 level of confidence. For purposes of this study there is evidence that a difference in the achievement scores does exist among seniors relative to the ninth-grade science they had.

TABLE XII

ANALYSIS OF COVARIANCE OF ACHIEVEMENT PRETEST AND POSTTEST SCORES RELATIVE TO NINTH-GRADE SCIENCE TAKEN

Source	df	Sum of Squares	Mean Squares
Total	198	3,352.472	
Within	195	3,224.028	16.533
Difference	3	128.444	42.815

$F = 42.815/16.533 = 2.589$

With 3 and 195 df, alpha at the .05 level = 2.65

Hypothesis Three

There is no significant difference in the achievement scores of the present seniors who have taken one, two, three or four science courses.

The analysis of covariance is appropriate to test this null hypothesis and a significance level of .05 will be accepted for rejection.

In this analysis pretest and posttest scores of the ITED science section were arranged according to the number of science courses the students have received in high school. This arrangement is given in Table XXX of Appendix E and the calculations for the sums of squares in Table XXIX. In the random selection of the samples, four samples of 50 each were chosen from populations grouped according to the science related experience of the ninth grade. When these same subjects were arranged according to the number of science courses they had taken during their total high school tenure, groups were no longer equal. The variation, however, was surprisingly small. There were 51 students who took only one science course, 58 completed two science courses, 54 finished three science courses and 37 took four or more science courses. The analysis of covariance of these groups follows in Table XIII.

TABLE XIII

ANALYSIS OF COVARIANCE OF ACHIEVEMENT PRETEST AND POSTTEST SCORES RELATIVE TO NUMBER OF SCIENCE CREDITS

Source	df	Sum of Squares	Mean Squares
Total	198	3,352.472	
Within	195	3,244.054	11.507
Difference	3	108.418	36.136

F = 36.136/11.507 = 3.140

With 3 and 195 df, alpha = 2.65 at the .05 level of confidence
= 3.88 at the .01 level of confidence.

As indicated in Table XIII, the null hypothesis can be rejected and the alternate hypothesis that achievement in science is influenced by the total number of science courses, may be confirmed. The F value in Table XIII of 3.140 compared to an F value of 3.65 in the covariance analysis relative to ninth-grade science groups.

Interest

Hypothesis Four

There is no significant difference in the science interest scores of the present seniors who as ninth-grade students took either biology, general science, laboratory science or no science.

The Kruskal-Wallis One-Way Analysis of Variance by Ranks is appropriate to test this null hypothesis and a significance level of .05 will be accepted for rejection.

In this analysis scores from the science section of the Kuder Interest Inventory were utilized. This test was administered in April 1965, to all students in the samples. No pretest scores were available. The ranked scores are given in Table XXXI of Appendix E and the calculations for this analysis follow in Table XIV.

TABLE XIV

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE OF KUDER INTEREST SCORES RELATIVE TO NINTH-GRADE SCIENCE EXPERIENCE

Biology	General Science	Laboratory Science	No Science
$\Sigma R_1 = 5{,}318$	$\Sigma R_2 = 4{,}496.5$	$\Sigma R_3 = 6{,}013$	$\Sigma R_4 = 4{,}273.5$
$n_1 = 50$	$n_2 = 50$	$n_3 = 50$	$n_4 = 50$

$$H = \frac{12}{N(N+1)}\left[\frac{(\Sigma R_1)^2}{n_1} + \frac{(\Sigma R_2)^2}{n_2} + \frac{(\Sigma R_3)^2}{n_3} + \frac{(\Sigma R_4)^2}{n_4}\right] - 3(N+1)$$

$$H = \frac{12}{200(201)}\left[\frac{(5318)^2 + (4496.5)^2 + (6013)^2 + (4273.5)^2}{50}\right] - 3(201)$$

H = 11.4126 which with 3 df gives a P of .01

Table XIV indicates that the null hypothesis may be rejected and the alternate hypothesis may be accepted. The kind of science experience of students in the ninth grade does influence their interest in science to a significant degree.

Hypothesis Five

There is no significant difference in the science interest scores of the present seniors who as ninth-grade students took either biology, general science, laboratory science or no science.

The Kruskal-Wallis One-Way Analysis of Variance by Ranks is again appropriate to test this null hypothesis and a significance level of .05 will be accepted for rejection.

Table XXXII of Appendix E shows the ranking of the Kuder interest scores arranged according to the number of science credits the students had achieved. The sums of these ranks and the calculations for this analysis follows in Table XV.

TABLE XV

KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE OF KUDER INTEREST SCORES RELATIVE TO NUMBER OF SCIENCE CREDITS

One Credit	Two Credits	Three Credits	Four Credits
$\Sigma R_1 = 3{,}502$	$\Sigma R_2 = 5{,}387.5$	$\Sigma R_3 = 6{,}157.5$	$\Sigma R_4 = 5{,}054$
$n_1 = 51$	$n_2 = 58$	$n_3 = 54$	$n_4 = 37$

$$H = \frac{12}{N(N+1)} \left[\frac{(\Sigma R_1)^2}{n_1} + \frac{(\Sigma R_2)^2}{n_2} + \frac{(\Sigma R_3)^2}{n_3} + \frac{(\Sigma R_4)^2}{n_4} \right] - 3(N + 1)$$

$$H = \frac{12}{200(201)} \left[\frac{(3502)^2}{51} + \frac{(5387.5)^2}{58} + \frac{(6157.5)^2}{54} + \frac{(5054)^2}{37} \right] - 3(201)$$

$H = 35.83$ which with 3 df gives a P greater than .001

As indicated in Table XV the null hypothesis may be rejected and the alternate hypothesis, that the extent to which science has been pursued by students does influence their interest in science, may be confirmed. The H in Table XV which gives a relationship between interest and number of science credits, compares with an H of 11.4126 in Table XIV which gives the relationship between interest and the ninth-grade science experience.

Plans for Taking Science in College

Hypothesis Six

There is no significant difference in the extent to which seniors express plans for taking science courses in college relative to their ninth-grade science experience.

A chi-square analysis will be utilized to compare the extent to which the various ninth-grade science groups plan to pursue science in college. A significance level of .05 will be accepted to reject the null hypothesis.

Table XVI gives the number of students in each of the groups who expressed their plans for taking science in college in one of the three categories (See Appendix D for instrument). Numbers in parenthesis represent the expected frequencies which have been calculated by multiplying the total of each row by the total of each column and dividing by the total number of students. The little chi squares are calculated by squaring the difference in the observed and expected frequencies and dividing by the expected frequency. The total chi square then becomes the sum of all the little chi squares from each cell. In this manner the contribution of each cell to the total chi square can be seen.

As indicated by the chi square of Table XVI, the null hypothesis can be rejected and the alternate hypothesis, that plans for pursuing science in college are influenced by the kind of ninth-grade science experience of the students, may be confirmed. As might be expected, the no-science group probably contributed most to the total chi square with their expressed plan to take no more science than they were required to take in college. At the other extreme, more of the laboratory science group expressed plans to pursue a major in science during their college tenure than any other group. It also appeared that the laboratory science group tended to avoid the category which expressed plans for taking only that science which was required.

TABLE XVI

CHI-SQUARE ANALYSIS OF FUTURE PLANS FOR TAKING SCIENCE IN COLLEGE RELATIVE TO NINTH-GRADE SCIENCE

Students' Plans	Biology	General Science	Laboratory Science	No Science	Totals
Only That Required	16	16	12	28	72
(Expected f)	(18.46)	(18.36)	(18.36)	(18.36)	
*Chi Square	*.3033	*.3033	*2.2031	*5.0615	*7.8712
A Selected Few Classes	20	21	22	14	77
(Expected f)	(19.25)	(19.25)	(19.25)	(19.25)	
*Chi Square	*.0292	*.1590	*.3928	*1.4318	*2.0128
A Major in Science	14	13	16	8	51
(Expected f)	(12.75)	(12.75)	(12.75)	(12.75)	
*Chi Square	*.1225	*.0049	*.8284	*1.7696	*2.7254
Total Pupils	50	50	50	50	200
Total Chi Sq.	*.4550	*.4672	*3.4243	*8.3629	*12.6094

With a chi square of 12.6094 and 6 df, P lies between .05 and .02

Hypothesis Seven

There is no significant difference in the extent to which seniors express plans for taking science courses in college relative to the number of science courses they have taken.

A chi-square analysis will be utilized to compare the extent to which students who have had one, two, three, or four science credits plan to pursue science in college. A significance level of no less than .05 will be accepted for the rejection of this null hypothesis.

Table XVII gives the number of students in each of the groups who expressed their plans for taking science in college in one of the three categories (See Appendix D for instrument). The number in parenthesis again represents the expected frequencies and the number after the asterisk represents the chi square of each cell.

TABLE XVII

CHI-SQUARE ANALYSIS OF FUTURE PLANS FOR TAKING SCIENCE IN COLLEGE RELATIVE TO NUMBER OF SCIENCE COURSES

Students' Plans	One Credit	Two Credits	Three Credits	Four Credits	Totals
Only that Required	33	24	13	2	72
(Expected f)	(18.36)	(20.88)	(19.44)	(13.32)	
*Chi Square	*11.6737	*.4662	*2.1334	*9.6203	*23.8936
A Selected Few Classes	16	26	26	9	77
(Expected f)	(19.365_	(22.33)	(30.79)	(14.245)	
*Chi Square	*.6729	*.6031	*1.3056	*1.9318	*4.5134
A Major in Science	2	8	15	26	51
(Expected f(	(13.005)	(14.79)	(13.77)	(9.435)	
*Chi Square	*9.3125	*3.1172	*.1098	*29.0831	*41.6226
Total Pupils	51	58	54	37	200
Total Chi Sq.	*21.6591	*4.1865	*3.5488	*50.6352	*70.0296

With a chi square of 70.0296 and 6 df, P is greater than .001.

The above table indicates that the null hypothesis can be rejected and the alternate hypothesis, that the extent to which science has been pursued in high school influences students' plans for continuing their science in college. The greatest contribution to the total chi square was probably from the "Four Credit" group who indicated to a great extent their plans to major in science in college. The "One Credit" group may have also contributed, for they indicated a strong desire to take only that science which was required.

It is interesting to note the direct variation between the plans for a major in science and the number of credits; the more science the student takes, the more likely he is to plan to major in science. There is also a direct variation between the number who plan to take only that science which is necessary and the number of credits.

Plans for A Science Career

Hypothesis Eight

There is no significant difference in the extent to which seniors express plans for considering a science oriented career relative to their ninth-grade science experience.

A chi-square analysis will be utilized to compare the extent to which students who have taken biology, general science, laboratory science or no science plan to pursue a career in science. A significance level of .05 is appropriate to reject the null hypothesis.

This analysis will consider the students' responses to Item # 2 of the investigators instrument in Appendix D. Table XVII tabulates their responses relative to the ninth-grade science experience and computes the chi square.

The chi-square analysis indicates that the null hypothesis may be rejected and the alternate hypothesis confirmed, that students with the different ninth-grade science experiences will express to a significant degree, a difference in their plans for considering a career in science.

The largest contribution to the total chi square appeared to be from the laboratory science group who indicated to a large degree their plans for a science oriented career. It should be noted that the expected frequency in the bottom row of Table XVIII contains a smaller number than is necessary for best reliability. The analysis was performed however, by combining the last two rows. The resulting chi square still rejected.

TABLE XVIII

CHI-SQUARE ANALYSIS OF FUTURE PLANS FOR CONSIDERING A SCIENCE ORIENTED CAREER RELATIVE TO THE NINTH-GRADE SCIENCE GROUPS

Students' Plans	Biology	General Science	Laboratory Science	No Science	Totals
Not Science Oriented	28	32	20	32	112
(Expected f)	(28)	(28)	(28)	(28)	
*Chi Square	*00	*.5714	*2.2857	*.5714	*3.4285
Science Oriented	19	14	29	17	79
(Expected f)	(19.75)	(19.75)	(19.75)	(19.75)	
*Chi Square	*.0284	*1.674	*4.3322	*.1550	*4.6830
Science Research	3	4	1	1	9
(Expected f)	(2.25)	(2.25)	(2.25)	(2.25)	
*Chi Square	*.250	*1.3611	*.6944	*.6944	*2.9999
Total Pupils	50	50	50	50	200
Total Chi Sq.	*.2784	*3.6065	*7.3123	*1.4207	*12.6179

With a chi square of 12.6179 and 6 df, P lies between .05 and .02

Hypothesis Nine

There is no significant difference in the extent to which seniors express plans for considering a science-oriented career relative to the number of science courses they have taken.

A chi-square analysis will be utilized to compare the extent to which students who have had one, two, three or four credits in science plan to pursue a science-oriented career. A significance level of .05 will be accepted to reject the null hypothesis.

Student response to Item #2 of the questionnaire will again be considered, only in this instance, students were grouped according to the number of science courses they have taken. Table XIX below tabulates their responses grouped in this manner.

TABLE XIX

CHI-SQUARE ANALYSIS OF FUTURE PLANS FOR CONSIDERING A SCIENCE ORIENTED CAREER RELATIVE TO NUMBER OF SCIENCE CREDITS

Students' Plans	One Credit	Two Credits	Three Credits	Four Credits	Totals
Not Science Oriented	41	35	27	9	112
(Expected f)	(28.56)	(32.48)	(30.24)	(20.72)	
*Chi Square	*5.4185	*.1955	*.3471	*6.6292	*12.5903
Science Oriented	10	22	25	22	79
(Expected f)	(20.145)	(22.91)	(21.33)	(14.615)	
*Chi Square	*5.109	*.0361	*.6314	*3.7316	*9.5081
Science Research	0	1	2	6	9
(Expected f)	(2.295)	(2.61)	(2.243)	(1.665)	
*Chi Square	*2.295	*.9931	*.0760	*11.2866	*14.6507
Total Pupils	51	58	54	37	200
Total Chi Sq.	12.8225	*1.2247	*1.0545	*21.6474	*36.7491

With a chi square of 36.7491 and 6 df, P is greater than .001.

As indicated by Table XIX, the null hypothesis may be rejected and the alternate hypothesis that the extent to which science has been pursued in high school has a significant influence on the plans of seniors relative to a science-oriented career. The largest contribution to the total chi square apparently came from the "Four Credit" group who expressed more plans for science research than all the other groups combined. Again the direct variation between the plans for science research and number of credits can be seen. In addition the variation between the number planning other careers than science and the number of credits was inverse. It should again be noted that the number of students in the expected f of row three is less than that that required for valid results. The analysis was performed on a two-by-four table in which row three was combined with row two. The null hypothesis was still rejected, with P still greater than .001.

Students' Opinions of the Quality of Their Science Experience

Hypothesis Ten

There is no significant difference in the extent to which seniors express feelings of quality relative to their total science program and their ninth-grade science experience.

A chi-square analysis will be utilized to compare the extent to which students who have had in their ninth grade either biology, general science, laboratory science or no science, express the adequacy of the quality of their total high school science experience. A significance level of .05 is appropriate to reject the null hypothesis.

This analysis considers the students' responses to Item #3 of the questionnaire (Appendix D). Table XX shows the responses relative to the ninth-grade science groups and indicates a chi square which failed to reject the null hypothesis.

TABLE XX

CHI-SQUARE ANALYSIS OF STUDENT OPINIONS REGARDING THE QUALITY OF THEIR TOTAL SCIENCE PROGRAM RELATIVE TO NINTH-GRADE SCIENCE

Students' Opinions	Biology	General Science	Laboratory Science	No Science	Totals
Less Than Adequate	3	6	5	11	25
(Expected f)	(6.25)	(6.25)	(6.25)	(6.25)	
*Chi Square	*1.69	*.01	*.25	*3.61	*5.56
Just Adequate	42	37	37	37	153
(Expected f)	(38.25)	(38.25)	(38.25)	(38.25)	
*Chi Square	*.3676	*.0408	*.0408	*.0408	*.4900
More Than Adequate	5	7	8	2	22
(Expected f)	(5.5)	(5.5)	(5.5)	(5.5)	
*Chi Square	*.0113	*.5568	*1.3750	*1.9204	*3.8635
Total Pupils	50	50	50	50	200
Total Chi Sq.	*2.0689	*.6076	*1.6658	*5.5712	*9.9135

With a chi square of 9.9135 and 6 df, P lies between .20 and .10

The probability of .15 is not sufficient for this analysis. The largest contribution to the insignificant chi square apparently came from the no-science group who expressed the highest feelings of the inadequacy of their science program in terms of quality. The greatest cell chi square, in terms of their science program being more than adequate in quality, was expressed by the laboratory science cell.

<u>Hypothesis Eleven</u>

There is no significant difference in the extent to which seniors express feelings of quality relative to their total science program and the number of science courses they have taken.

A chi-square analysis will be utilized to compare the extent to which students who have had one, two, three or four science credits, express the adequacy of the quality of their total high school science experience. A significance level of .05 is appropriate to reject this null hypothesis.

This analysis again considers the students' responses to Item #3 of the questionnaire but in this case the responses are tabulated by number of science credits. Table XXI which follows shows this tabulation and the chi-square analysis.

TABLE XXI

CHI-SQUARE ANALYSIS OF STUDENT OPINIONS REGARDING THE QUALITY OF THEIR TOTAL SCIENCE PROGRAM RELATIVE TO NUMBER OF CREDITS

Students' Opinions	One Credit	Two Credits	Three Credits	Four Credits	Total
Less Than					
Adequate	10	11	1	3	25
(Expected f)	6.375)	(7.25_	(6.75)	(4.625)	
*Chi Square	*2.0612	*1.9396	*4 8981	*0.5709	*9.4698
Just					
Adequate	40	45	45	23	153
(Expected f)	(31.015)	(44.37)	(41.31)	(28.305)	
*Chi Square	*.0248	*.0089	*.3296	*.9942	*1.3575
More Than					
Adequate	1	2	8	11	22
(Expected f)	(5.61)	(6.38)	(5.94)	(4.07(	
*Chi Square	*3.7882	*3.0069	*.7144	*11.7997	*19.3092
Total Pupils	51	58	54	37	200
Total Chi Sq.	*5.8742	*4.9554	*5.9421	*13.3648	*30.1365

With a chi square of 30.1365 and 6 df, P is greater than .001.

The chi square in Table XXI indicates that the null hypothesis can be rejected and the alternate hypothesis, that the number of credits which students have accumulated, significantly influence their feelings of the quality of their total science experience may be confirmed. The largest group contribution to the total chi square appears to come from the "Four Credit" group, who felt to a large extent that the quality of their total science program was more than adequate. A direct variation is again observed between the number of those who felt that their science was more than adequate and the number of science credits received. However, the inverse variation between those expressing "less than adequate" opinions and the number of science credits was not consistent and expresses little meaning.

Students' Opinions of the Quantity of Their Science Experience

Hypothesis Twelve

There is no significant difference in the extent to which seniors express satisfaction with the quantity of science they have taken relative to their ninth-grade science experience.

A chi-square analysis will be utilized to compare these expressions of opinions and a significance level of .05 is appropriate to reject the null hypothesis.

This analysis considers the students' responses to Item #4 of the questionnaire in Appendix D. Table XXII shows the tabulations of these opinions relative to quantity and the chi-square analysis which fails to reject the null hypothesis. The largest contribution to the insignificant chi square seemed to come from the laboratory science group who were inclined to feel they had more science than was necessary. Sixty-nine per cent of the 200 students indicated they had about what was necessary, apparently satisfied with the quantity of their science program.

TABLE XXII

CHI-SQUARE ANALYSIS OF STUDENT OPINIONS REGARDING THE QUANTITY OF THEIR TOTAL SCIENCE PROGRAM RELATIVE TO NINTH-GRADE SCIENCE

Students' Opinions	Biology	General Science	Laboratory Science	No Science	Totals
Less Than Necessary	11	10	6	14	41
(Expected f(	(10.25)	(10.25)	(10.25)	(10/25)	
*Chi Square	*.0548	*.0060	*1.7621	*1.3719	*3.1948
What Was Necessary	36	34	36	35	138
(Expected f)	(34.5(	(34.5)	(34.5)	(34.5)	
*Chi Square	*.0652	*.0072	*.0652	*.0072	*.1448
More Than Necessary	3	6	8	4	31
(Expected f)	(5.25)	(5.25)	(5.25)	(5.25)	
*Chi Square	*.9642	*.1071	*1.4404	*.2976	*2.8093
Total Pupils	50	50	50	50	200
Total Chi Sq.	*1.0842	*.1203	*3.2677	*1.6767	*6.1489

With a chi square of 6.1489 and 6 df, P lies between .50 and .30

Hypothesis Thirteen

There is no significant difference in the extent to which seniors express satisfaction with the quantity of science they have taken relative to the number of science credits they have received.

A chi-square analysis will be utilized to compare these expressions of opinions and a significance level of .05 is appropriate to reject the null hypothesis.

This analysis again considers the students' responses to Item #4 of the questionnaire. Table XXIII shows the tabulations of these opinions and the chi-square analysis.

TABLE XXIII

CHI-SQUARE ANALYSIS OF STUDENT OPINIONS REGARDING THE QUANTITY OF THEIR TOTAL SCIENCE PROGRAM RELATIVE TO THE NUMBER OF SCIENCE CREDITS

Students' Opinions	One Credit	Two Credits	Three Credits	Four Credits	Totals
Less Tnan Necessary	17	14	6	4	41
(Expected f)	(10.455)	(11.89)	(11.07)	(7.585)	
*Chi Square	*4.0972	*.3744	*2.3220	*1.6944	*8.4800
What Was Necessary	32	39	41	26	138
(Expected f)	(35.19)	(40.02)	(37.26)	(25.53)	
*Chi Square	*.2891	*.0259	*.3754	*.0086	*.6990
More Than Necessary	2	5	7	7	21
(Expected f)	(5.355)	(6.09)	(5.67)	(3.885)	
*Chi Square	*2.1019	*.1950	*.3310	*3.4976	*5.1255
Total Pupils	51	58	54	37	200
Total Chi Sq.	*6.4882	*.5953	*3.0284	*4.2006	*14.3125

With a chi square of 14.3125 and 6 df, P lies between .05 and .02

The chi square in Table XXIII indicates the null hypothesis may be rejected and the alternate hypothesis, that the extent to which students pursue science in high school influence their feelings on how necessary this science was to their college plans, may be confirmed. The largest contribution to the total chi square appeared to be from the "One Credit" group who felt to a large extent that they had taken less science than was necessary for their college plans. Seven members of the "Four Credit" group felt they had more science than was necessary. This was apparently the largest contribution of any cell on this side of the continuum. A direct variation was again observed between the number of science courses taken and the extent to which students express feelings of adequacy.

Students' Opinions of Ninth-Grade Course Content

Hypothesis Fourteen

There is no significant difference in the extent to which seniors feel their ninth-grade science was either too general or too specific in its content.

A chi-square analysis will be utilized to compare these expressions of opinions and a significance level of .05 is appropriate to reject the null hypothesis.

This analysis considers the students' responses to Item #5 of the questionnaire in Appendix D. Since it applies only to those students who actually took a ninth-grade science, the no-science group did not respond to this item. The chi-square analysis will therefore be calculated utilizing a three-by-three contingency table which is shown on the following page.

Table XXIV indicates that the null hypothesis can be rejected and the alternate hypothesis, that the ninth-grade science groups differ significantly in their feelings regarding whether their ninth-grade science course should have gone more in detail in a single science, or have been more exploratory into several sciences, may be confirmed. The largest contribution to the total chi square seemed to be from the laboratory science group in which a significant number declined to express feelings that their ninth-grade science should have been more exploratory.

The biology group indicated significantly greater inclination to express feelings that their ninth-grade science should have been more exploratory than the laboratory science group. The laboratory science group, however, indicated greater inclination than the biology group to state that their ninth-grade science should have been less exploratory.

TABLE XXIV

CHI-SQUARE ANALYSIS OF STUDENTS' OPINIONS OF THE COURSE CONTENT OF THEIR NINTH-GRADE SCIENCE RELATIVE TO ITS EXPLORATORY NATURE

Students' Opinions	Biology	General Science	Laboratory Science	Totals
Should Have Been More Exploratory	11	17	1	28
(Expected f)	(9.3333)	(9.3333)	(9.3333)	
*Chi Square	*.2976	*4.7619	*7.4404	*12.4999
Should Have Been Just As It Was	37	23	40	100
(Expected f)	(33.333)	(33.333)	(33.333)	
*Chi Square	*.4022	*3.2033	*1.3334	*4.9400
Should Have Been Less Exploratory	2	11	9	22
(Expected f)	(7.3333)	(7.3333)	(7.3333)	
*Chi Square	*3.8787	*1.8333	*.3789	*6.0909
Total Pupils	50	50	50	150
Total Chi Sq.	*4.5796	*9.7985	*9.1527	*23.5308

With a chi square of 23.5308 and 4 df, P is greater than .001.

Students' Opinions of Their Ninth-Grade Laboratory Activities

Hypothesis Fifteen

There is no significant difference in the extent to which seniors express the adequacy of their ninth-grade science experience in terms of the preparation they received for the laboratory activities of the senior high school science program.

A chi-square analysis will be utilized to compare these expressions of opinions. A significance level of .05 is appropriate to reject the null hypothesis.

Table XXV gives the tabulations for the students' opinions regarding the adequacy of their ninth-grade science class in preparing them for the laboratory activities of the senior high school.

TABLE XXV

CHI-SQUARE ANALYSIS OF STUDENTS' OPINIONS OF THEIR NINTH-GRADE SCIENCE CLASS RELATIVE TO THE PREPARATION THEY RECEIVED FOR THE LABORATORY ACTIVITIES OF SENIOR HIGH SCHOOL

Students' Opinions	Biology	General Science	Laboratory Science	Totals
Less Than				
Adequate	6	21	6	33
(Expected f)	(11)	(11)	(11)	
*Chi Square	*2.2727	*9.0909	*2.2727	*13.6363
Just				
Adequate	36	21	32	89
(Expected f)	(29.6666)	(29.6666)	(29.6666)	
*Chi Square	*1.3522	*2.5318	*.1835	*4.0675
More Than				
Adequate	8	8	12	28
(Expected f)	(9.3333)	(9.3333)	(9.3333)	
*Chi Square	*.1904	*.1904	*.7619	*1.1427
Total Pupils	50	50	50	150
Total Chi Square	*3.8153	*11.8131	*3.3181	*18.4650

With a chi square of 18.4750 and 4 df, P is greater than .001.

Table XXV indicates that the null hypothesis can be rejected and the alternate hypothesis, that seniors do feel significantly different about how well their ninth-grade science class prepared them for senior high school science classes, may be confirmed. The largest group contribution may have come from the general science group who felt to a large extent that they had less than adequate preparation for the senior high school science classes.

CHAPTER V

SUMMARY AND CONCLUSIONS

Introduction

This study has attempted to evaluate some ninth-grade science programs being used in the Wichita schools in 1961-1962. These different programs have been described in Chapter II and throughout the study they have been referred to as courses, classes, treatments and methods. They comprised the major independent variables of the study. The evaluation was made in terms of the extent to which students were motivated to pursue science in high school, their plans for taking science in college or including science in their career, and their own evaluation of their ninth-grade experience. Evaluations were made also in terms of students' science achievement scores and science interest scores.

This chapter will include a summary of the findings and conclusions, limitations, and recommendations.

Summary of Findings and Conclusions

The laboratory science group was found to have pursued science in high school significantly more than the biology group and the no-science group. The laboratory group compiled more science credits than the general science group though not significantly greater. The reader must be cognizant, however, that the general science group had not completed their requirement for graduation in a laboratory science. Consequently this group was compelled to take at least one course in the senior high school. The total science credits then does not represent a true measure of their interest in science.

The most revealing aspect of this particular comparison was the extent to which the laboratory science group exceeded the biology group in their pursuance of science. This difference was most apparent when a comparison was made in the ratio of students who took no more science after their ninth-grade science. Sixteen of the biology group terminated their science training while only six of the laboratory science students felt so inclined (See Table XXVI in Appendix E).

The no-science group was well at the bottom. It is logical to assume that this is where they should fall--that since they were not inclined to enroll in a ninth-grade science, one could hardly expect that suddenly they would become science oriented. There is, however, a small group, particularly within the college ranks, who have expressed their feelings that concentrated attempts at teaching science when students are young and immature, may produce as many "drop-outs" as "recruits". There are studies in fact, mentioned in Chapter II, which support this claim. Within the scope of this study, however, their was no indication that students are more highly motivated by postponing their science until they are more mature or are at least within the ranks of the senior high school. The opposite conclusion was in fact indicated, in that 29 members of the no-science group took only a single required course in the senior high school (See Table XXVI in Appendix E).

A conclusion of this study relative to the motivation of ninth-grade students is that a labcratory science course such as that described in Chapter II, given to ninth-grade students of the upper ability level, is the most appropriate of the science courses described in this study, to encourage and motivate these students to pursue more science in high school.

Achievement

This study found that the total number of science courses taken by students had a greater influence on their achievement in science than the ninth-grade course they had taken. No significant difference was found among all the groups involved in this study when their pretest and posttest science scores were considered. When the sample was grouped according to the number of science courses they had taken during their tenure in high school, a significant difference was found in achievement. The variation was direct--as students took more science, they made higher scores.

Concluding remarks regarding achievement can not digress far from the rather cold results just stated. However, it is reasonable to say that since a significant difference was found in the extent to which the ninth-grade groups pursued science, and the extent to which science was pursued (number of science courses) significantly influenced achievement, the ninth-grade treatment did indirectly influence achievement. Also it should be mentioned that the statistical analysis reported in Chapter IV was quite close in rejecting the null hypothesis of no difference. Had the significance been set at the .06 level rather than the .05 level, the conclusions here could have been explicit rather than implicit. In the opinion of the investigator, the ninth-grade course does make a difference in the achievement scores.

Interest

This study found that when the sample of seniors were grouped either by the ninth-grade science course they have had, or by the number of science courses they have taken, there was a significant difference in their interest in science. Table XIV shows that the laboratory science group ranked well above the biology group, which in turn ranked well above the general science group and the no-science group.

In the analysis comparing the number of science courses and interest, a direct variation was found. Students with four credits in science had higher scores than those with three credits, who in turn had higher scores than students with two or one credit.

A conclusion of this study relative to interest is that both the kind of science in the ninth grade and the amount of science taken throughout highschool, significantly influence the interest of academically talented students in science. The study further concludes that the laboratory science activities contribute more to this interest in science than any other group involved in this study.

Plans for Taking Science in College

In this analysis it was found that both the kind of ninth-grade science and the total number of science courses significantly influence the plans of academically talented students for taking science in college. The group which expressed the greatest interest in taking science courses in college was the laboratory science group. The biology and general science groups were tied for second place and the no-science group was much lower. On the basis of these results the conclusion regarding this variable is that laboratory science is the best suited of the courses described in this study, to motivate academically talented students to pursue courses of science in college.

Plans for a Science Career

As was found in the analysis of plans for pursuing science in college, this analysis of plans for a science career found that both the kind of ninth-grade science and the number of science courses taken in high school, significantly influence the plans of academically talented seniors for considering a career in science. Again the laboratory science group expressed an interest in a science-oriented career considerably more than the other three groups, which were similar in their expression of plans. On the basis of these results the conclusion regarding this variable is that the laboratory science course is the best suited, of the courses described in this study, to encourage academically talented students to consider a career in science.

Students' Opinions of the Quality of Their Science Experience

An attempt was made in this analysis to determine if talented seniors felt differently about the quality of their total science experience. More specifically did those students who had biology as ninth graders, for example, feel differently about the quality of their science program than those students who had laboratory science, general science or no science in the ninth grade. No significant difference was found. The no-science group did indicate to an insignificant degree that their science program had been inadequate. There was an indication, though also insignificant, from the laboratory science group of a "more than adequate" feeling.

When the students were grouped according to the number of science credits they had received, a highly significant difference was found. The more science the students had taken, the more likely they were to express a "more than adequate" opinion. The less science they had taken, the more likely they were to express a "less than adequate" opinion of the quality of their science experience.

The conclusion is that the influence of the kind of ninth-grade science taken by the talented students is "washed out" through subsequent science or the lack of subsequent science, relative to quality. It would seem that students' opinions reflect a direct relationship between quality and quantity.

Students' Opinions of the Quantity of Their Science Experience

In this analysis, as in the preceding analysis, students again exercised the normal tendency to express the average. About 70 per cent of the sample felt that they had taken about "what was necessary" in terms of quantity of science. No significant difference was found among the groups relative to the ninth-grade science groupings. When the sample was grouped according to the number of science courses, a highly significant difference was found. The more science the students had taken, the more likely they were to feel they had more science than was necessary. The less science they had taken the more likely they were to feel that they had taken less science than was necessary.

The conclusion is that the ninth-grade science experience does not influence talented seniors one way or another with regard to their feelings of whether they have taken the right amount of science or not.

Students' Opinions of Ninth-Grade Course Content

In this analysis, an attempt was made to determine if students who had taken biology, laboratory science or general science felt that their class had been either too general or too specific in its content. A significant difference was found among the groups, the largest difference coming from the general science group and the laboratory group. A rather surprising finding in this analysis was the extent to which the general science group avoided the middle ground answer and expressed feelings that their ninth-grade science should have been more exploratory or less exploratory. Pure conjecture is that those general science students who thought their science should have been more exploratory were really registering a protest against the general science practice of little or no experimentation, rather than against the lack of exploration. Only one of the laboratory science students thought that laboratory science should be more exploratory, but nine felt it should have been less exploratory. Only two of the biology students thought biology should be less exploratory but eleven thought it should have been more exploratory. Perhaps the only conclusion is that students in both the biology and the laboratory science groups have simply expressed the often heard criticisms of both groups. With the conflicting expressions from the general science group, the investigator would hesitate to conclude much more from this analysis.

Students' Opinions of Their Ninth-Grade Laboratory Activities

A significant difference was found among the three groups involved in this analysis relative to their evaluation of their ninth-grade laboratory activities. The big difference was from the general science group who emphatically declared their ninth-grade laboratory experience to be less than adequate. There was little difference between the biology and laboratory science groups. The conclusion relative to laboratories is that in the opinion of students, both biology and laboratory science provide adequate laboratory activities. General Science fails decidedly in this respect.

Limitations

In interpreting the findings of this study, the reader should be cognizant of certain associated limitations, three of which will be discussed subsequently.

Perhaps the greatest limiting factor was that the study was restricted to the Wichita schools and inferences can be made only thereto. There is no reason to think that the Wichita population was entirely unique in relation to what science to teach in the ninth grade. This study however, presents no evidence to indicate otherwise.

Secondly, the ex post facto design necessarily introduces some limitations on the findings. The investigator is aware that his conclusions and implications have been extended to the maximum within the strength of such a design.

A third limitation is that the findings apply only to the upper ability level. This limitation was actually a part of the ex post facto design and was necessarily inherent. As much as the investigator would like to implicate the entire ability range with the findings of this study, there is no evidence within the study to permit or justify such practice.

Recommendations

In view of the limitations mentioned above, it would appear that only conservative recommendations would be in order. The results of the several analyses present sufficient evidence to recommend that laboratory science be offered as the ninth-grade science course for talented students in Wichita. The findings indicate that the more science courses students have taken, particularly laboratory science, the more likely they are to excel relative to the variables under investigation. The writer feels that the findings would have been even more conclusive, relative to the last statement, if the entire ability range could have been included. Knowledge of the learning process indicates that activity centered experiences give positive reinforcement to learning at all ability levels and become essential at the average and below average ability levels. An extension of the first recommendation is that a laboratory centered science be given to every ninth-grade student who desires to pursue a science.

This study also indicated that the sooner students start their science program, the more likely they are to continue in science. The writer would not however, recommend that ninth-grade science be made a required subject. Students should still be permitted to postpone fulfilling their science requirement should they so desire. The recommendations relative to this finding are as follows: (1) The laboratory centered activities should be extended into the seventh and eighth grades where science is required. (2) The ninth-grade laboratory science should become the third phase of a continuing junior high school science program. (3) All students should be properly counseled and informed relative to the scope and sequence of a continuing program. (4) The senior high schools should build on the program of the junior high schools.

In Chapter II, the writer attempted to point out the folly of concentrating the efforts of a science curriculum development program upon an isolated segment or grade level. A recommendation relative to this observation is that curriculum changes in science at any level be considered solely within their relationship to the entire science program from kindergarten through the twelfth grade.

Regarding future studies, the writer recommends that a study similar to this investigation be conducted in which the design could be truly experimental and a representative sample of the whole population be used. Studies should also be initiated to discover the most effective techniques of presenting a laboratory science program. As more mature concepts are introduced to younger students, the curriculum must be re-examined to determine its continuing adaptability. Studies should be extended to all levels of the elementary schools in an attempt to determine the value of laboratory centered activities at these levels.

Finally the investigator suggests a follow-up study of the same sample used in this investigation. It could prove most beneficial to follow these students through college and examine their activities relative to science.

SELECTED BIBLIOGRAPHY

1. Abelson, Philip H. "Creativity in the Sciences." Science, 140 (June 1963), 1260-1271.

2. Bicak, Laddie J. "Achievement in Eighth Grade Science by Heterogeneous and Homogeneous Grouping." Science Education, 48 (February 1964), 13-22.

3. Bingham, Eldred N. "What Science to Teach in the Ninth Grade." Science Education, 47 (April 1963) 226.

4. Blanc, Sam S. "New Direction in Junior High School Science." School Science And Mathematics, 64 (April 1964) 282-284.

5. Bloom, Benjamin S. Taxonomy of Educational Objectives. Ann Arbor, Michigan, Edwards Brothers, 1956 73-74.

6. Bloom, Samuel W. "Strengthening the Junior High School Science Program." The Science Teacher, 30 (November 1963) 18-21.

7. Caldwell, Loren T. "A Content Study of Earth Science Courses in Selected Secondary Schools." Science Education, 48 (October 1964) 361-362.

8. Caldwell, Otis W. "General Science or Special Science." School Review, 24 (1915) 426-435.

9. Clark, William S. General Science. New York, The American Book Company, 1912 363 pp.

10. Cohen, David. "The Significance of Recent Research in Secondary School Science." Science Education,48 (March 1964) 157-167.

11. Conant, James B. "Introductory Statement." The Identification and Education of the Academically Talented Student in the American Secondary School: Conference Report. Washington, D. C., National Education Association, 1958 15-17.

12. Coulter, John M. "The Mission of Science in Education." School Review, 23 (1915) 1-8.

13. Crumrine, William M. "An Investigation of the Stability of Interests of High School Students." (Unpublished Masters Thesis, Kalamazoo: Western Michigan University, May 1959), 75 pp.

14. Downing, Elliot R. "The Problem of Science Teaching in the Secondary Schools." School Science and Mathematics, 26 (March 1926) 201-203.

15. "Education of the Gifted." National Education Association Educational Policies Commission, Washington, D. C., (June 1950) p 2.

16. Fairbanks, H. W. "Physical Geography Versus General Science." School Science and Mathematics, 10 (1910) 761-772.

17. Fischler, Abraham S. "Junior High School Science." School Science and Mathematics, 64 (January 1964) 21-30.

18. Garrett, Henry E. Statistics in Psychology and Education. New York, David McCoy Co. Inc. 1958 284-295.

19. Goldberg, Isadore. "The Project Talent Interest Inventory." Project Talent, Pittsburg, University of Pittsburg Press, 1964.

20. Grossnickle, Foster E. "Arithmetic for Those Who Excel." The Arithmetic Teacher, 3 (October 1963) p 41.

21. Hanna, P. R. "National Curriculum Commission." Journal of the National Education Association, 49 (January 1960) 25-27.

22. Hurd, Paul D. "The New Curriculum Movement in Science." Science Teacher, 29 (February 1962) 6-9.

23. Iowa Tests of Educational Development - General Manual, Chicago, Science Research Associates, 1951 p 17.

24. Johnson, Palmer O. and Jackson, Robert W. Modern Statistical Methods. Chicago, Rand McNally & Company, 1959 p 505.

25. Klausmeier, Herbert J. and Wiersma, William. "Effects of Condensing Content in Mathematics and Science in the Junior and Senior High School." School Science and Mathematics, 64 (January 1964) 4-11.

26. Kuder, Frederic G. General Interest Survey Manual Form E, Chicago, Science Research Associates, 1954, p 5.

27. Lee, Eugene C. "With All Deliberate Speed." School Science and Mathematics, 63 (March 1963) 190-194.

28. Lerner, Morris R. "Integrated Science." The Science Teacher, 31 (February 1964) p 37.

29. Mallinson, George G. "Junior High School Science and the Implications of the Science Motivation Project." School Science and Mathematics, 64 (October 1964) 613-624.

30. Mallinson, George G. "Content and Emphasis to Implement the Curriculum Structure for Science Teaching in Michigan." Newsletter of the Michigan Science Teachers Association, (July 1958) p 15.

31. Mann, C. R. "Physical Geography Versus General Science." School Science and Mathematics, 11 (1911) 17-19.

32. Mathews, William H. "Growth of Earth Science in Secondary Schools." School Science and Mathematics, 63 (November 1963) 637-645.

33. Martin, Viva D. "General Science Weighed in the Balance." School Science and Mathematics, 24 (February 1924) 156-158.

34. Millikan, R. A. "The Problem of Science Teaching in the Secondary School." School Science and Mathematics, 25 (December 1925) 966-975.

35. "Biology Syllabus" New York State Board of Education, N Y. (1910).

36. Norton, Jerry L. "The Need for an Activity Centered Program." Science Education, 47 (April 1963) 285-291.

37. Norton, Monte S. "Enriching the Program for Giften Students." School Science and Mathematics, 59 (February 1959) 101-106.

38. Page, Thorton. "The Changing Art of Science Teaching." Modern Viewpoints in the Curriculum, ed by Paul C. Rosenbloom, New York, McGraw-Hill, 1964.

39. Poll, Ernest N. "Diversified Learning Situations and Student Choice." School Science and Mathematics, 65 (January 1965) 62-67.

40. Renner, John W. "Why Change Science Teaching?" School Science and Mathematics, 64 (May 1964) 413-420.

41. Romey, William, and Merril, John H. "A Comparison of the Performance of Ninth-Grade and College Students in an Earth Science Laboratory Activity." Science Teacher, 31 (March 1964) 157-167.

42. Rosen, Sidney. "The Origins of High School Biology." School Science and Mathematics, 59 (November 1959) 473-489.

43. "Harvard Project" Science Digest, (January 1965) p 23.

44. Sharkan, William W. "Ninth-Grade Biology--Pros and Cons." School Science and Mathematics, 59 (December 1959) 718-722.

45. Shroud, Melvin L. "Earth Science for Junior High School." The Science Teacher, 30 (November 1963) 53-54.

46. Showalter, Victor. "Unified Science." The Science Teacher, 31 (February 1964) p 25.

47. Siegel, Sidney. Nonparametric Statistics For The Biological Sciences New York, McGraw-Hill Book Co. Inc. 1956 p 194.

48. Skinner, Ray Jr., and Davis, O. L. Jr. "Earth Science: The New Look in Ohio School Science Programs", School Science and Mathematics 65 (February 1965) 127-131.

49. Stalnaker, John M. "Itendification of the Academically Talented." The Idenfification and Education of the Academically Talented Student in the American Secondary School: Conference Report. Washington, D. C., National Education Association, 1958 18-27.

50. Stephenson, Robert C. "The Earth Science Curriculum Project." The Science Teacher, 31 (March 1964) p 21.

51. Taba, Hilda. Curriculum Development: Theory and Practice. New York, Harcourt Brace & World Inc. 1962 p 447.

52. Travers, Robert, M. W. Educational Measurement. New York, The Macmillan Company, 1955 p 105.

53. Thelen, L. J. "Facts and Concepts of Chemistry of Importance for Introductory High School Biology." Science Education, 48 (December 1964) 447-453.

54. Tyler, R. W. "Do We Need a National Curriculum?" National Association of Secondary School Principals Bulletin, 44 (February 1960) 76-85.

55. "Offerings and Enrollments in Science in Public High Schools." U. S. Office of Education Publication Bulletin 118. Washington, D. C. 1963 p 7.

56. Walter, H. E. "High School Biology." School Science and Mathematics, 8 (1916) p 721.

57. Watson, Fletcher G. "Curriculum Design in Science." The Science Teacher, 30 (March 1963) 13-16.

58. Weaver, Edward K. "Science and the Curriculum." School Science and Mathematics, 59, (March 1959) 238-250.

59. Webb, Hannor A. "How General Science Began." School Science and Mathematics, 59 (June 1959) 421-430.

60. Weisbruch, Fred T. "A Laboratory Oriented Course for Ninth-Grade Science." School Science and Mathematics, 63 (June 1963) 493-502.

61. Weisbruch, Fred T. "Content Versus Method." Catholic School Journal, 64 (June 1964) p 73.

62. Wiesner, Jerome. "Education for Creativity in Science." Science, 140 (June 1963) 1292-1293.

63. Witty, Paul H. "Todays Schools Can Do Much For The Gifted Ohild." The Nations Schools, 57 (February 1956) p 72.

64. Yager, R. E. "Analysis of Effects in Placement of General Biology in Grade Nine." School Science and Mathematics, 63, (April 1963) p 305.

APPENDIX A

Science Transcript

Name______________________________________

High School________________________________

Please check the science courses taken during each of the following years. Please be particularly careful concerning the class of science pursued during the ninth grade, watching especially for a distinction between "Laboratory Science" and "General Science".

Ninth Grade (1961-1962)	Tenth Grade (1962-1963)	Eleventh Grade (1963-1964)	Twelfth Grade (1964-1965)
Gen Sci________	Basic Sci_______	Basic Sci_______	Basic Sci__________
Biology________	Biology_________	Biology_________	Biology____________
Lab Sci________	Chemistry_______	Chemistry_______	Chemistry__________
None __________	Botany _________	Botany__________	Botany ____________
	Physics_________	Physics ________	Physics____________
	Geology_________	Geology ________	Geology____________
	Astronomy ______	Astronomy_______	Astronomy__________
	Physiology______	Physiology______	Physiology_________
	Biology II _____	Biology II______	Biology II_________
	________________	Chemistry II____	Chemistry II_______
	________________	________________	___________________

APPENDIX B

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HMS-002

APPENDIX C

Science Interest Test

For each item there are a list of things to do in groups of three. First read the list of all three activities in a group. Decide which of the three you like most and circle the "M" which follows that activity. Then decide which activity you like the least and circle the "L" which follows this activity. You may like all three activities in a group or you may dislike all three. In either case show what your choices would be if you had to choose. For each group of activities it is essential that you choose the activity most preferred and the activity least preferred.

1. Visit a weather station -- M L
   Visit a company that prepares advertising --------------------- M L
   Visit a factory where typewriters are made--------------------- M L

2. Take a course in drawing --------------------------------------- M L
   Take a course in the science of plant and animal life --------- M L
   Take a course in metal working -------------------------------- M L

3. Visit the laboratory of a famous inventor --------------------- M L
   Visit a national park in the mountains ------------------------ M L
   Visit a place where a famous battle was fought ---------------- M L

4. Read about how famous scientists made their discoveries ------- M L
   Read what some people think a perfect world would be like ----- M L
   Read about the early pooneers of the country ------------------ M L

5. Help people learn to get along better with others ------------- M L
   Catch rare animals for a museum ------------------------------- M L
   Cash checks for people in a bank ------------------------------ M L

6. Join a club that discusses problems of modern life ------------ M L
   Join a club that discusses new books -------------------------- M L
   Join a club that studies the stars and planets ---------------- M L

7. Earn part of your expenses in college by heoping in a laboratoryM L
   Earn part of your expenses in college by grading papers ------- M L
   Earn part of your expenses in college by playing in a band ---- M L

8. Write a history of the Red Cross ------------------------------ M L
   Search for new facts about a famous event in history ---------- M L
   Write a musical play -- M L

9. Be well known as a director of scientific research ------------ M L
   Be well known as a social worker ------------------------------ M L
   Be well known as a person who writes his opinions of books ---- M L

10. Design the scenery for a play -------------------------------- M L
    Test a new product in the laboratory to see how good it it ---- M L
    Write an article for housewives on how to fix electric things - M L

11. Write the business news for a newspaper ---------------------- M L
    Work on the development of a new metal that is light and strong M L
    Manage a well-planed village for factory workers -------------- M L

12. Visit a fine arts museum ------------------------------------- M L
Visit a place where poor people can go to have fun ----------- M L
Visit a laboratory where new medicines are developed --------- M L

13. Write the words for a song ------------------------------------ M L
Discover a sure cure for hay fever --------------------------- M L
Develop better ways of doing office work for a business ------ M L

14. Explain new discoveries in science to children --------------- M L
Show children how to use time tables ------------------------- M L
Explain to children how the buying value of the dollar changes M L

15. Write a newspaper column on current events ------------------- M L
Give popular lectures on chemistry ---------------------------- M L
Help young people choose what to do for a living ------------- M L

16. Be in charge of a large department in a store ----------------- M L
Do research to improve television ----------------------------- M L
Organize social activities for groups of poor people --------- M L

17. Talk to people to decide whether to hire them ----------------- M L
Do chemical research -- M L
Write human-interest stories for a newspaper ----------------- M L

18. Draw a picture of sailboats ---------------------------------- M L
Try different sails on a toy boat to see which works best ---- M L
Write a poem about sailboats ---------------------------------- M L

19. Read new evidence about the causes of various diseases ------- M L
Read about how leaders of industry become successful --------- M L
Read about how to raise animals on a farm -------------------- M L

20. Sell art supplies --- M L
Grow flower seeds --- M L
Raise white mice for scientists ------------------------------- M L

21. Perform laboratory experiments -------------------------------- M L
Make furniture -- M L
Sell insurance -- M L

22. Visit a showing of machines that solve problems -------------- M L
Visit a showing of machines that copy drawings rapidly ------- M L
Visit a famous research laboratory ---------------------------- M L

23. Be an expert on cutting jewels ------------------------------- M L
Do research on developing a better kind of rubber ------------ M L
Give music lessons -- M L

24. Add up customers' bills in a cafeteria ----------------------- M L
Teach children how to make model airplanes ------------------- M L
Keep record books for scientists ------------------------------ M L

25. Direct a playground for poor children ------------------------ M L
Be a cook in a restaurant -------------------------------------- M L
Sell medicines to doctors -------------------------------------- M L

26. Pick cherries -- M L
Drive a tractor on a farm -------------------------------------- M L
Work in a chemistry laboratory --------------------------------- M L

27. Read about research on various diseases ---------------------- M L
Read about improved methods of raising cattle ------------------- M L
Read about improvements in methods of building houses ---------- M L

28. Go on trips to find rare animals ----------------------------- M L
Go on trips to fight diseases among the natives ---------------- M L
Have a job helping people who are very poor -------------------- M L

29. Read about plays of long ago --------------------------------- M L
Read about music of long ago ------------------------------------ M L
Read about studies of how words influence people --------------- M L

30. Be the best arithmetic student in a class -------------------- M L
Be the most helpful student in the class ----------------------- M L
Be the best science student in the class ----------------------- M L

31. Do experiments with electricity ------------------------------ M L
Run a printing press --- M L
Raise fine dogs -- M L

32. Repair automobiles --- M L
Design buildings --- M L
Do research on travel through space ---------------------------- M L

33. Paint pictures of people ------------------------------------- M L
Do research on earthquakes ------------------------------------- M L
Build bridges -- M L

APPENDIX D

Investigators Instrument

Name ______________________________

Your responses to the following items are essential to a doctoral curriculum study being conducted relative to such items. You were chosen to participate by random selection from a larger population of students whose science scores on the ninth-grade Iowa Tests of Educational Development were above the 75th percentile. Your sincere cooperation will be very much appreciated. Please circle the letter which best fits the way you feel about each statement.

I. At the present time I am considering enrolling in science in college to the extent of:
   a. No more science than will be required
   b. A few selected courses
   c. A major in science

II. At the present time I am considering to some degree an occupation which
   a. Is not concerned with science
   b. Is associated with science (teaching science, nurse, etc.)
   c. Is dedicated to science research

III. In view of my college plans and possible career, I consider the quality of my high school science experience (9-12) as -
   a. Less than adequate
   b. Just adequate
   c. More than adequate

IV. In view of my college plans and possible career, I consider the quantity of the science courses I have taken (9-12) to be -
   a. Less than necessary
   b. About what is necessary
   c. More than necessary

V. Relative to my total high school science experience, I believe that my ninth-grade science course should have -
   a. Introduced more of several sciences
   b. Done about what it did
   c. Gone more in depth into a single science
   d. I did not take a ninth-grade science course

VI. To the extent that my ninth-grade science prepared me for the laboratory work in the senior high school, I would say that my ninth-grade science course was -
   a. Less than adequate
   b. Just adequate
   c. More than adequate
   d. I did not take a ninth-grade science course

APPENDIX E

Tables

TABLE XXVI

TOTAL SCIENCE COURSES TAKEN BY STUDENTS
IN NINTH-GRADE SCIENCE GROUPS

Biology		General Science		Laboratory Science		No Science	
1	2	2	3	1	3	1	1
1	2.5	2	3	1	3	1	1
1	2.5	2	3	1	3	1	1
1	2.5	2	3	1	3	1	1
1	3	2	3	1	3	1	2
1	3	2	3	1	3	1	2
1	3	2	3	2	3	1	2
1	3	2	3	2	3	1	2
1	3	2	3	2	3	1	2
1	3	2	3	2	4	1	2
1	3	2	3	2	4	1	2
1	3	2	4	2	4	1	2
1	3	2	4	2	4	1	2
1	3	2	4	2	4	1	2
1	3	2	4	2	4	1	2
1	3	2	4	2	4	1	2
2	3	2	4	2	4	1	2
2	3	2	4	3	4	1	2
2	3.5	2	4	3	4	1	2
2	4	2	4	3	4	1	2
2	4	2	4	3	4	1	3
2	4	3	4	3	4	1	3
2	4	3	4	3	4.5	1	3
2	4	3	4	3	5.5	1	3
2	4	3	4	3	6	1	3
	115.0		143.0		147.0		76.0
Mean = 2.30		Mean = 2.86		Mean = 2.94		Mean = 1.52	

TABLE XXVII

PRETEST AND POSTTEST ITED SCIENCE SCORES

Biology				General Science				Laboratory Science				No Science			
Pretest X		Posttest Y		Pretest X		Posttest Y		Pretest X		Posttest Y		Pretest X		Posttest Y	
14	18	12	38	17	19	18	22	18	14	24	22	16	18	25	21
26	16	16	19	14	16	13	10	17	25	24	26	17	14	27	19
16	14	18	14	18	17	17	28	14	17	17	21	16	17	23	22
16	19	17	28	16	27	18	27	17	14	17	23	18	17	21	17
15	18	19	18	17	17	24	19	23	18	26	24	24	14	23	25
20	19	26	18	19	22	19	26	25	18	25	23	18	17	18	23
18	24	17	27	17	14	26	27	20	15	18	25	15	16	16	20
21	17	23	15	16	18	17	26	25	18	27	23	17	14	17	15
18	21	25	28	14	14	23	23	25	17	21	21	17	17	15	22
16	17	15	17	17	18	22	24	15	22	21	23	16	16	26	25
19	23	19	28	16	14	15	18	17	18	26	25	18	24	26	15
19	25	27	28	17	16	17	21	15	18	20	27	16	19	14	20
17	16	20	12	14	16	17	22	19	25	27	28	17	16	23	22
20	16	22	18	24	16	14	21	22	17	28	25	23	22	23	23
17	25	20	27	14	17	13	27	19	16	28	18	15	15	13	23
14	17	15	16	14	16	14	21	17	24	31	23	18	23	21	30
23	19	26	27	14	18	23	19	24	18	30	23	17	22	14	29
14	27	20	29	14	16	14	19	19	22	2;	26	14	25	12	26
17	16	28	25	14	26	17	31	21	28	31	31	17	14	19	13
16	25	15	21	14	14	17	16	16	25	28	23	18	20	23	26
17	14	18	26	14	22	19	17	21	25	30	27	15	18	22	26
14	22	14	30	14	19	20	25	19	20	19	26	14	18	17	18
17	18	23	16	19	16	23	22	22	21	19	26	17	16	29	26
24	18	31	15	15	17	20	23	23	25	26	30	31	14	26	15
18	23	27	28	22	18	31	27	24	21	30	28	21	16	18	23

Biology	General Science	Laboratory Science	No Science
$\Sigma X = 993$	$\Sigma X = 838$	$\Sigma X = 997$	$\Sigma X = 867$
$\Sigma X^2 = 18{,}019$	$\Sigma X^2 = 14{,}472$	$\Sigma X^2 = 20{,}551$	$\Sigma X^2 = 68{,}445$
$\Sigma Y = 1071$	$\Sigma Y = 1032$	$\Sigma Y = 1231$	$\Sigma Y = 1055$
$\Sigma Y^2 = 24{,}443$	$\Sigma Y^2 = 22{,}434$	$\Sigma Y^2 = 31{,}019$	$\Sigma Y^2 = 23{,}329$
$\Sigma XY = 20{,}549$	$\Sigma XY = 17{,}680$	$\Sigma XY = 24{,}864$	$\Sigma XY = 18{,}605$
$M_x = 18.66$	$M_x = 16.76$	$M_x = 19.94$	$M_x = 17.34$
$M_y = 21.42$	$M_y = 20.64$	$M_y = 24.62$	$M_y = 21.10$

TABLE XXVIII

CALCULATION OF SUMS OF SQUARES IN COVARIANCE ANALYSIS OF ACHIEVEMENT RELATIVE TO NINTH-GRADE SCIENCE

Total Residuals	Within Residuals
$\Sigma y^2 = Y^2 - (\Sigma Y)^2/N$ $= 101,225 - 19,263,321/200$ $= 101,225 - 96,316.61$ $= 4,908.39$	$\Sigma y^2 = \Sigma Y^2 - \left[\frac{(\Sigma Y_1)^2}{n_1} + \frac{(\Sigma Y_2)^2}{n_2} + \frac{(\Sigma Y_3)^2}{n_3} + \frac{(\Sigma Y_4)^2}{n_4}\right]$ $= 101,225 - 96,809.02$ $= 4,415.98$
$\Sigma x^2 = 68,455 - 13,213,225/300$ $= 68,455 - 66,066.125$ $= 2,338.875$	$\Sigma x^2 = 68,455 - 66,368.62$ $= 2,086.38$
$\Sigma xy = \Sigma XY - (\Sigma X)(\Sigma Y)/N$ $= 81,698 - (3635)(4389)/200$ $= 81,698 - 79,770.075$ $= 1,927.925$	$\Sigma xy = \Sigma XY - \frac{(\Sigma X)_1 (\Sigma Y)_1}{n_1} \ldots$ $= 81,698 - 80,121.02$ $= 1,576.98$
$SS = \Sigma y^2 - (\Sigma xy)^2/\Sigma x^2$ $= 4,908.39 - \frac{(1,927.925)^2}{2,388.875}$ $= 3,352.472$	$SS = \Sigma y^2 - (\Sigma xy)^2/\Sigma x2$ $= 4,415.98 - \frac{(1,576.98)}{2,086.38}$ $= 3,224,028$

TABLE XXIX

CALCULATION OF SUMS OF SQUARES IN COVARIANCE ANALYSIS OF ACHIEVEMENT RELATIVE TO THE NUMBER OF SCIENCE COURSES

Total Residuals	Within Residuals
$\Sigma y^2 = 101,225 - (4389)^2/200$ $= 4,908.39$	$\Sigma y^2 = 101,225 - 96,633.881$ $= 4,591.119$
$\Sigma x^2 = 68,445 - (3635)^2/200$ $= 2,388.875$	$\Sigma x^2 = 68,455 - 67,157.534$ $= 1,297.466$
$\Sigma xy = 81,698 - (4389)(3635)/200$ $= 1,927.925$	$\Sigma xy = 81,698 - 79,952.939$ $= 1,745.061$
$SS = 4,908.39 - 1,555.918$ $= 3,352.472$	$SS = 4,591.119 - 2,347.065$ $= 2,244.054$

TABLE XXX

PRETEST AND POSTTEST ITED SCIENCE SCORES

One Credit				Two Credits				Three Credits				Four Credits			
Pretest X		Posttest Y		Pretest X		Posttest Y		Pretest X		Posttest Y		Pretest X		Posttest Y	
14	16	12	26	23	14	26	17	16	22	19	26	16	19	25	25
26	18	16	26	14	14	20	19	14	14	14	26	25	16	21	22
16	16	18	14	17	14	28	25	19	18	28	26	14	17	26	23
16	17	17	23	16	17	25	23	18	24	18	23	22	22	30	23
15	23	19	23	17	16	18	20	19	18	18	24	18	18	16	25
20	15	26	13	14	14	14	15	24	18	26	26	18	18	25	27
18	18	17	21	17	17	23	22	17	18	25	18	23	25	28	28
21	17	23	14	24	16	31	25	31	16	28	26	14	17	18	25
18	14	25	12	18	14	27	15	17	14	17	15	16	16	21	18
16	17	15	19	18	19	28	20	23	16	28	23	16	24	22	23
19	18	19	23	17	16	18	22	25	19	28	21	16	18	21	23
19	15	27	22	14	22	13	23	16	21	12	31	17	22	27	26
17	14	20	17	18	15	17	23	16	16	18	28	16	28	21	31
20	17	22	29	16	23	18	30	25	31	27	30	18	25	19	23
17	21	20	26	17	22	24	29	17	19	16	19	16	25	19	27
14	21	25	18	19	25	19	26	19	22	27	19	26	20	31	26
16	18	25	21	17	14	26	13	27	23	29	26	15	21	16	26
17	14	27	19	16	20	17	26	14	24	20	30	22	25	17	30
16	17	23	22	14	20	23	18	19	14	23	22		21		28
18	17	21	17	17	25	22	27	15	25	20	26				
24	18	23	24	16	25	15	21	22	17	31	21				
18	17	18	24	17	15	17	21	19	14	22	23				
15	14	16	17	14	17	17	26	16	18	10	24				
17	17	17	17	14	14	14	20	17	18	28	23				
17	23	15	26	14	19	13	27	27	15	27	25				
	25		25	14	22	14	28	18	18	27	23				
				14	19	23	28	17	17	19	21				
				14	17	14	31								
				14	24	17	30								

One Credit	Two Credits	Three Credits	Four Credits
$\Sigma X = 3901$	$\Sigma X = 1003$	$\Sigma X = 1006$	$\Sigma X = 725$
$\Sigma X^2 = 16,321$	$\Sigma X^2 = 17,991$	$\Sigma X^2 = 19,398$	$\Sigma X^2 = 14,745$
$\Sigma Y = 1034$	$\Sigma Y = 1241$	$\Sigma Y = 1242$	$\Sigma Y = 872$
$\Sigma Y^2 = 21,930$	$\Sigma Y^2 = 28,143$	$\Sigma Y^2 = 29,914$	$\Sigma Y^2 = 21,238$
$\Sigma XY = 18,523$	$\Sigma XY = 22,106$	$\Sigma XY = 23,648$	$\Sigma XY = 17,421$
MX = 17.666	MX = 17.293	MX = 18.629	MX = 19.594
MY = 20.274	MY = 21.396	MY = 23.000	MY = 23.567

TABLE XXXI
KUDER INTEREST SCORES RANKED

Biology	General Science	Laboratory Science	No Science
18-5	14-2	18-5	13-1
23-12	18-5	27-22.5	18-5
24-15	18-5	29-27.5	19-8
25-16.5	21-10	30-31.5	20-9
25-16.5	23-12	32-46.5	23-12
25-16.5	26-19.5	32-46.5	25-16.5
26-19.5	27-22.5	32-46.5	38-25.5
27-22.5	27-22.5	33-51	29-27.5
30-31.5	28-25.5	35-60	30-31.5
30-31.5	31-39	35-60	30-31.5
32-46.5	31-39	35-60	30-31.5
34-54.5	31-39	36-68	31-39
36-68	33-51	36-68	31-39
37-75	33-51	38-81.5	31-39
38-81.5	34-54.5	38-81.5	31-39
39-89	35-60	40-96.5	32-46.5
39-89	35-60	40-96.5	32-46.5
39-89	36-68	40-96.5	34-54.5
39-89	36-68	41-103.5	34-54.5
39-89	36-68	41-103.5	35-60
40-96.5	37-75	42-111	36-68
41-103.5	37-75	42-111	36-68
42-111	38-81.5	43-116.5	37-75
42-111	39-89	45-126	37-75
44-121	39-89	46-131.5	38-81.5
44-121	40-96.5	46-131.5	38-81.5
44-121	40-96.5	46-131.5	38-81.5
44-121	40-96.5	47-139.5	38-81.5
46-131.5	41-103.5	48-150	40-96.5
46-131.5	41-103.5	48-150	41-103.5
47-139.5	42-111	49-159	42-111
47-139.5	42-111	49-159	42-111
47-139.5	44-121	50-164	42-111
47-139.5	45-126	50-164	43-116.5
48-150	45-126	50-164	44-121
48-150	46-131.5	51-169.5	44-121
48-150	46-131.5	51-169.5	46-131.5
48-150	47-139.5	52-175	57-139.5
49-159	47-139.5	52-175	48-150
49-159	48-150	52-175	48-150
51-169.5	48-150	52-175	48-150
53-180	48-150	55-189.5	50-164
42-180	48-150	55-189.5	50-164
53-180	49-159	56-193	51-169.5
54-185.5	51-169.5	56-193	51-169.5
54-185.5	53-180	56-193	52-175
54-185.5	54-185.5	56-193	53-180
56-193	58-199	57-197	54-185.5
57-197	60-200	57-197	54-185.5
35-60	31-39	36-68	31-39

TABLE XXXII

KUDER INTEREST SCORES RANKED BY CREDITS

One Credit	Two Credits	Three Credits	Four Credits
13-1	14-2	18-5	27-22.5
18-5	18-5	23-12	31-39
18-5	18-5	29-27.5	32-46.5
19-8	31-10	31-39	34-54.5
20-9	23-12	31-39	36-68
23-12	26-19.5	31-39	36-68
24-14	27-22.5	32-46.5	38-81.5
25-16.5	27-22.5	32-46.5	39-89
25-16.5	28-25.5	32-46.5	40-96.5
25-16.5	30-31.5	33-51	42-111
25-16.5	30-31.5	34-54.5	43-116.5
36-19.5	31-39	35-60	44-121
27-22.5	31-39	35-60	44-121
28-25.5	31-39	36-68	45-126
29-27.5	31-39	36-68	45-126
30-31.5	32-46.5	38-81.5	45-126
30-31.5	33-51	39-89	47-139.5
30-31.5	33-51	39-89	47-139.5
30-31.5	35-60	39-89	48-150
31-39	35-60	40-96.5	48-150
32-46.5	35-60	40-96.5	49-159
34-54.5	36-68	41-103.5	49-159
34-54.5	36-68	42-111	49-159
35-60	36-68	42-111	51-169.5
35-60	37-75	42-111	51-169.5
36-68	37-75	42-111	52-175
36-68	37-75	43-116.5	52-175
37-75	38-81.5	44-121	52-175
37-75	39-89	44-121	53-180
38-81.5	39-89	46-131.5	53-180
38-81.5	40-96.5	46-131.5	54-185.5
38-81.5	40-96.5	46-131.5	55-189.5
38-81.5	40-96.5	46-131.5	56-193
38-81.5	41-103.5	47-139.5	57-197
39-89	42-111	47-139.5	57-197

(continued next page)

40-96.5	42-111	47-139.5	58-199
40-96.5	42-111	47-139.5	60-200
41-103.5	42-111	48-150	
41-103.5	46-131.5	48-150	
41-103.5	46-131.5	48-150	
41-103.5	46-131.5	49-159	
44-121	47-139.5	50-164	
44-121	48-150	50-164	
44-121	48-150	51-169.5	
46-131.5	48-150	51-169.5	
47-139.5	48-150	52-175	
48-150	48-150	53-180	
48-150	49-159	54-185.5	
48-150	50-164	54-185.5	
53-180	50-164	54-185.5	
56-193	50-164	56-193	
	51-169.5	56-193	
	51-169.5	56-193	
	52-175	57-197	
	53-181		
	54-185.5		
	54-185.5		
	55-189.5		
3,502.0	5,387.5	6,157.5	5,054.0
$n_1 = 51$	$n_2 = 58$	$n_3 = 54$	$n_4 = 37$

VITA

David Stanley McElhiney

Candidate for the Degree of
Doctor of Education

Thesis: An Evaluation of Ninth-Grade Science for the Academically Talented.

Major Field: Educational Administration

Biographical:

Personal Data: Born at Ashland, Kansas, August 3, 1926, the son of Percy E. and Grace McElhiney.

Education: Received the Bachelor of Science degree from Northwestern State College, Alva, Oklahoma, with a major in Chemistry in May, 1949; received the Master of Education degree from Phillips University in May 1954, with a major in administration; received the Master of Science degree from Oklahoma State University in May, 1958, with a major in natural science; pursued graduate work in science and education at Oklahoma University, Norman, Oklahoma, Emporia State College, Emporia, Kansas, and Wichita State University, Wichita, Kansas; and completed the requirements for the Doctor of Education Degree at Oklahoma State University, in August, 1965.

Professional Experiences: Served as radioman with the U. S. Navy from 1944 to 1946; as teacher of mathematics and science at Gage School, Gage, Oklahoma, 1949-1950; as teacher of mathematics and science at Mooreland High School, Mooreland, Oklahoma, 1950-1951; as principal of Mooreland Grade School, Mooreland, Oklahoma, 1951-1955; as principal of Mooreland High School, Mooreland, Oklahoma, 1955-1957; as participant in a National Science Foundation Academic Year Institute at Oklahoma State University, Stillwater, Oklahoma, 1957-1958; as chemistry teacher at Wichita High School Southeast, Wichita, Kansas, 1958-1960; as assistant principal of Truesdell Junior High School, Wichita, Kansas, 1960-1962; as principal of Allison Junior High School, Wichita, Kansas, 1962-1964; and as graduate research and teaching assistant at Oklahoma State University from 1964-1965.

Professional Organizations: Member of Wichita City Teachers Association; Kansas State Teachers Association; National Education Association; Kansas Association of Secondary School Principals; National Association of Secondary School Principals; and Phi Delta Kappa.