A STUDY OF THE DISCOVERY AND DEVELOPMENT OF SCIENCE TALENT IN SECONDARY SCHOOL PUPILS

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TABLE OF CONTENTS

INTRODUCTION

The best teachers are interested in helping the students in their classes develop to the limit of their potentialities. Most of these students have average or below average abilities, but there are a few in each group who are above average or superior and have potential as specialists in the field of mathematics and science. There are definite needs in these fields for the superior students. Neglect of these talented students means a potential loss in manpower which is a serious loss to the development of science in this country.

To help these students realize their total abilities is also furthering the overall objectives of secondary school education. Secondary school education is dedicated to the philosophy of guiding each pupil to develop to his fullest capacity.

The problem of identifying the talented student and helping him realize his potential has been one which concerns many science teachers. Through tests, observation, and cumulative records, these talented students may be identified. After identification, ways of improving instruction in science and concrete ideas on methods of helping these students are needed.

The purpose of this report is to present to the secondary school science teacher, methods of identifying and developing the potential of the student talented in mathematics and science. It is recognized that the physical facilities of the school, the initiative and leadership of the administration, and the cooperation of qualified teachers are factors necessary for the success of any program designed to help the talented student. However, these factors will not be discussed because of the necessary limitations in scope of this report. The material for this report was obtained by a review of the available related literature and the experience and thinking of the writer.

A REVIEW OF SCIENCE TEACHING OBJECTIVES IN SECONDARY SCHOOLS

The position of science in the secondary schools has undergone a change since science curriculums were developed. The first science was presented for facts needed by those pupils going into professional fields. The objectives were stated as to provide primarily a type of experience which would help students in their personal and social problems.

A review of science teaching revealed how the transition of these science teaching objectives occurred. There appeared to be no record of any science offerings in the curriculums of the Latin grammar schools which were the first formal education systems in the United States (Heiss et al., 14). These schools declined in numbers and importance within a hundred years because they failed to meet the needs of the times. The curriculums were limited and extremely narrow.

The Latin grammar schools were gradually replaced by the Academies which began about 1750 and became the dominant type of secondary education until 1850 (14). They had a broader type of curriculum than the Latin grammar schools and were intended to meet the needs of boys and girls not going to college. Science education in America began in the Academies when natural philosophy, forerunner of physics, was included in the curriculum (14).

The establishment of the English High School in Boston in 1821 started the development of the free public high school. The science offerings in these early high schools consisted of natural philosophy, natural history, and chemistry (14). The growth of the high school movement was steady but slow until the beginning of the 20th century. Since then high schools have grown rapidly in numbers, population, and breadth of curriculum.

The science education in the early academies and high schools was taught primarily for the practical and informational value (14). There was little laboratory or demonstration work and great emphasis was placed on the memorization of factual material. The courses were popular and taken by many who were not going on to college. Most of the teaching was done by the lecture and recitation methods.

Natural philosophy consisted of material selected from fields of physics, astronomy, and earth science (14). The textbooks on natural science indicated that the authors were interested primarily in acquainting the student with the practical aspects of science. It was largely descriptive with very little laboratory work.

Botany and zoology constituted the natural history offered in these high schools. They were separate courses with little effort to integrate them as is common in the present day biology courses. The emphasis was on the learning of facts.

Chemistry was offered as an elective. Some high schools offered it while others did not. There was little or no laboratory work done by the students prior to 1860 since many schools had difficulty in getting apparatus and chemicals.

Between 1821, when the public high schools were originated and 1872, when the college domination period began, there was little change in the science courses offered (14). In 1872 Harvard College announced that physics and other high school science would be accepted for college entrance. Other colleges soon followed Harvard's lead. The science textbooks for high schools were written by college teachers and the courses became just simplified and condensed college courses having little value beyond that of meeting college entrance requirements. One of the standards which the colleges set up for the high school to meet was a list of 46 acceptable experiments in physics called the Descriptive List. The colleges condemned the short courses in high school and proposed a four year sequence of science courses. For the first year, physical geography; second year, biology; third year, physics; and the fourth year, chemistry (14).

This college domination had a narrowing influence which was extended well down into the present century (14). It tended to stop individual teachers from using initiative. The use of syllabi limited the field of each subject studied and the application of the subject to the locale in which the subject was taught. There was also an overemphasis on subject matter and a consequent undervaluation of the science method of study. Some present day textbooks still emphasize this viewpoint.

There were some beneficial results from the college domination of high school sciences. The Descriptive List appeared at the psychological moment when the demand for object teaching reached its full force (14). The influence of the List was to exalt this demand into a requirement of quantitative laboratory work. Teachers and school boards learned how a laboratory method of teaching could be used in physics with the use of material at hand and a small outlay for equipment. From this beginning, laboratories were developed for the teaching of chemistry and natural philosophy as well as physics. Another beneficial result was the requirement of a college degree for high school teachers.

Since the period of college domination which lessened in 1900 the high schools have experienced a great deal of expansion and readjustment. The enrollment in the high schools had increased rapidly and with this increase there had been a demand that the curriculum meet the needs of the students. One of the most significant changes to meet these needs was the introduction of general science to replace physical geography as the first year science subject. This change was an attempt to meet the need for a terminal course in science for those students not going on to college.

Several attempts were made by different committees and commissions to determine and state the objectives and place of science in the high school. Each report advanced the idea of teaching science from a practical viewpoint. In 1947 the National Society for the Study of Education published its Forty-sixth Yearbook entitled "Science Education in American Schools" (14). This report stressed the importance of science taught for its functional value in aiding the adjustment of individuals. It recognized and endorsed the present science sequence through the elementary and high schools. It urged support for the growing tendency to offer physical science in the high school for those pupils not going farther in the study of science.

Today's objectives of teaching science are not greatly different from early objectives but there has been a change in emphasis (Hurd, 18). In 1953 the trends reported showed that science then was regarded as a way of life and a philosophy of living rather than exclusively a study of methods. Science teaching should be directed more toward human betterment not only materialistically but culturally.

The main objectives of science teaching over a 50 year period have been to train students in the scientific method of thinking, to develop certain scientific attitudes within students, to acquire a fund of useful information, and to develop an understanding of the major principles of science (Hurd, 19). In the last 20 years a change in these objectives has occurred. The first two have remained much the same, the last two have declined in importance, and two other objectives have been added. They are to enrich the leisure hours of the students and develop an appreciation for science and its achievements; and to offer opportunities to explore the vocational aspects of the different science fields.

The purpose of preparing students for college is declining in interest and emphasis. One reason for this change is that facts are retained a very short time but the application of the principles of science, habits of critical thinking, and skills in problem solving are retained longer. The overall objective of science teaching in today's schools is to develop the potential individual in whatever field his interest and ability may be suited (Mallinson and Buch, 26).

RECOGNITION OF NEED FOR CONSERVATION OF THE TALENTED STUDENT

The objectives of science teaching covered the total population of secondary school youth but there had not been an emphasis on developing the talented student.

Every individual is entitled to his just share of attention and effort directed toward developing his maximal potentialities. It would be unrealistic to insist that equal opportunities must always take the form of identical experiences (Hildreth et al., 16). Equal opportunity should be interpreted as equivalent opportunity in terms of the child's needs and capacities.

It had been recognized that the sub-normals needed special attention but most schools and educators had failed to adapt instruction to the child who was above average or superior (Curtis, 10). One reason for this neglect was the failure to recognize the need for helping the bright student as a major problem. It was believed by educators and communities that such students would get along all right without special attention from the teacher or the school. A second reason was the difficulty that the teacher encountered in trying to devise instructional materials and procedures which would aid in encouraging the development of the potentialities of pupils whose intellectual level was above that of the teacher. Other reasons for the neglect of the talented in schools were the feeling of distrust of anything not understood and therefore ignored, and that strange American desire to be as much like the average person as possible (Barbe, 4). People did not like to be recognized as different.

The neglect of the talented youth had two serious effects. It deprived the student with exceptional ability of the opportunity to develop the best of which he was capable. A person working at a level lower than he is capable of doing is not a happy, well adjusted person.

The second effect of this neglect of the talented represented a loss of manpower and leadership which this country could not afford (Hildreth et al., 16). The talented children of today become the leaders and outstanding thinkers of tomorrow, provided favorable circumstances permit them to obtain the necessary stimulation and training to develop their powers. The potentialities of talented children and youth in schools should be regarded as the most valuable human resource this country has. Talented individuals are the future discoverers who will contribute most to building a better world.

Much of the literature sounded a plea for scientific talent (Astin, 2). One of the most striking and important indications of the acuteness of the current shortage in scientific manpower and its importance to the national welfare was a recent policy statement of the Office of Defense Mobilization. This policy statement emphasized the importance of scientists and engineers in the establishment of the strongest possible defense. Should war come, it was well established and widely recognized that the scientist and the engineer were indispensible to ultimate victory. Furthermore, there was no limit in principle to the advances which can be made in science and technology. The practical limits were imposed largely by the limited number of individuals with training and ability along these lines. The problem then was to formulate national policies and to take actions consistent with these policies and with principles of a voluntary manpower program. This should be done in order to guarantee the most effective use of existing resources of scientific and technical personnel and to encourage the training of increasing numbers of additional scientists and engineers.

The need for scientists and engineers is not a temporary crisis. Students electing to make a career in science have before them a minimum of four years, and in some instances eight to ten years of intensive educational training before they become productive scientists. The need for scientists is an expanding one and is not dependent solely on wartime or preparedness (Astin, 2). Science by its very nature is an expanding phenomenon. Almost every discovery made of advancement in science has opened up new fields for exploration and need for more specialists trained in these new fields. New advances in technology often offered opportunities for new development of tools, instruments, new materials, and devices which in turn accelerated the discovery process itself. There was a regenerative feedback effect between science and technology.

There seemed to be ample reason to believe that there was a large supply of individuals capable of contributing to the field of science and engineering who were not doing so. At the time of this study there were many students in the educational systems whose capabilities in scientific fields were not being recognized and encouraged. One report said that a little more than 200,000 young persons who ranked in the highest one-fourth of their age group failed to go to college (Flynt, 11). Another stated that less than one-half of those capable of going to college went, and only one-third graduated from college (Chauncey, 9). Still another report said that only 40 percent of the high school graduates of college ability were granted a degree (Brown and Johnson, 7). The Educational Policies Commission said that 10 percent of 6,000,000 boys and girls in high school have "I.Q.s" of better than 120 but that only half of the gifted youth who are graduated from secondary school go on to college (Meister, 27). Wolfle reported the following significant information (Wolfle, 39). For high school graduates who had intelligence in the top 20 percent and grades in the top 40 percent of their class, only 47 percent graduated from college. This left a total of 106,000 students in this ability group not graduating. To proceed further, of those high school graduates with intelligence in the top 8 percent and grades in the top 40 percent, only 54 percent graduated from college, leaving 40,000 not graduating. Of those students with intelligence in the top 2 percent and grades in the top 20 percent, only 62 percent graduated, leaving 9,000 of the nation's best science prospects not graduating.

Wolfle (39) also reported that the reasons those students who possessed adequate ability as measured by standardized tests of academic aptitude and satisfactory previous school work did not attend college were lack of motivation by school and influence by home environment. Financial problems were also listed as a reason for non-attendance in college, but this was believed not to be of paramount importance. Other variables that influenced attendance were sex, cultural background, geographic location, ethnic, and religious background.

IDENTIFICATION OF THE TALENTED

It was mentioned that the first systematic plan for identifying and guiding the gifted child was by Plato 2350 years ago (Morgan, 28). He suggested that the state identify those gifted individuals by academic and situational tests given in early childhood. He suggested the selection be for both sexes. His plan was never put into effect. Since that early time, identification has been largely by academic achievement. In England, situation tests which detected qualities of leadership were used. Within the last 30 years the United States has been outstanding for research concerning the gifted. One of the most significant pieces of work had been by Terman (35). His report stated that children of I.Q. of 140 or higher were appreciably superior to unselected children in physique, health, and social adjustment; markedly superior in moral attitudes as measured either by character tests or by trait ratings; and vastly superior in their mastery of school subjects as shown by a three-hour battery of achievement tests. Their achievement in all different subjects refuted completely the traditional belief that gifted children are usually one-sided.

The follow-up studies of the gifted children studied proved that tests of general intelligence given as early as six, eight, or ten years, told a great deal about their ability to achieve success immediately or later in the future. Tests did not predict what personality factors or what accidents of fortune would affect the fulfillment of exceptional ability. To achieve greatly in any field would take a lot of the kind of general intelligence that required ability to engage in abstract thinking. Other important factors that determine the level of achievement were the quality of the school's intellectual climate; the proportion of able and inspiring teachers; and the amount of conscious effort that was made not only to discover, but to motivate the talented student.

It was recognized that in order to help gifted youth to develop their best potentialities for their own sake and for the security and advancement of civilization, early identification of their talents and adequate provisions for its development must be made. Early identification is extremely important. Once a talented youth had missed the early years of training and opportunities for development it was almost impossible for him to learn these omitted techniques.

In a study done at Hunter College on superior and gifted children, it was stated that the I.Q. of the superior child could be arbitrarily set at 120 or above and the gifted child or very superior at 130 or above (Hildreth et al., 16). These I.Q.s were based on scores from the Stanford-Binet I.Q. test, 1937 revision.

The talented students have been defined as those who were in the upper 20 percent of the students of their age group in general intelligence and who were adept in science and mathematics (Brown and Johnson, 7). The talented children as referred to in this report were those defined as the upper 20 percent of the students.

Formal Methods of Identifying the Talented Student

The methods of identifying the student with potential in mathematics and science were classified under two general headings (Brown and Johnson, 7). The formal method was the giving and interpretation of appropriate tests. The informal method involved teachers' opinions and the study of cumulative records.

Aptitude and Achievement Tests. A good comprehensive battery of tests given to students could do much to identify talented students and assign them into workable and recognizable groups with potential in science (7). One big advantage of standardized tests was that they enabled the teacher to determine if the student was superior as compared to national norms as well as superior in comparison to his classmates.

To be most effective as a guidance instrument, the tests should measure depth as well as breadth in understanding and knowledge. Although tests which measure memory and the recalling of certain facts have some value, it would be much more desirable to use tests which require reasoning in solving problems.

The testing of different areas of abilities was important as there would be no single ability that would determine whether a student was potential material for science training. One factor, however, which stood out in predicting aptitude and success in science was quantitative reasoning. The next most important factor in identifying the superior students in mathematics and science was verbal comprehension. Unless the student could read satisfactorily he had small chance of succeeding as a scientist. This need not be an eliminating factor if the deficiency were detected in time to be remedied.

Other factors which proved helpful in detecting superior ability in science were mechanical reasoning, abstract reasoning, and spatial visualization. These abilities were essential to success in many courses required in college curriculums.

The measurement of any one single ability would not determine the potential scientist. It would be possible to have a student high in verbal ability and low in quantitative reasoning or one who would be able to comprehend mathematics but who would be low in verbal comprehension. Generally a student high in reasoning ability would be high in verbal comprehension.

A test which would give a measurement of both quantitative reasoning and verbal comprehension was preferred over a test which gave just single measurement of I.Q. Three tests which have been accepted for measuring these abilities will be discussed. This does not mean that others were not of equal or even superior merit. These three have been selected because they were widely used and had been successful.

The Iowa Tests of Educational Development were a compromise of aptitude and achievement measurements (Buros, 8 and Froelich and Benson, 12). They were designed for grades nine to thirteen, but were a little too difficult for 9th graders. There were nine sub-tests which included "Background in the Natural Sciences," "Ability to Do Quantitative Thinking," and "Ability to Interpret Reading Materials in the Natural Sciences." These tests covered physics and biology better than chemistry. They contained some geology and astronomy. The tests called for thinking rather than strictly memory. A minimum of three half-days were required to give the tests. The cost was about 75 cents per pupil. The tests were not especially good for profile interpretation but gave the percentile ranks by half-years.

The Cooperative General Achievement Tests were designed for grades ten to twelve and for college entrance (8, 12). The tests cover the three fields of natural science, mathematics, and social studies. They were intended to measure proficiency rather than test mastery of specific course content. The length of each test was 40 minutes which was subdivided. Fifteen minutes were allowed for knowledge of items and concepts, and 25 minutes for comprehension and interpretation. These tests were particularly helpful where the academic background of the students was widely divergent or when a long period of time had elapsed since the student had studied in the fields involved. The tests were valuable to the classroom teacher in estimating the individual growth of the student in his ability to use scientific method and particularly those aspects of the scientific method related to the drawing of inferences and conclusions. The price of the complete battery was approximately 40 cents per pupil.

The Differential Aptitude Tests were designed for grades eight to twelve (8). These tests are adapted for an earlier age group than the tests previously mentioned. These tests stressed several abilities rather than a single ability and were power tests rather than speed tests. They were good for predicting educational and vocational success. The sub-tests included verbal reasoning, numerical ability, abstract reasoning, spatial relations, mechanical reasoning, clerical speed and accuracy, and language usage. The cost of the complete set was approximately 80 cents per pupil including the answer sheet.

Interest Tests. Interests would be of secondary importance in identifying the talented in mathematics and science (Brown and Johnson, 7). The results of these tests alone cannot be used to predict the talented. All students interested in the areas of mathematics and science may not have the ability to succeed in these fields. Interests may be "faked" or unstable in adolescents. The pattern of interest that a test discloses would be more important than the score on any particular occupation. According to one report, interest tests should be given three times; in the sixth or seventh grades, the ninth grade, and again in the eleventh or twelfth grade (Roberts, 31).

One of the best tests available was the Kuder Preference Record (8, 12). This test was easy to administer. It required one hour to give and the scoring time was five minutes. The interpretation of results was not difficult. It yielded scores for nine areas of interests: mechanical, computational, scientific, persuasive, artistic, literary, musical, social service, and clerical. The pupil indicated which of three activities he liked the most and which he liked the least. The booklets which were reusable were 35 cents each. The answer sheet and profile sheet added approximately 45 cents more.

The Brainard Occupation Reference Inventory yielded scores in 28 occupational sections which combined to indicate interests in seven fields (8, 12). It was suitable for high school and above. It was self-administered and self-scored. The cost was comparable to the Kuder test.

Another test that was widely used was the Strong Vocational Interests Blank (8, 12). These tests were designed to reveal the extent to which a student's interests agreed with those of persons engaged in certain occupations. It was not suitable for pupils under 17 years of age. The cost compared with the other two tests mentioned.

The interest inventories were misused if utilized for exploring the occupational motivation only (Roberts, 31). The tests were useful to the students for discovering avocational pursuits and hobbies and for determining the student's major course selection. The tests were useful to the teacher in selecting the type of classroom activity suitable for the students as revealed by scores on the tests.

Informal Methods of Identifying the Talented Student

It was obvious that the students who ranked high with an I.Q.

of 120 or above and showed favorable inclination in aptitude offered wonderful potentialities in the fields of science and mathematics. But these students were not common. Klinge (23) believed that there were superior science students who rank lower than this. Students with I.Q.s of 110 to 120 often show greater interest and ability than those in the group above 120. The verbal emphasis on tests may not identify these students. Klinge had found teachers' recommendations to be highly satisfactory. A student was rated superior when he responded favorably to an enriched program and thus was identified to the teacher and to himself. No matter what the I.Q. of a student was, if he did not respond to extra help, he was not a potential scientist. In this respect the teacher was the best judge of potentialities.

There was no doubt that the teachers' opinions were of value in identifying the talented students in mathematics and science (Brown and Johnson, 7). However, their opinions may be often inaccurate. They may be influenced by student friendliness, obedience, and attractiveness. Completing routine assignments perfectly may be mistaken as a sign of high potential in science or mathematics. Creativeness of the student and conformity to inflexible regulations would be hard to reconcile. Special interests of superior students may even hinder achievement in unchallenging school subjects. Investigators have reported that attempts of teachers to identify the future leaders in science were correct in only 15 cases in 100. This would not mean that teachers' opinions were of no value or that they could not be improved. Teachers could improve their judgment by observing many informal criteria that indicated aptness in mathematics and science (Jones, 22). Keeping record of their predictions and, after the student has left high school, checking the predictions with his achievement, would be helpful in improving predictive techniques. If the records indicated in detail the criteria used in making predictions, they would be valuable to other teachers.

It had been found that when gifted pupils were compared with other children the mentally gifted also tended to be superior in physical, social, emotional, and moral qualities (Oliver, 29; Terman and Oden, 36).

Certain characteristics would reveal to the observant teacher, the talented child (Sheehan, 32; Brown and Johnson, 7). Extraordinary memory seemed to indicate a capacity for superior learning. An important aspect of this extraordinary memory was the ability to recall facts from several years back.

Intellectual curiosity was often characterized by a persistence in asking questions and an eagerness to investigate marginal content, which usually challenged only those who were intellectually mature.

Ability to do abstract thinking may be revealed by unusual insight into probable discrepancies and by skill in formulating hypotheses from new data.

Ability to apply knowledge to other situations was found in superior students. A student who selected formulas and principles appropriate to a new situation and evaluated the results accurately was exhibiting such ability.

Persistence in worthwhile behavior was a characteristic common to leaders in science. A scientist would not give up easily. This type of perseverance should not be confused with aimless plodding.

It was also found that superior students learn rapidly and easily (Oliver, 29). They were bored with practical applications, adept in self-evaluation, gifted in linguistics, ingenious, easily motivated, easily assumed responsibility, had a wide range of human interests, possessed social poise, were creative, purposeful, wanted reasons for assignment, strong in character, and were able to reason.

The identification of the talented student in mathematics and science would be the outcome of the wise use of the child's complete cumulative record. The cumulative record folder should contain I.Q. scores, a profile chart, a detailed elementary school record, anecdotal records of the student's behavior in class and out of class, and scores on tests in verbal comprehension, English, mathematics, mechanical ability, space perception, and interests.

The methods of identifying the talented which were discussed in the literature reviewed tended to stress the recognition of the talented by the school, teachers, and administrators. It would be important that emphasis be placed on the ability of these talented youth to recognize their own potential and that their parents also recognize their children's talents.

PROVISIONS FOR THE TALENTED

It was not enough that the talented student be identified and provided with the proper incentives. He must be furnished an opportunity to learn, practice, and use his talents. It was the responsibility of the school to provide these opportunities. Carrying out this responsibility would be most difficult for a school unless it was guided by an inspired administrator, aided by an understanding community, and assisted by energetic, intelligent, highly trained, and cooperative faculty members. Money would need to be available to carry out a proposed program.

Different types of programs which provided opportunities for the talented were used in many schools. There was no one best method. Each school with provisions for the talented worked out the plan which seemed to be most suitable for its needs. By studying what other schools were doing successfully, it would be possible to formulate and organize a program to fit any school.

The four phases of such a program for the talented were classed as: Organizational Provisions, Classroom Activities, Out-of-Class Activities, and Guidance Procedures (Brown and Johnson, 7).

Organizational Provisions

Special Schools. A separate school was one organizational method for providing educational opportunities for the talented. In such a school the talented student was challenged by working with youth of similar ability. Amazing achievements had been accomplished by such schools (7). Separate public schools for the talented were found in New York City, Baltimore, Philadelphia, Boston, and Cincinnati. Studies of the graduates of these schools indicated that the schools had produced well-rounded individuals.

Special Classes. A special class was another organizational method used to provide improved opportunities for the talented. Many educators have felt that the opportunity to share socially, politically, religiously, and occupationally with all pupils including those of lesser abilities than the talented possess, was an important part of the education of the gifted (McWilliams, 25). Therefore, these students had been given general education in a heterogeneous group in the lower grades and then had been placed in special classes in the upper grades. This procedure gave the talented student a more democratic outlook by work with students who could not share in the special classes and encouragement and challenge by work with his peers in those areas where he could develop his analytical and creative powers.

Morgan (28) felt that homogeneous grouping in special classes was to be highly recommended, but that delaying the grouping until the student reached the secondary level might result in missing some talented students who might have been identified earlier. Homogeneous grouping in special classes would be out of the question except in thickly populated areas.

A system of special classes had been practiced at the Susan Miller Dorsey High School in Los Angeles, California, where the procedure allowed for higher standards scholastically and for encouragement and guidance in the constructive work of the talented youth (Witty, 38). All the pupils in the school took the tenth grade Life Science course. During the first semester the top five percent from this class were selected on the basis of I.Q. of 120 or above, reasoning ability, reading proficiency, recommendations of previous teachers, and interest in science. The second semester these students were allowed to enter a special class under the supervision of one teacher. There was the same sequence of material that was presented to the regular class, but enrichment was offered to the students in the special class. From the students in the special class, a selection was made for accelerated courses in chemistry and physics. In addition to the work in the special classes, opportunity was provided for the talented students to act as laboratory assistants in the regular class.

In the Thomas Carr Howe High School in Indianapolis, Indiana, where there was an enrollment of 1300 pupils, special provisions were made for the talented in science (Klinge, 23). After the first 12 weeks of the fall semester, each teacher in sophomore biology was asked to select the students who fell into one or more of four categories: 1. students who had definitely decided to major in science; 2. students who had indicated an intention to minor in science; 3. students who were making the top grades in the class; and 4. students who showed some special aptitude in science as revealed through hobbies or special interests. From this group of students enough were selected to form one class for the spring semester of biology. This class was called the "Special Biology Class." The consent of each student was obtained before he was put into this class. The sequence of topics was the same in this special class as that in the regular classes of biology. As these students needed less time on each unit, less drill and paper work, there was more time left over for special work. Each student was asked to pursue a semester project. This project would be one which had a real scientific investigation, not just an intensive library research exercise. Each science teacher in the school gave this class a lecture on a special topic which broadened the scope of the topic being studied. Grading in this class was on the same basis and requirement as that of the regular biology class. Those students who showed particular promise were encouraged to take the advanced courses in science. Each student was urged to select one of the science teachers as his adviser, not only for academic and vocational information, but as a sponsor for a project which he would pursue while he was in high school. The students were not forced into these special provisions so it was a matter of salesmanship. The teachers tried to sell the vocation of science and sell the desirability of certain training from high school courses that might lead to scholastic aid in college.

At the Oak Park High School, Oak Park, Illinois, some ability grouping was done (Bloom, 5). There were three classes of chemistry offered. The regular class in chemistry was a college preparatory course; the medium class in chemistry offered the same subject matter but less of it; and the third class was for the slow learners and was called "Living Chemistry."

A two-track plan was a type of ability grouping used in many schools (Brown and Johnson, 7). Where the enrollment was large enough to allow at least two classes of a subject, a division based on ability and achievement was often arranged. This was particularly adaptable to courses in mathematics. One such division could be "Algebra" for one class, and "General Mathematics" for another class with lower ability achievement. Some schools used a similar plan for science. Very few schools used a two-track plan for years above the ninth grade. Some did offer a consumer mathematics course to one group of seniors in high school, and college algebra to another.

In the Bedford, Ohio city schools the gifted children were provided for by a tutoring and guidance program (Holcomb, 17). The program extended through grades one to twelve. The talented children attended regular classes but received special tutoring in special classes. A total of approximately 80 pupils received this special education yearly. They felt that this answered the need of the talented children.

In assigning pupils to special classes, two practical aspects should be considered. The teacher assigned to these classes should be satisfied with the assignment and qualified for it. The students should be permitted to transfer from one type of class to another from year to year or within the year. In order to do this, all sections of the courses should study the same basic content with enrichment opportunities for the rapid learner.

Acceleration. Acceleration was one of the oldest methods of providing for the talented student and was still used in many schools. Schools which offered an accelerated program for their talented children were several junior high schools in New York City and the Lee Junior High School in Baltimore, Maryland (McWilliams, 25). Both schools permitted students to enroll in an accelerated program in the junior high years which permitted them to finish the three years in two years. One disadvantage to this type of program was the "squeezing" out of the educational experiences of these pupils those activities which provided for social exploration and development.

Brown and Johnson (7) felt that students in the secondary schools could be advanced as much as two years without causing ill effects in their social development. They reported a study made in a Minnesota community which had practiced an accelerated program of permitting superior students to cover the seventh and eighth grades in one year. Some of these accelerated students have now graduated and no undesirable personality traits appeared to have developed.

At Hunter College Experimental School, New York, it was felt that acceleration as a means of providing for the talented youth was not a satisfactory method (Hildreth et al., 16). Besides the skipping of important subject matter and missing the activities which lead to proper social development, too often the accelerated child was too young for the advanced subject matter to have meaning to him. This was especially true for elementary children. Acceleration could be done in the senior high with some success.

Most educators believed that acceleration should be regarded as a possible means for aiding the individual pupil. Acceleration was considered advisable only when careful study was made of the physical and social maturity of the child. The acceleration should guarantee maximum benefit to the child's development in every respect.

Variable Student Load. One easy method of providing for the talented was the variable student load. Some students were allowed to take extra classes offered in the school or enroll in correspondence courses. Variable student loads provided opportunities for the child to explore many more areas than otherwise would be possible. However, the time taken for the extra courses might deprive the student of a free period that could be used more profitably to continue any interest that had been aroused during the school year.

Enrichment. The most widely used administrational and organizational procedure of planning for talented youth was to enrich the curriculum so as to provide the maximum educational opportunities for these students (Brown and Johnson, 7). They could be encouraged in activities that took place in the classroom or outside of class. Enrichment activities would provide outlets for research interest and for creative ability in every phase of the secondary school program. It would provide the opportunity for the talented to work at a rapid rate and discourage laziness that came from assuming the slow pace of the less talented (Henry, 15). These enrichment activities may be used equally well in the large or the small high school. The talented youth may be helped in his exploration of the intellectual and cultural opportunities of his society through individual and group experiences in a variety of activities. Special time should be allotted to aid these pupils (7). This time may be headed under such names as "Exploration Hour," "Special Needs Period," or "Major Interest Workshops."

The enrichment program should consist of enrichment material and not more advanced work or busy work. If advanced material is used the program will consist of acceleration (7).

The most difficult part of providing for the talented by the enrichment procedure was to allow him to remain in a heterogeneous class and take care of his individual needs within the framework of the regular class activities. The difficulty was the lack of time and resources of the average classroom teacher to cope with the individual needs of each pupil. If this type of program was used, the teacher would need assistance of many kinds. Very few schools had enrollments small enough to allow for providing proper enrichment on an individual basis in the classroom without unfair burdens of time and effort on the teacher. In several cities the position of teacher-consultant had been created to fill this need. The teacher-consultant visited both teacher and pupil regularly to help with methods and materials. This method had proved successful (McWilliams, 25).

One junior high school provided an interesting enrichment program for its superior students in science. The class assignments always included suggestions to fast workers for further reading, for developing extra experiments, or for writing up more complete data. Besides these provisions there were three extra curricular features for students with special interest or high ability in science and mathematics. First, one science teacher had a free period in which he met either individually or in small groups those students who showed potentiality in science and mathematics. These students were aided in developing correlated science projects growing out of social studies. As a second feature, a science club met three days a week.

The third feature was an elective advanced science study course. The enrollment in the special science course was limited to 20 students and met five periods a week in a laboratory. The students selected topics to be studied and the teacher chose the most popular topic. This offered an increased opportunity for individual science learning. Small group demonstrations, hall case exhibits, reports on special science topics or gadgets were some examples of ways this program was enriched.

Boyer (6) put much stress on individual work. The teacher's energies were the natural limit on the variety of work done at one time, but once the techniques of enrichment were patiently tried, the teacher would find it worth the effort. The special science class provided for maladjustments. The talented child who was a problem in other classes or at home gained a new and wholesome lift in his attitudes toward intellectual activity through the opportunity to use his developing talents willingly and busily in the science class. In this program, a student might not, except under extreme conditions, be taken out of his elective science class because he misbehaved or was behind in other classes in school.

In the North Phoenix High School, Phoenix, Arizona, three teachers worked together as a team (Bloom, 5). They were the biology, chemistry, and physics teachers. They selected the talented students who were in the ninth or tenth grade and who had unusual interest and ability in science. Early each year these students were chosen from the biology and general science classes. The science teachers acted as advisers who helped the students to elect their courses of study and to plan their projects. The students were given opportunities to work before and after school on their special interests. Wide use was made of community specialists and resources. This program was characterized by identifying talented students as early as possible, guiding them in their work, working as a team on the development of the talented student, and offering a differentiated program.

In the Wilbur Wright High School, Dayton, Ohio, there were no special classes for superior students (Strahler, 33). The school allowed no special promotion or early entrance. Instead, a widely enriched program was instituted which gave the superior students the chance to exercise superior behavior and mental traits and to give more of their ability and talent. Many methods used in the classroom allowed for varied levels of achievement within the same activity and yet allowed for individual differences. An example of the enriched program was a vertical file of information which was under the care of a superior student but for the use of all. A second example of the enrichment program was in the handling of book reviews. The students made book reports which they put on cards, stating how difficult the book was to read, how it compared with other books on the same subject, and who might particularly enjoy the book (7). A committee of two superior students separated the good reports from the poor reports according to pre-set standards. They then prepared and kept a file of the good reports for use by all the students. In this enrichment program, the superior students were encouraged to work in groups to counteract egoism and were watched for unwholesome work habits.

Classroom Activities

The classroom provisions for the talented youth referred to the procedures that are primarily the responsibility of the classroom teacher and under his direct supervision. There were many types of instruction used to aid the talented regardless of the organizational provision. What actually went on in and out of the classroom in the way of activities for the talented youth was of much more importance than the organization under which they were used. The best organization possible for a school would fail without the activities offered by energetic and inspired teachers. Good teachers could develop ways of helping superior students within almost any organization. Well-adapted organization was important but the final source of success was the teacher.

Read and Write Activities. The most common classroom procedure was called the "read and write" method (Brown and Johnson, 7). The pupil read some material in a book or magazine, then wrote a report. Or, the student studied some problems in a book and wrote his solution of the problems.

The organization and planning of this method varied greatly (7). For example, there was general encouragement for the student to read more widely on the topic being studied and report to the class when he desired; or being encouraged to work more problems in a mathematics class with little recognition for the extra work. As another example, the material to be read might be part of the general class assignment.

The "read and write" method of providing enrichment for the talented provided many worthwhile opportunities for the pupil to develop his potential in science and mathematics (7). The material to be read was the result of the teacher and pupil planning together. The material was within the ability of the student, but challenging. The superior and the other students should see how the material was related to and contributed to the general activities of the class. If the contribution was superior, recognition was given.

Recognition for superior work was given in various ways. Other students were guided to show their approval of outstanding work. The principal, teachers other than the advisers, specialists in the field in which superior work was done, and parents were shown the students' work. The work was exhibited in the classroom or in the hall, or written up and published in the school paper or newsletters. The best method of showing recognition was determined by the teacher who knew the background of the student and the local environment. Although students desired recognition for a job well done, this was not the only incentive to do extra work.

Some educators said that "read and write" methods involved only general encouragement of all students to do supplementary problems for extra credit and had little value in the program to help superior students unless the assignments were carefully planned and supervised (7). Although the method was a relatively easy way of providing for the talented, it did not have to be vague and unplanned. The mutual planning of the report with the student and teacher provided encouragement to use correct and accurate methods of literature research, and the proper way of writing or presenting the report. These techniques were of great value to the student when he went on to college and was given similar work with less guidance.

Project Activities. The project method was very popular and useful for providing additional educational opportunities for the talented student. Besides adding to the talented student's development, the project was of value to the rest of the class and to future classes. The project was a class activity or an individual endeavor.

The class project was generally a comprehensive activity which contributed to the objective of the class (7). It was a project that furthered the subject matter and was of evident benefit and value to the whole class. The projects were varied such as ways to show the use of geometry in everyday affairs or the effect of diet on the physical growth of youth. The projects required the gathering of information from actual experiments or from books, magazines, and specialists. The construction of models and murals was used to express the ideas involved. Teachers had found the class project beneficial to the superior student as it offered an opportunity for him to develop leadership qualities, learn to work with other students, and extend the applications of his basic knowledge.

In the small class project the entire class did not contribute (7). The project, however, contributed or was directly related to the class purposes. For instance, when a class studied communications, a group might be particularly interested in the telegraph. By a special project they furthered their own knowledge and skill and at the same time contributed much to the whole class. At one school a small group of students was organized in a "Biology Squad." The purpose was to furnish live specimens for the high school biology laboratory. Besides helping the other classes, those students who participated were motivated to increase their own knowledge.

Many teachers found the small group project valuable in providing enrichment for the rapid learner in science and mathematics. It did require that the teachers be familiar with a wide range of subjects but there was much literature that could furnish information concerning science and mathematics for successful small group projects. Such material could be obtained from the National Association of Science Teachers, and the American Association for the Advancement of Science.

Assistance to the Teacher Activities. Some teachers allowed students to participate in the teaching activities such as the conduct of a class. There were two reasons why this activity was beneficial to the student. First, it helped him appreciate and become interested in the teaching phase of science, and second, it gave him an opportunity to become more familiar with laboratory equipment and its operation. The recognition which the talented pupil received from this activity was carefully handled to prevent untoward jealousy among other students (Brown and Johnson, 7). It was reported that one teacher in New York allowed the talented students to use the classroom when she was not present (Jewett and Hull, 20). Under the supervision of a superior student, the pupils worked on approved individual projects. This same procedure had been used in Denver, Colorado and Minneapolis, Minnesota with success.

The superior student was allowed to act as the assistant during the laboratory period (20). The student helped the slower pupils to set up apparatus, checked on safety precautions, and followed the pupils needing assistance through their work. Three of the schools which had found this method to be successful were: the North Phoenix High School in Phoenix, Arizona; Oak Park High School, Oak Park, Illinois, and the Susan Miller Dorsey High School in Los Angeles, California. Zim (40) said that there was undisputed educational value to talented pupils and a real practical value to the school when pupils were permitted to assist the teacher. Laboratory squads were organized to prepare and give out material for science laboratory experiments and work. These squads helped take supply inventories, prepare stock solutions, clean microscopes, or care for laboratory animals.

Assistance to Other Students. Another frequently used method was to permit the superior student to help other students in the class (7). When used in moderation it had some value but if the tutoring or coaching was confined in one area in which the student was already familiar, it reached a point of diminishing returns. Zim (40) reported that the superior students assisted younger pupils. Superior students in the secondary school helped the elementary teacher by organizing little clubs at the elementary level or by presenting a talk on some phase of science on which he may have particularly worked. This was of value to both the secondary superior student and the elementary students.

The superior student made microscope slides for biology classes which developed techniques which might stand him in good stead in future laboratory work (40). He maintained a school museum, or developed a science library for the science classroom by reviewing books which might be used, checking books in or out when the library was established, and caring for the physical setup of the library.

To teach democratic living along with this pupil activity, the superior student should understand that any specialist needed to delve into his area of interest deeply but he was also obligated to contribute his acquired knowledge to the welfare of his society.

Out-of-Class Activities

Out-of-class activities, according to Brown and Johnson (7) had the following characteristics. The activities were planned and developed out of class. The activity did not contribute directly to the class purposes at that time. The activity was supervised by the teacher.

Science and Mathematics Clubs. The most frequently used method of providing out-of-class activity for the talented or those interested in mathematics or science was the mathematics and the science clubs (Henry, 15). The clubs usually met during the school hours. To further this activity the Science Clubs of America had been organized. From this source, a charter might be obtained with material and information for activities and projects, and rules and suggestions for organizing the science clubs. The advantage to students working in science clubs was much more informal work which gave an opportunity for the student to choose his own project, develop his own methods of procedure, and use his time at his own convenience. Thus, the student pleased himself instead of the teacher. Enjoying science was a purpose of these clubs through the recreational reading of science fiction, working out puzzles, and practicing magic. The projects started and developed through the science club often encouraged the student to enter the project in contests and fairs.

Community specialists in the fields of science and mathematics were brought into the science club meetings to help present programs in their particular fields (Johnson, 21). Engineers and other scientists had much to offer such a program. Professional mathematic and science groups including soil conservationists, health company representatives, and civilian defense workers also had contributed to the success of science clubs organized in schools. Interested students through personal contact in the fields of professional science, attended the science meetings. They were encouraged in money earning projects such as photography, collecting biology material, repair services, and even inventions (Zim, 40).

Science assemblies, sponsored by the science clubs, offered an opportunity for out-of-class activities, provided a way of interesting other students in science, and allowed members of the science clubs to demonstrate their initiative, leadership, and talents. Membership in these clubs was entirely voluntary, and the stress was on individual development of projects rather than on a group project. Teachers were given time to devote to this important type of instruction for the talented and interested pupils in the class. Considering the time spent on athletics and the extra salary and expensive equipment provided, in comparison to the need for the development of the talented in our society today, there could be little argument that time, place, and recompense for the teacher should be provided.

Contests, Exhibits, Fairs, and Conferences. Contests, exhibits, fairs, and conferences in the scientific and mathematical fields were other methods of providing out-of-class activities for the interested or talented student. Through these activities, talents were not discovered, but the recognition achieved by the participants was a means of motivation. The encouragement inspired in the student a desire for further scientific experimentation, and provided a recognition for talented youth without exploiting them (Jones, 22). It encouraged further work in the sciences in college and industry. These activities were a means of focusing attention not only of pupils but of the whole community on science. This provided also a means of educational salesmanship to the community on the value of the education the students were receiving. Talented students were encouraged to qualify themselves to apply for scholarships at universities in the field of science by participation in these activities.

One of the best known activities in the contest area was the Westinghouse Science Talent Search by the Westinghouse Educational

Foundation. The Science Talent Search Test was designed to measure science aptitude (Long, 24). The test was hard and two and one-half hours long with the intention of eliminating those without perseverance. The test had been found to serve as a stimulus to other students to try harder. Entry also included a written report of a project and an evaluation of the student by his teachers. In 1953, 16,344 students took the test but only 2,409 completed the requirements. The judges selected 40 students to come to Washington, D.C. for interviews. Honorable mention was given to 260 other students. The contest was supported by the Westinghouse Educational Foundation and was conducted by the Science Clubs of America.

Another nation-wide contest was sponsored by the Future Scientists of America Foundation and was designed for all science students in grades seven through twelve.

Jones (22) reported a Summer Science Camp as conducted in St. Louis, Missouri, which was successfully helping to make useful citizens of the talented or interested students in mathematics or science. Under the auspices of the Kirkwood High School of St. Louis, the camp met two to four hours a day for eight weeks with high school credit given for attendance. Rocks and minerals were studied. Visits were made to industries, zoos, botanical gardens, and construction work such as bridges and buildings. Career information was disseminated at all the visits made as well as solicited from other sources.

Guidance Procedures

The identification and helping of the talented student in science and mathematics would be the responsibility of the entire faculty, but a large share of this responsibility must rest on the guidance director.

As Terman (36) pointed out, there was a need for guidance with these talented youth. Without guidance there was frequent failure to identify the gifted and a failure to provide the kind of counseling service needed. Counseling was needed to insure that the talented youth was getting the training he needed and the kind of training best adapted to his interests. There was the danger that the talented student, because he was talented, would have difficulty in deciding on the field which he was best suited to enter. The guidance director was in a favorable position to help that student understand his talents, interest, and abilities.

The functions of the guidance director were felt to be important in many areas (Strong, 34). The guidance director with the help of the teacher should discuss with the pupil and parents the pupil's potentialities in relation to educational and vocational opportunities. They should help to increase the pupil's sense of responsibility for his gifts. Parents and teachers should be alerted to the school and community opportunities for the development of students with high ability. Boys and girls need to know and understand their own potentialities and their responsibilities for developing them for their own good and for the good of society (Gordon, 13). They need the proper incentive and right moral values to use their talents for the advancement and good of all mankind. They should develop an active interest in discovering their talents, understanding them, and finding ways of developing them. By engaging the cooperation and understanding of the parents, a major incentive will be provided for these youth.

The guidance program can aid in the identification of the talented by giving and interpreting tests. The guidance director can help the individual understand himself. The guidance director can help individuals get the experiences he needs in the school and community for a well-rounded development. Parents often need help in avoiding the extremes of exploitation or denial to their talented child in using all of his potentialities. The guidance director should take an active part in curriculum planning to help modify the curriculum to the needs of the superior student.

Other ways the guidance director can aid the conservation of the talented is by seeking appropriate scholarships or other financial assistance; by directing students to appropriate reading materials to help plan careers that are best suited to abilities; by directing talented students to community resources that will enrich their interests (Witty, 37).

Much help can be given the talented youth by providing guidance material (Badley, 3). There are guidance materials that are readily available from a variety of sources, and easily applicable, especially in the science field. The Science Research Associates, 57 W. Grand Ave., Chicago, 10, Illinois, furnished individual booklets on such things as mental health, home life, and hobbies. American Education Publication, 356 Washington St., Middletown, Connecticut, also provided useful material for the vocational and educational guidance of youth interested in science.

The guidance director must work very closely with the individual teachers. It was the responsibility of the guidance director to coordinate activities of the different teachers and offer help and guidance to the teacher as well as to the student. The guidance process is an integral part of the classroom activities, and many teachers need help in becoming efficient and better informed guidance workers.

The science teacher can encourage students to explore career opportunities in relation to each topic studied. There should be an open file of career information available for student use (Johnson, 21). Displays of career information such as pamphlets, articles, and pictures can be put in each science room. Encouragement should be given to read books on scientists, engineers, and technicians. Teachers can encourage pupils to undertake projects and invite scientists and engineers to class.

The guidance director, with the help of the teachers, should plan a career conference day (7, 21). The purpose would be to help the student make a more intelligent choice of future activities by information and counsel received direct from specialists. Representatives of different occupations and colleges would present their fields, giving the opportunities and qualifications for each field.

A list of specialists in different fields who are willing to help young scientists would be available to the teachers. When a student became interested in a certain area, these specialists could assist the student in planning an exploratory project which would give an insight into the field of interest. Such timely guidance required careful planning by the administration and the understanding cooperation of lay persons, but the benefit to both the student and the specialists would be great. The purpose of the career conferences then would not be limited to one day, the career day, each year. Conferences could be arranged for the benefit of the parents; to help them become acquainted with the education of their superior child.

Margaret Patterson (30), editor of the Searchlight, had summarized the characteristics and achievements that the winners of the Science Talent Search contest stated they wished had been part of their high school education. The science teacher would find a knowledge of these points helpful in areas where he guided the talented to better prepare for a science career. A knowledge of these points would be helpful for the student to make him aware of the extra effort needed to make the most of his potential. These characteristics and achievements are:

1. How to study more effectively
2. How to elect subjects wisely
3. How to worry less about grades
4. How to reason
5. How to write easily and fluently
6. How to work harder
7. How to develop better reading habits
8. How to get along with people
9. How to relax in social situations
10. How to develop standards for making decisions
11. How to be self-confident
12. How to be broad-minded
13. How to be humble

The Talent Search Contest winners also said that more science, especially mathematics; more languages; and more science skills such as mechanics, machine shop, and mechanical drawing would have been helpful. The students thought many of these things could be done outside of schools. They urged participation in extra-curricular activities that aid in development of well-adjusted individuals. The winners suggested that young people explore many phases of science, not bury themselves in a specialty immediately. There would then be a broad perspective and education rather than just the technical training. This broadening helped the student to cross traditional lines and train for such occupations as biochemists or mathematical biophysicists.

Suggestions to prepare for the science contest were made by the winners which included acquiring a good solid background in basic sciences, including mathematics; becoming an authority, or at least having superior working knowledge and ability in one field; learning thoroughly the methods common to all science; and learning to work well with other prople. Other suggestions were to keep an open mind to new ideas in any science, and in all fields by reading widely, attending lectures, meetings, and exhibits; to take special courses to serve widened interest; to learn the use of new scientific tools; to join club or professional groups; and to widen the circle of friends, acquaintances, and contacts. These suggestions not only helped prepare for a science contest, they helped to prepare a career in science.

Some students who realize their potentialities and sincerely want to develop them will come to a faculty member and ask just what they can do to help develop the right personality and habits. As most guidance directors and teachers know, the most helpful personal characteristics can be developed by a little daily effort which will help these students go further in science. Reliability can be developed by the use of a daily schedule and volunteering for committees and offices to get practice in carrying out assignments faithfully (1). Accuracy comes with practice in double checking work. Impatience should be stifled since it takes perseverance to win. Cooperation should be practiced by mixing with people, and joining clubs and church groups. Objectivity should be strived for to avoid arrogance, egoism, and bullying. Listening to both sides of issues, refraining from snap judgments, and an open admission of error all contribute to objectivity. Straight thinking is important to develop, and learning new tools by taking as many courses as possible such as mathematics and logic, help in this area. Hobbies like chess teach the pupils to think ahead. Intellectual curiosity could be developed by listing questions that come to mind, then looking up the answers. Practical imagination may be developed by reading science fiction which also teaches bold thinking. Effective expression is a very useful tool which may be practiced by literature reading and exercises in grammar and composition. Public speaking, good letter writing, and the reading of well-written books help in learning to express thought effectively. Humility is an important characteristic for the talented to learn and it may be taught effectively by keeping the student always learning, broadening knowledge into other fields, and taking full advantage of all educational opportunities.

Ambition to strive for more advanced degrees helps to combat the "know-it-all" personality.

The superior science student must be helped to develop a critical attitude (Klinge, 23). Too often the superior student whose powers of memory are usually great, accepts too much at face value. A budding scientist must develop his critical faculties, to carefully examine all conclusions whether his own or from others. When the student begins to be critical, he begins to have questions and problems appear for his consideration. When he attempts to solve these problems in a critical manner, he has progressed toward scientific success.

The superior student is interested in the theoretical aspects of the subject at hand (23). This preoccupation with the theoretical outlook on science is easily seen in the great interest in science fiction with its imaginative treatments and its insistence on the theoretical being made possible. College textbooks and current science literature are good sources of current theories which can be presented in the science course in the secondary school. Class discussions of scientific research with some emphasis on the hypotheses proposed, offers good exercise in a careful analysis of theories.

It is too easy to emphasize academic achievement with superior students (Hildreth et al., 16). They respond to reading so easily that there is a tendency to let them read too much. Reading widely helps to develop but does not make a scientist. They need to learn to do things as well as read about the works of others.

The superior student is interested in and needs a continuous evaluation of his role in science (23). The grading system must be such that he can see precisely how he is being evaluated, so that he too may enter into the process. He is vastly interested in the subject and will want to evaluate himself to discover his strong and weak points.

A file of current standardized tests available to teachers and students is a valuable aid in helping the student and teacher evaluate the student's progress. With but little aid from the teacher, the superior student can administer and score his own tests to determine the extent of his knowledge. In this way a student can see for himself just where he stands on a national basis. A superior student is often apt to get a mistaken viewpoint of his abilities when he compares himself to the rest of an average class. A true picture of the student's ability is needed by the student, teacher, and parent in planning for his future.

SUMMARY

The purpose of this report was to present to the secondary school science teachers, methods of identifying and developing the potential of the students talented in mathematics and science. The limitations of the paper restricted or excluded a discussion of the importance of physical facilities of the school, initiative and leadership of the administration, and the cooperation of qualified teachers. It is recognized that these factors are necessary for success in helping the talented.

Today's objectives in teaching science are not greatly different from earlier objectives but there has been a change in emphasis. The main objectives of science teaching over a 50-year period have been to train students in the scientific method of thinking, to develop certain scientific attitudes within students, to acquire a fund of useful information, and to develop an understanding of the major principles of science. Two new objectives have been added. They are to enrich the leisure hours of the students and develop an appreciation for science and its achievements, and to offer opportunities to explore the vocational aspects of the different science fields.

The talented students in the schools have been neglected because the educators and community have failed to recognize the need for helping the bright student; the teachers find difficulty in developing instructional guidance and procedures; the associates of the talented have had a feeling of distrust for his talent, and therefore ignored it; and the talented themselves had a desire to be as much like the average person as possible. This neglect had two serious effects. It deprived the individual of his fullest development, and his country lost talent and leadership it could not afford.

There seemed to be ample reason to believe that there was a large supply of individuals capable of contributing to the field of science and engineering who were not doing so. Of high school graduates who had intelligence in the top 20 percent and grades in the top 40 percent of their class, only 47 percent graduated from college, leaving a total of 106,000 students in this ability group not graduating. The main reasons for this loss of manpower were lack of motivation and the influence of home environment.

Early identification of the talented and adequate provisions for its development must be made. The talented child, as referred to in this discussion, was defined as one who was included in the upper 20 percent of secondary school students in general intelligence.

Formal methods of identifying the talented which were presented were the administration and interpretation of appropriate tests. Aptitude and achievement tests measure the different areas which show whether the student would be potential material for science training. Three tests for measuring these abilities were discussed. Interest tests were considered of secondary importance in identifying the talented in mathematics and science. Three tests which help in this area were discussed.

Informal methods of identifying the student talented in mathematics and science depend on the perspicacity of the teacher in noting particular characteristics that label a superior student, the student's response to extra help, and predicative records kept by the teacher. The identification of the talented student in mathematics and science would be the outcome of the wise use of the child's complete cumulative record. Emphasis should be placed on the need for the student's recognition of his own potential.

It is the responsibility of the school to provide opportunities for the talented students to learn, practice, and use their talents. Four phases of the provisions for these opportunities were discussed. The first phase, organizational provisions, included special schools, special classes, acceleration, variable student load, and enrichment. The second phase, classroom activities, was the "read and write" method, projects, helping the teacher, and helping other students in class. The third phase, out of class activities, included a discussion of mathematics and science clubs, contests, exhibits, fairs, and conferences. The last phase included the guidance procedures which discussed the dual role of the guidance director. It was his responsibility to help the teacher recognize and develop the talented child and also help the talented child to recognize his talent and his responsibility for its development. Characteristics that the talented student would need to develop in education were given as suggested by former students who had succeeded in these fields.

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A STUDY OF THE DISCOVERY AND DEVELOPMENT OF SCIENCE TALENT IN SECONDARY SCHOOL PUPILS

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INTRODUCTION

There are definite needs in the fields of science and mathematics for the superior students. To help these students realize their total abilities is also furthering the overall objectives of secondary school education. The purpose of this report was to present to the secondary school science teachers, methods of identifying and developing the potential of the students talented in mathematics and science. The material for this report was obtained by a review of the available related literature and the experience and thinking of the writer.

A REVIEW OF SCIENCE TEACHING OBJECTIVES IN SECONDARY SCHOOLS

Today's objectives in teaching science are not greatly different from earlier objectives, but there has been a change in emphasis. The main objectives of science teaching over a 50-year period have been to train students in the scientific method of thinking, to develop certain scientific attitudes within students, to acquire a fund of useful information, and to develop an understanding of the major principles of science. Two new objectives have been added. They are to enrich the leisure hours of the students and develop an appreciation for science and its achievements; and to offer opportunities to explore the vocational aspects of the different science fields.

RECOGNITION OF NEED FOR CONSERVATION OF THE TALENTED STUDENT

The talented students in the schools have been neglected because the educators and the community have failed to recognize the need for helping the bright student; the teachers find difficulty in developing instructional guidance and procedures; the associates of the talented have had a feeling of distrust for his talent, and therefore ignored it; and the talented themselves had a desire to be as much like the average person as possible. This neglect had two serious effects. It robbed the individual of his fullest development, and his country lost talent and leadership it could not afford.

There seemed to be ample reason to believe that there was a large supply of individuals capable of contributing to the field of science and engineering who were not doing so. Of high school graduates who had intelligence in the top 20 percent and grades in the top 40 percent of their class, only 47 percent graduated from college, leaving a total of 106,000 students in this ability group not graduating. The main reasons for this loss of manpower were lack of motivation and the influence of home environment.

IDENTIFICATION OF THE TALENTED

Early identification of the talented, and adequate provisions for its development must be made. The talented child as referred to in this discussion, was defined as one who was included in the upper 20 percent of secondary school students in general intelligence.

Formal methods of identifying the talented which were presented were the administration and interpretation of appropriate tests. Aptitude and achievement tests measure the different areas which show whether the student would be potential material for science training. Three tests for measuring these abilities were discussed. Interest tests were considered of secondary importance in identifying the talented in mathematics and science. Three tests which help in this area were discussed.

Informal methods of identifying the student talented in mathematics and science, depend on the perspicacity of the teacher in noting particular characteristics that label a superior student, the student's response to extra help, and predicative records kept by the teacher. The identification of the talented student in mathematics and science would be the outcome of the wise use of the child's complete cumulative record. Emphasis should be placed on the need for the student's recognition of his own potential.

PROVISIONS FOR THE TALENTED

It is the responsibility of the school to provide opportunities for the talented students to learn, practice, and use their talents. Four phases of the provisions for these opportunities were discussed. The first phase, organizational provisions, included special schools, special classes, acceleration, variable student load, and enrichment. The second phase, classroom activities, was the "read and write" method, projects, helping the teacher, and helping other students in class. The third phase, out-of-class activities, included a discussion of mathematics and science clubs, contests, exhibits, fairs, and conferences. The last phase included the guidance procedures which discussed the dual role of the guidance director. It was his responsibility to help the teacher recognize and develop the talented child and also help the talented child to recognize his talent and his responsibility for its development. Characteristics that the talented student would need to develop in education were given as suggested by former students who had succeeded in these fields.