

**A COMPARATIVE STUDY OF
SCIENCE ACHIEVEMENT AND
SCIENCE COURSE-TAKING PATTERNS
OF HIGH SCHOOL STUDENTS**

MASTER'S PROJECT

**Submitted to the School of Education
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Master of Science in Education**

by

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CHAPTER I
INTRODUCTION

Science Achievement

Science achievement of high school graduates is an area of concern in the United States. Various studies show our country falling behind in comparison with other countries in recent years (Beardsley, 1992; Byrne, 1985; Jacobson, 1987; Kantrowitz and Wingert, 1992). In addition, fewer students have been choosing to pursue science-related careers since 1983 (Fisher, 1992; Grandy, 1987). This is expected to result in a shortage of scientists in our country's future. Lagging science achievement and lack of career interest in science are being portrayed as a crisis in popular literature (Adams, 1989; Beardsley, 1989; Johnson, 1990; Koretz, 1992; Shamos, 1988; Stone, 1989; Tifft, 1989). Acting in response to this crisis, educators and educational institutions are attempting to change recent trends.

A variety of suggestions to improve science achievement and interest have been made. These focus mostly on recruitment and training of quality teachers, curriculum reforms and increasing the number of required courses (Beardsley, 1992; Culotta, 1990;

Glatthorn, 1988; Holden, 1989; National Science Foundation, 1983; Worthy, 1988). Some researchers feel that many high school science courses should be less demanding and focus more on science/technology/society issues, so that more students will be attracted to them (Walford, 1983; Wright, 1988; Yager, 1988).

In this research project, the relationship between achievement and course-taking patterns of students is of particular interest. An assumption is frequently made that an increased number of courses will result in a higher level of achievement. This seems to make sense, but would it apply to students of all ability ranges and interest levels? Generally, studies have found that the more science coursework a student experiences, the higher his/her science achievement will be (Laing, 1987; McLarty, 1988; Schmidt, 1983; Sebring, 1985). In at least one case, though, the relationship between number of courses and achievement in science was questionable, and obviously much less strong than the same relationship in mathematics (Jones, 1986). It has also been noted that grades achieved in high school science (omitting failing and D grades) are not very good predictors of college chemistry grades (Craney, 1985). Two groups of high ability students, one having completed a high school chemistry course and the other without high school chemistry, showed similar achievement and attitude

scores after a summer college chemistry program (Yager, 1988).

Science education does seem to be at a crucial point in time. Changes to curriculum and student course-taking patterns need to be oriented toward increasing both interest and achievement in science. Designing and implementing appropriate courses to accommodate a wide range of student abilities will also be important. Many high school science courses have become very academic and abstract in their orientation. This may benefit some students, but it is resulting in lower enrollments in science courses beyond those required for graduation.

Problem

A general chemistry course has been offered as an elective for students of Springboro High School (Springboro Community Schools, Ohio) beginning in the 1987-1988 school year. Creation of this course reflected concerns of both the administration and the science faculty in providing appropriate science instruction for all students. Science courses previously in place for the junior and senior year were very difficult for students lacking strong math backgrounds. General chemistry was one of two new courses developed specifically to enable all interested

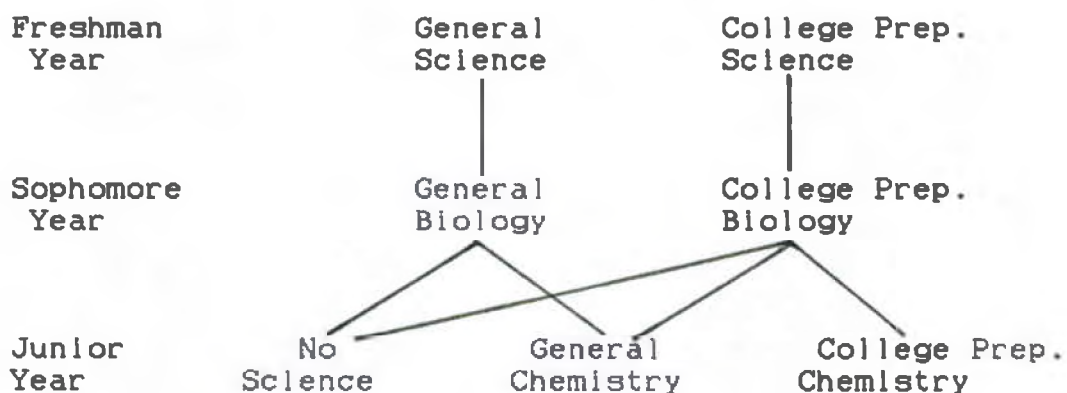
students to complete four years of high school science. By providing these courses, it was hoped that the number of students completing science courses in addition to the two required for graduation would increase. Also, this course should benefit prospective college students in increasingly selective college admission processes. Many colleges and universities are suggesting that all applicants, regardless of intended major or concentration area, take a chemistry course in high school.

Prior to the 1987-1988 school year, students at Springboro High School could enroll in college preparatory chemistry for a third year of science. There were no other options. College preparatory chemistry was designed to be the third year science course taken by students in the higher of two tracks offered during the first and second years of high school science. This chemistry course moves at a fast pace and requires a good foundation in math. It has proven very difficult for some students. Therefore, many students who were in the higher track during their first two years have not been successful in college preparatory chemistry. Other students, following the lower track during the first two years, did not have an appropriate third year course. The creation of general chemistry was intended to provide a course better suited to the needs of these two groups of students.

The purpose of this research project is to collect and analyze student data from the first six years in which general chemistry was offered at Springboro High School. The data will be used to describe academic characteristics of students choosing the various science course options. The data will also be used to determine the effectiveness of this general chemistry course in providing an opportunity for students to increase science achievement. Analysis of the course's effect on student achievement may substantiate the success and validity of the course. Alternatively, analysis of achievement may suggest a need to examine the course's content, methodology and/or existence.

TABLE 1

SCIENCE COURSE FLOWCHART



This research will test the null hypothesis that general chemistry does not result in any science

achievement increases in students at Springboro High School. Table 1 shows science course sequences most commonly followed by students during their first three years of high school. Students enrolled in general chemistry can be divided into two groups by their science backgrounds prior to general chemistry. Each of these groups will be compared to students not taking general chemistry but with similar backgrounds. One group of students, from the lower track, would probably have terminated science coursework with two years of high school science if general chemistry did not exist. This group's students have completed two science courses, one in general science and one in general biology. General chemistry provides an opportunity for students with this background to take a third year of science and to be exposed to chemistry. These students will be compared to students with identical science backgrounds who did not enroll in general chemistry.

The second group is composed of students enrolled in general chemistry who have completed college preparatory science and college preparatory biology as their first two high school science courses. They would have either enrolled in college preparatory chemistry or not have taken a third science course if general chemistry was not offered. Those choosing college preparatory chemistry may have encountered frustration and low grades. The administration and

science faculty hope these students, by completing general chemistry, will experience an increase in science achievement greater than if they had enrolled in college preparatory chemistry or had not taken a third science course.

Assumptions and Limitations

Several assumptions are being made during this research. First and most important is the assumption that science courses at school are the main contributing factor affecting science achievement. Unmeasured and unknown factors, including exposure to science outside of the classroom through parents, television, reading, employment, etc., are not addressed. In addition, student attitudes and interests are not being considered. Certainly, these do have an effect on achievement, but it will be assumed that by controlling for other quantifiable variables each group will be similar in these areas. Also, students have not been assigned to take or not take general chemistry by any designed process. All course selections have occurred through normal school guidance procedures in which students themselves are the primary decision-makers.

Science achievement data of students in this research will be collected from two group standardized

tests. One is administered during the year prior to the general chemistry course, and the other is taken near the end of the year during which general chemistry is taken. Therefore, an assumption is being made that the standardized tests used contain material which adequately assesses science achievement, including skills and achievement gained by studying chemistry. Since the earlier test is used in reporting academic progress of our district's students at the tenth grade level and the other is a college admission test, it is felt by the researcher that the tests used do serve as important indicators of science achievement.

A final consideration is the limitation of determining course value strictly through achievement scores. Many important aspects of the general chemistry course are not in the cognitive area. Student outcomes in affective, behavioral and psychomotor areas are considered to be important by the administration and faculty. These will not be analyzed during this research, but they are important elements of the general chemistry course. Therefore, any resulting conclusions of this research on achievement gains of students provide only a partial evaluation of the general chemistry course. A complete evaluation of the course would need to examine areas other than achievement.

CHAPTER II

REVIEW OF LITERATURE

Introduction

Concern for science achievement of students in the United States has occurred at several times in our nation's history. In the late 1800's, new strong standards, to be completed by students prior to college admission, were developed for high school science programs. Chemistry was to include many prescribed lab activities as a part of its program. These initiatives resulted in lecture-based chemistry courses giving way to ones that were almost entirely laboratory-based. This upheaval in methods of teaching chemistry caused considerable confusion and much experimentation, but a relative equilibrium was reached by the turn of the century. By then a combination of lab and lecture formed the substance of most chemistry courses (Walford, 1983).

The next major change in science teaching occurred in the 1960's. When the Soviet Union launched a satellite into orbit around the Earth in 1957, a perception quickly developed that the United States' role as the leading nation in technology and science

was threatened. During the 1960's, massive curriculum projects and initiatives were propelled in reaction to the Soviet launch. Science programs were designed and implemented to improve science teaching from elementary through secondary school. Many of these included heavy emphasis on experimentation, data collection and development of analytical skills (Walford, 1983).

Current concerns of science education center on claims of declining achievement beginning in the 1970's and continuing into the 1980's. In addition, many individuals perceive our nation as being economically threatened by the developing science/technology capabilities of other nations. A final aspect of current concerns is that the number of students choosing science and engineering careers has continued to decline since 1982 (Fisher, 1992; Fullilove, 1987). Evaluation of science career interest declines, as detailed in forty seven books and reports, showed that many students like science and understand its value. However, the most important factor in deciding to become a scientist was how well the student did in math and science in school. A survey of scientists showed that forty four percent became interested in their current professional field during high school, and many cited a close relationship to a teacher or an encouraging parent as a key factor (Fullilove, 1987).

These findings suggest a need to provide positive school experiences, opportunities to interact with an encouraging adult, and programs promoting high levels of science achievement in high school.

The remainder of this literature review is divided into four sections. First is an overview of the status of science achievement in the United States. This will be followed by reviewing reactions of the educational community toward improving science achievement. Next, studies attempting to ascertain the role of various factors within chemistry classrooms on student achievement will be reviewed. Finally, studies that have been concerned with the relationship between course-taking patterns and science achievement will be described.

Science Achievement

In 1981, the National Commission on Excellence in Education finished a report for the Secretary of the Department of Education and the American people on the status of education in our nation (Gardner, 1983). The report's title, "A Nation at Risk: The Imperative for Educational Reform," indicated the degree to which the commission felt attention must be paid to our country's educational systems. Findings included a well-documented decline in science achievement scores

of United States' 17-year-old students as indicated by national assessments in 1969, 1973, and 1977. Evidence also showed that United States' scores were low in comparison to other countries, and that college board achievement tests were also showing declines. Concerns were raised that a generation of scientifically and technologically illiterate Americans was being raised (Gardner, 1983). The situation is even more complex when analyzed closely. An average citizen today is better educated and more knowledgeable than an average citizen of a generation ago, but the average graduate of high schools and colleges today is not as well-educated as an average graduate twenty-five years ago. Twenty-five years ago, a much smaller segment of the population completed high school and college (Gardner, 1983). A larger percentage of our population completing schooling yet the average product of the schools is of lesser quality.

A study by the National Center of Education Statistics (Alsalam, 1992) showed that science achievement for 17-year-olds declined from 1970 to 1982 and then increased to 1990 but was still not back to the level of 1970. At the same time, Scholastic Aptitude Test (SAT) scores declined to a low in 1980, increased 16 points by 1987 then decreased 10 points to 1990. Similar results were found in studies by the

Educational Testing Service (Barton & Coley, 1991; Mullis, 1991). Declining achievement during the 1970's was followed by gains in the 1980's, but science achievement in the United States continued to trail behind that of other countries. On the college level, an increase in the number of bachelor's degrees in science being conferred occurred from 1978 to 1988 but fewer master's degrees were awarded. Doctoral degrees also increased but not enough to keep pace with population growth (Barton & Coley, 1991).

Much of the concern over science achievement centers around results of several international comparative studies. Most important of these was the Second International (IEA) Science Study. It involved testing of students in fifth, ninth, and twelfth grades from twenty-four countries in 1983 and 1986. Results in chemistry achievement showed that United States' students, even those with two years of high school chemistry, trailed behind students of other nations. United States' students with one year of chemistry achieved a score of 27, and those with two years of chemistry scored 41. In contrast, students from Japan scored 62, England 73 and a block average of nine countries scored 55 (Jacobson, 1988).

Comparing achievement of students in the United States to those of other nations has yielded results

that are disturbing. A question arises as to whether the comparisons are occurring in a fair manner. In the Second International Science Study, the samples from grades five and nine were equitable samplings of student populations from the countries involved. But by the twelfth grade, while United States' samples were representative of ninety percent of all twelfth grade age individuals in the population, all other countries' samples were representative of smaller percentages of the population at that age: Canada seventy-one percent, Japan sixty-three percent, and England twenty percent (Jacobson and Doran, 1988). This selectivity of students being compared should have been expected to affect results observed. A report from the National Academy of Sciences - National Research Council (Bradburn and Gelford, 1990) detailed suggestions for appropriate comparisons in international studies. One suggestion focused on the importance of ensuring that similar student groups are being compared. An unintentional reason for sampling differences is that many nations' educational frameworks result in students dropping out of the educational system or being channelled into various types of schools at selected ages. Even if sampling procedures were more equal, United States' students still show lower achievement than students of most other countries.

What differences in countries' educational systems result in science achievement variation? A study comparing the United States and four other industrialized countries (Soviet Union, France, Japan and West Germany) found the most striking difference to be that in the United States students have greater accessibility to high schools and colleges (Bishop, 1989; Nerad, 1986). The other nations have national exams based on national academic standards that control student movement through the educational system. In these four nations, education is viewed as a national tradition that challenges all students and involves them in the national community. In contrast to this, the emphasis in the United States is on spending time in school and doing well in comparison to other students. United States' students spend less time and energy toward learning than students in other countries, but United States' parents are more satisfied with outcomes as long as grade point average and class rank meet their standards. So instead of pushing for increasing achievement, parents want their children to do well compared to others. Parental pressure on schools is not to increase achievement but to increase class rank and grade point average of their children. In other countries, parents pressure schools for achievement so their children will do well on

national exams. In addition, the labor markets of several other countries (much more than in the United States) tend to reward achievement in school with pay rates, job placement and promotional opportunities (Bishop, 1989).

Another difference seems to be one of perception in the role schools and education play in developing an individual's intellect. In most countries, parents and students view achievement as being the outcome of hard work and effort. In contrast, a prevalent attitude in the United States is that achievement is due to the "right" genes (National Education Goals Panel, 1992). This attitude tends to focus attention on finding who can do well, instead of making sure that all students achieve to a high level. A possible consequence of this attitude is that students in the United States spend less time on homework and spend more time watching TV than students do in other countries. Surprisingly, students in the United States were more likely to do experiments, use calculators and have science books in their homes (National Education Goals Panel, 1992). So despite United States' students having, in general, lower achievement in science when compared to other countries, they do have access to items that should be instrumental in developing high science achievement.

In addition to attitudes and social expectations, key elements present in countries having high achievement may be the amount of science taught in high school and the curriculum design enabling large percentages of students to achieve scientific literacy. An overview of science programs in various countries (Gardner, 1991) illustrated that educational systems of the Soviet Union and Eastern Europe focused on producing scientifically literate citizens regardless of their future careers. Curricula are very traditional with much fact and concept-based learning and little emphasis on the use of higher order thinking skills. Each year in secondary school all science areas are taught so that by graduation nearly all students have spent more than 340 hours in chemistry classes. This system successfully produces a scientifically literate citizenry, but students continuing with advanced education in the sciences are generally not as productive or creative as students from the United States (Gardner, 1991).

Efforts to Improve Science Achievement

Concerns of science achievement have spurred evaluation of curriculum and methodology by national, state and relevant professional organizations. A major difference between this current concern and that which

occurred in the 1960's is the realization that science understanding and knowledge is important for all citizens. Reform measures of the 1960's are now viewed as having been elitist and geared for the top students (Walford, 1983). Those initiatives were successful in developing a small number of students into creative, productive scientists that led NASA as well as many corporations into the productive technologies of the 1960's, 1970's and 1980's. Leaders now feel that the reforms of the 1960's need to be undone to make science accessible for all students. Science literacy is defined as understanding (1) the processes of science, (2) basic science terms and concepts, and (3) impacts of science on society (Miller, 1989). The need for science literacy in the general population was shown in a survey of sixty governmental leaders at local, state and national levels (Walford, 1983). Of this group, seventy-four percent had taken high school chemistry and forty-five percent college chemistry, but ninety-four percent responded that their jobs, at least occasionally, involved chemistry related issues. Most of them felt ill-prepared to adequately understand many science issues on which they made decisions. Another study of the general population (Miller, 1989) found that only one in twenty Americans met a minimal definition of scientific literacy. Current thinking

suggests that science teaching must reach as many students as possible and prepare them for their future lives regardless of whether or not they feel that includes science.

In "A Nation at Risk," recommendations included establishing requirements for three years of high school science for graduation. It also included a suggestion that science courses be revised and updated for both college-bound and non-college-bound students (Gardner, 1983). The 1989 Education Summit of the president and governors established National Goals for Education to be reached by the year 2000. These included to achieve a high school graduation rate of ninety percent and for students of the United States to be first in the world in math and science (Executive Office of the President, 1990).

One method proposed and being implemented to reach these goals is to increase the amount of science coursework taken by students in high school. From 1980 to 1987, forty-three states increased math graduation requirements and forty states increased science graduation requirements. These changes resulted in chemistry enrollments increasing from thirty-one percent of students graduating from high school in 1980 to forty-five in 1987 (Blank and Enger, 1992). From 1982 to 1987, the average number of science credits at

the time of graduation rose from 2.19 to 2.63 (Kolstad and Thorne, 1989). A study of high schools with mostly lower-achieving students (sixteen schools in California, Florida, Michigan, and Pennsylvania) showed the number of science credits rising from an average of 1.86 in 1982 to 2.82 in 1989 and chemistry enrollments increasing from thirteen percent to twenty-nine percent of students (Clune, 1991). In Ohio, forty-nine percent of 1990 high school graduates had taken chemistry, and the average chemistry class size was twenty-three students (Blank and Enger, 1992). Evaluation of changing course-taking patterns showed that an overall increase in science course-taking was occurring, but increases were at mostly lower level courses (Blank and Enger, 1992). Concerns exist as to whether increases in enrollment and science credits truly increase overall science achievement.

Major curriculum reform initiatives are currently under way as the American Association for the Advancement of Science (AAAS) and the National Science Teacher's Association (NSTA) show leadership and possible directions. AAAS's 2061 project is focusing on building interconnections between key concepts usually taught in separate courses (Jones, 1990). A benchmark document has been drafted and reviewed by committees across the country. Revisions have occurred

and the resulting text was published in 1993. The text suggests learner objectives at various grade levels in all major areas of science. Emphasis is placed on general concepts in all science areas as well as on understanding processes of science, interactions of science and society, and the past, present and future of scientific development (Project 2061, 1993). NSTA has developed a Scope, Sequence and Coordination project that proposes to do away with traditional curricula in which a separate science area is taught each year and to have every year include all science disciplines (Culotta 1990; Beardsley, 1992).

Ohio is currently undergoing revision of science curriculum and a state model science curriculum is nearing completion at this time. This model will probably follow many suggestions of AAAS as it tries to not stress details and memorization of facts but is more concerned with major concepts and science-society interactions. It is arranged with five broad goals as an organizing structure. The five goals are the nature of science, the physical setting, the living environment, societal perspectives, and thematic ideas (Ohio Department of Education, 1993).

In summary, the goal of curriculum revision is to make science accessible for a greater percentage of students and to increase overall science literacy of

the population. Schools and educational institutions will search for methods to achieve this goal and to revise their course offerings and course content with this in mind.

Factors Affecting Science Achievement

Within a chemistry class, achievement of students is influenced by numerous factors. Some of these involve characteristics of the student's home and environment that are not easily or often influenced by workers at school. Other factors involve characteristics students carry into the classroom such as ability, motivation, prerequisite knowledge and skills, and student cognitive operational level. Finally, achievement is influenced by activity within the classroom, including instructional methods, classroom strategies, teacher characteristics and curriculum. A variety of studies have been conducted to assess effects of many of these variables in chemistry and science classrooms. A comparison study by Reynolds and Walberg (1992) attempted to determine which factors were the most important in promoting student achievement. They showed that the three most important factors, in order, were prior achievement, home environment (parental expectations, socioeconomic status) and instructional time (attendance in class, time doing homework). All

other factors, such as motivation, attitude, class environment and instructional quality, have small effects in comparison to the first three. The authors recommended that any factors which schools and teachers can influence that may affect achievement should be investigated and results utilized to produce optimal learning environments. In this study a review of selected studies will result in a listing of characteristics that facilitate chemistry achievement.

Using data from the 1985-86 National Assessment of Educational Progress, home environment of students in grades seven and eleven was found to correlate strongly to science achievement. Findings suggested a positive relationship exists between student achievement and educational level attained by parents. Also an inverse relationship was found between students' science achievement and the amount of TV watched (Gorman and Yu, 1990). Teachers have virtually no impact on these and many other aspects of their students' environments, but it should not be ignored or forgotten that they greatly affect student achievement.

Many citizens and politicians concerned with quality education of students have suggested that private schools are more effective and that access to them should be available to more students. Any quick look at private school test scores and student data

certainly gives the impression that private schools do a very good job. Data analyzed from tenth graders from the "High School and Beyond" project was tested to compare private and public schools (Staver and Walberg, 1986). Private school achievement was found to be better, but this superiority of private schools disappeared when statistics were adjusted to compensate for student characteristic differences such as ability test scores, parent educational achievement levels and experiences beyond school that contribute to achievement. The study's authors concluded that private school science achievement was better only due to the students attending the schools (Staver and Walberg, 1986).

A study of sophomores in biology classes showed no relationship between self-concept in science and science achievement that follows (Sellars, 1981). The study showed that students having high mental ability and who achieved high in biology will have highest self-concept in science. So instead of self-concept leading to high achievement, it seems that high achievement leads to high self-concept. In a similar manner, the amount of enthusiasm and enjoyment expressed by eighth grade Australian students was found to be related more strongly to prior achievement

than to achievement that follows (Punch and Rennie, 1989).

An investigation of student motivation and study habits of high school science students divided achievement motivation into two categories - those with a goal of learning and understanding for its own sake and those with a goal of performing well in class. It was found that those truly interested in learning valued deep process studying and those concerned with grades employed memorization strategies (Nolen and Haladyna, 1990).

Harpole (1987) found significant gender differences in areas of achievement and lab skills in high school chemistry. Females seemed to prefer lab activities, situations involving working with others and opportunities to help other students. Males preferred working with numbers and logic, math problems and logically organized coursework. Achievement in various areas of chemistry was consistent with these gender differences.

Several studies of high school chemistry investigated the role of cognitive learning styles. Students of the age at which chemistry is taught include some in concrete operational stage, some in formal operational stage, and others undergoing transition from concrete to formal reasoning. Students

capable of formal reasoning show higher achievement in chemistry (Krajcik and Haney, 1987). The manner in which students handle proportional reasoning serves as an example. At the concrete level, students can understand constant ratios equal to small whole numbers. An example of this would be a situation in which two pieces of candy cost \$.25, and students are to determine the cost of four pieces of candy. But a problem stating that twelve pieces cost \$.16, and asking the student to determine the cost of fifteen pieces cannot be comfortably handled until students are on a formal operational level. Nonformal operational students try to memorize ways to solve these problems, but they become frustrated because they cannot truly understand them (Krajcik and Haney, 1987).

Applying information on operational levels of students to the classroom, Moody and Gifford (1990) discovered that the best arrangement for lab groups to facilitate student achievement is to put together students with similar levels of formal reasoning ability. This allows them to communicate on the same cognitive level, whatever that level is, and therefore attain the highest achievement possible. The same study also investigated lab group size and gender grouping. Conclusions included that highest achievement gains will occur when lab groupings are of

two students, homogeneous in gender and formal reasoning ability (Moody and Gifford, 1990).

Teacher behavior is certainly important in the classroom. A study of high school and middle school science students compared student achievement to twelve indicators of teacher classroom management used on a Georgia Teacher's Performance Assessment (McGarity and Butts, 1984). The indicators are concerned with teacher effectiveness in (1) giving clear directions and explanations, (2) providing opportunities to participate, (3) maintaining learner involvement, (4) reinforcing and encouraging, (5) using time efficiently, (6) attending to routine tasks, (7) being warm and friendly, (8) being sensitive to needs and feelings, (9) providing feedback about behavior, (10) promoting comfortable relationships, (11) keeping class behavior acceptable, and (12) managing disruptive behavior. All indicators separately were found to be significant in influencing achievement. These indicators could be used as evaluation criteria enabling all teachers to increase their effectiveness.

Teaching of science material seems to be most effective in increasing achievement when all three phases of the learning cycle are present and in the correct sequence. Studies in both high school chemistry and physics classes support proper sequencing

and use of all three phases (Abraham and Renner, 1983; Abraham and Renner, 1986; Renner, 1988). This cycle concept traces back to Piaget's mental functioning model and has influenced development of various science curriculum projects (SCIS and ESS). The three phases in order are exploration (acquire data), conceptual invention (form concept), and expansion of idea (including relating to existing knowledge).

Cooperative learning as a teaching strategy seems to be capable of producing achievement comparable to traditional methods. An advantage of cooperative learning is its tendency to generate more positive attitudes and to reduce anxiety of students (Pedersen, 1992; Humphreys, 1982).

Ability grouping in middle school students seems to help advanced students, harm slower ones and have a negligible overall effect (Hoffer, 1992). A synthesis of high school studies involving ability grouping (Slavin, 1990) concluded that no significant effect exists due to ability grouping. Neither of these studies presented much description of how the classes of varying ability were handled differently by the teacher. Despite Slavin's conclusions, two studies included in his study do show positive results of ability grouping. Platts (1965) and Chiotti (1961) show significant positive gains by both high and low ability

group students in studies involving science and math classes in which ability grouped classes were compared to non-grouped ones.

Based on findings of this literature search, recommendations for chemistry teaching to provide optimal classroom environment for achievement include:

1. Know students' levels of concrete/formal reasoning, and teach commensurate with their limitations and abilities.
2. Lab/study groups should ideally have two students of the same sex with similar operational reasoning level.
3. Regularly use all three phases of the learning cycle in order.
4. Be aware of the twelve teacher behavior categories from the Georgia Teacher Performance Assessment.

Course-Taking Patterns and Science Achievement

Earlier sections of this literature search investigated the concern of science achievement in the United States and several initiatives to try to improve that achievement. In addition, many specific factors that influence achievement in science classes were detailed. The purpose of this current research is to collect data and evaluate an initiative at one high

school to increase science achievement and the number of science courses taken by students. Adding a general chemistry class, for students who otherwise did not have a good option for a junior year science class, was intended to improve science achievement of specific student population groups in the school. Literature concerned with relating achievement to course taking of science in high school will be reviewed in this section. A limited number of studies of this type have been conducted.

Jones (1986) found a very small relationship between test scores and courses taken in the High School and Beyond Study. Less than two percent of test score variance is due to science courses taken, according to his research and analysis. He felt that the science test was not very reliable as an achievement indicator due to its small size (ten minutes - twenty questions), the influence of knowledge acquired out of classroom, and the variability of science instruction across the country. His analysis included the number of science courses taken, but no information on the courses, other than that they were biology, chemistry or physics, was presented. The data was adjusted statistically for home environment differences (including father's occupation, parent's level of education, family income, household possessions), general intelligence (measured

as verbal achievement as found on reading and vocabulary tests from the High School and Beyond Study), and previously acquired science skills (pretest).

Another study of the same High School and Beyond data (Spade, 1985) found that schools do influence science performance and that this occurs mostly by their influence on the taking of science courses. Instead of treating all students as one group, this study separated students of schools that had mostly high ability students from students of schools with mostly low ability students. Comparisons were made between student performance on two tests, one the sophomore year and another the senior year. In general, the more science courses taken by students between the two test times, the more positive the senior test was in relation to the sophomore one. Strongest effects of this tendency were found in high ability students. In low ability students additional courses helped most if the students were in a low ability school. In high ability schools low ability students were not helped as much by additional science classes (Spade, 1985). Spade suggested that possibly in the high ability schools the lower ability science students could not compete well in science courses after the sophomore year. If true, this suggests a

need for appropriate post-sophomore level courses for lower ability students in high ability schools.

These two studies seem to show different results from the same data. In Jones' study, characteristics of the entire school that students attend are not considered and levels of courses were not investigated. Spade's study does categorize schools by general ability level and effects on individual students of different ability were considered. Possibly Jones' result of little effect resulted from low ability students with little gain in high ability schools cancelling out gains of higher ability students and low ability students in low ability schools. Although he suggests it may be significant, Jones does not clearly show whether special courses for lower ability students in high ability schools could make a difference in their achievement. What is clear from these two studies is that results obtained from mixed group (ability) samples may cause one to overlook that smaller subgroups may show significant variations from the overall trend. To truly determine the best course arrangement for a group of students with special characteristics, a study needs to focus on that group and not look at overall average trends.

A study to test relationships of the number of courses in various subjects and student scores on the

ACT assessment was conducted by Laing (1987), who used data from twenty percent of fall 1985 ACT results (31,419 students). This study did find a significant relationship between high school courses and the ACT science score. No adjustments were made for student ability or other student characteristics. The results were probably predictable due to the nature of the comparisons. Unlike certain subjects, such as English and social studies, which are usually required the junior and senior years, science is usually taken during these years mostly by higher level students. This would result in those with more science courses usually being those of higher ability and their ACT scores should be higher. Laing's study probably does more to validate who elects to enroll in science courses beyond those required by high schools than it does to show the effect of those science classes.

McLarty (1988) also looked at ACT scores (2,353 students) using data scores in test areas as a dependent variable and testing for relationships to a variety of independent variables, including grade point average, gender, race, course grades, courses taken or not. McLarty found that grade point average was the most effective variable in predicting ACT test scores.

The Scholastic Aptitude Test (SAT) and subject achievement test results also have been examined for

relationships to course-taking patterns. Morgan's study (1989) made adjustments to account for differences in academic achievement in high school by grouping grade point averages into categories of A's, B's, and C's and below. Natural science along with math and foreign language have the highest relationship with SAT scores in math. Achievement tests also support the conclusion that more courses result in higher achievement.

Recent data from 1990 NAEP (Jones, 1990) showed that students score higher on science achievement tests if they have taken more semesters of science in high school. But the data also indicated the additional coursework benefited some population subgroups more than others. At all levels of course-taking, blacks trailed behind non-blacks, and females trailed behind males. This difference between population subgroups become even more pronounced as the number of courses taken became greater.

To summarize studies relating course-taking to achievement, it may be concluded that in most cases positive relationships do exist between the number of science courses and achievement. What is not clear, though, is how much of this is due to the additional courses taken and how much to the tendency of higher level students to take more science courses.

CHAPTER III

RESEARCH METHODOLOGY

Setting

Springboro High School of Springboro Community Schools is located in a district undergoing considerable population growth and a changing community nature. This school district was formerly composed of a small town surrounded by farmland, but it is quickly changing into a suburban area that eventually will be contiguous with south Dayton suburbs. Many housing developments currently being constructed are designed to accommodate upper middle class families. Due to the changing nature of the district's population and socioeconomic setting, the high school is experiencing growth and has need to evaluate and modify academic programs.

The student population of the high school was just under 700 during the 1992-1993 school year (the last year of collected data). This population is nearly all Caucasian with just a few individuals of other racial backgrounds. In recent years, more than 60% of graduates entered post-secondary education programs.

Data Collection Procedure

Student data were collected from the graduating classes of 1988-1993. These years represent the first six graduating classes having opportunity to enroll in the general chemistry class. Data were collected for students who attended Springboro High School all four years of high school, completed any chemistry course taken their junior year, have ACT results in their files, and have information on other variables used in this study. For each student information was obtained on science courses and grades, grade point average (GPA), ACT science subscore (ACTSCI), tenth grade CAP verbal ability score (CAPVERB), tenth grade CAP quantitative ability score (CAPQUAN), tenth grade nonverbal ability score (CAPNONV), and tenth grade TAP science achievement score (TAPSCI). All tenth grade students at Springboro High School take the CAP-TAP tests. These results, in the form of national percentiles, were expected to be useful in comparing characteristics of students choosing different science course options for the eleventh grade year.

Student Groups for Comparison

Achievement gains of students taking general chemistry were be compared to those of students choosing other options. Students were be placed into one of five groups based on science courses completed, including whether or not they choose to enroll in general chemistry.

Groups I and II consist of students who have taken general biology during their sophomore year. In addition, Group I members have taken general chemistry and Group II members did not complete another science class. Groups III, IV and V include students who have taken college preparatory biology during their sophomore year. Group III members have also taken college preparatory chemistry, Group IV members have taken general chemistry, and Group V members have taken no additional science courses (See Table 1, p 5, and Table 2, p 37).

Analysis of Data

Analysis of data included both descriptive statistics and the testing of relationships between variables. Means and standard deviations were calculated for the six student characteristic variables

In each of the five groups. Pearson correlation coefficients were determined along with their significance to indicate which variables show a relationship to ACT science scores. T-tests and analysis of covariance were utilized to examine possible relationships more closely and to examine the effect of course-taking patterns on ACT natural science achievement.

CHAPTER IV

RESULTS

Student data were collected for 304 students. All of these except seven fit into the five groups formed by course-taking patterns. These seven had unusual course-taking patterns. The number of students in each group is shown in Table 2. As can be seen from the table, Group III has the most members with nearly one-half of the total. Groups II and V, the groups whose members did not take any chemistry class, had the smallest sizes at 24 and 33, respectively. Groups I and IV, the groups whose members completed general chemistry, had sizes of 45 and 58 members, respectively.

TABLE 2

STUDENT NUMBERS IN COURSE-TAKING PATTERN GROUPS		
Group	Course-Taking Pattern	Number
I	gen. biology-gen. chem.	45
II	gen. biology-no chem.	24
III	c.p. biology-c.p. chem.	137
IV	c.p. biology-gen. chem.	58
V	c.p. biology-no chem.	33

Once the students were assigned to groups, analysis was performed independently on each group to determine the mean and standard deviation for each of the six variables. This data is displayed in Table 3.

TABLE 3
MEANS AND STANDARD DEVIATIONS
OF SIX VARIABLES FOR DATA IN FIVE GROUPS

Variable		I	II	Group III	IV	V
ACTSCI	mean	17.1	18.4	22.1	19.6	20.1
	std dev	3.1	3.0	4.8	3.8	3.7
CAPVERB	mean	48.8	60.0	78.3	69.9	72.4
	std dev	21.4	22.9	15.6	19.0	18.7
CAPQUAN	mean	47.0	57.8	80.3	64.8	76.9
	std dev	24.7	23.3	19.2	24.4	18.4
CAPNONV	mean	45.7	53.1	77.7	63.9	68.4
	std dev	23.6	27.6	21.5	26.8	26.1
TAPSCI	mean	48.2	44.2	75.2	62.8	69.2
	std dev	22.4	27.0	16.4	21.5	21.7
GPA	mean	2.32	2.46	3.30	2.63	2.92
	std dev	0.45	0.66	0.61	0.51	0.49

TABLE 4

PEARSON CORRELATION COEFFICIENTS
FOR ALL FIVE DATA GROUPS
WITH ACTSCI AS DEPENDENT VARIABLE
AND OTHER VARIABLES AS INDEPENDENT VARIABLES

Variable		GROUP				
		I	II	III	IV	V
CAPVERB	r	0.2476	0.6180	0.5518	0.3759	0.5890
	p	0.1010	0.0013*	0.0001*	0.0036*	0.0003*
CAPQUAN	r	0.1754	0.2116	0.4349	0.1752	0.4072
	p	0.2491	0.3208	0.0001*	0.1884	0.0187*
CAPNONV	r	0.2708	-0.1072	0.3982	0.2324	0.3197
	p	0.0720	0.6181	0.0001*	0.0791	0.0697
TAPSCI	r	0.1724	0.6527	0.5468	0.2610	0.0631
	p	0.2573	0.0005*	0.0001*	0.0479*	0.7272
GPA	r	0.2052	0.4830	0.5985	0.3930	0.4314
	p	0.1763	0.0196*	0.0001*	0.0023*	0.0137*

* significant at $p < .05$

Next, Pearson correlation coefficients were determined using ACTSCI scores as the dependent variable and the other five variables as independent variables to determine which variables are significantly correlated to the ACTSCI achievement results. A confidence level of .05 was used. This data is displayed in Table 4. For Group I, none of the

variables showed significant correlations with ACTSCI scores. In all four remaining groups, ACTSCI scores showed significant correlations with CAPVERB scores and GPA. TAPSCI scores showed significant correlations with ACTSCI scores in Groups II, III and IV. CAPQUAN scores were significantly correlated with ACTSCI scores in Groups III and V. CAPNONV scores were significantly correlated with ACTSCI in Group III.

Analysis of groups was chiefly be concerned with comparing Group I to Group II, and comparing Groups III, IV and V with each other. In Groups I and II, all student samples are considered important since the two course-taking patterns are available to all students completing general biology. But Groups III, IV and V represent a different situation. Many students completing college preparatory biology will definitely, without hesitation or thought, enroll in college preparatory chemistry. These students generally have strong math backgrounds and have been very successful in previous science courses. Other students, who have weaker math backgrounds and have been less successful in science courses, need to make a decision whether to enroll in college preparatory chemistry, general chemistry, or no chemistry. These are the students of concern in Groups III, IV and V. So instead of using all students from those three groups, only these

students needing to make a choice between the three options will be used in evaluating course patterns for Groups III, IV and V.

To separate these students from others in the three groups, a decision was made to establish two criteria: a grade point average of less than 3.3 and a grade of B- or lower in college preparatory biology. These criteria seem to describe nearly all students in Groups IV and V. Using these criteria reduces student numbers of Group III from 137 to 65, Group IV from 58 to 52, and Group V from 33 to 24. This eliminates from subsequent analysis 72 students from Group III who are deemed to be appropriately placed in college preparatory chemistry.

With the modifications of group memberships in Groups III, IV and V by the described criteria, these groups were again evaluated for Pearson correlation coefficients. The results are listed in Table 5. As before, the confidence level was set at .05. In these reduced group sizes differences occur in which variables have significant correlations with ACTSCI scores. All three groups show significant relationships between CAPVERB scores and ACTSCI scores. GPA is now only significant in Groups III and IV. CAPQUAN scores are significant in Group V, and TAPSCI scores are significant in Group III.

TABLE 5
 PEARSON CORRELATION COEFFICIENTS
 USING ACTSCI AS DEPENDENT VARIABLE
 FOR GROUPS III, IV AND V FOR
 STUDENTS WITH B- OR LOWER IN C.P. BIOLOGY

Variable		Group		
		III	IV	V
CAPVERB	r	0.4078	0.3167	0.6088
	p	0.0006*	0.0222*	0.0010*
CAPQUAN	r	0.2203	0.1379	0.3964
	p	0.0711	0.3296	0.0450*
CAPNONV	r	0.1829	0.1711	0.2756
	p	0.1355	0.2252	0.1730
TAPSCI	r	0.3215	0.1581	0.0208
	p	0.0075*	0.2629	0.9195
GPA	r	0.3393	0.3783	0.3325
	p	0.0043*	0.0057*	0.1044

* significant at $p < .05$

Next t-tests were used to determine whether Groups I and II exhibit significant differences in any of the six variables. An initial analysis of the data determined whether the variance was equal or unequal and then the appropriate t-test was utilized. Table 6 shows the results of these calculations. The only significant difference in student variables between these two groups is for CAPVERB score. All other variables do not exhibit significant differences between the two groups.

TABLE 6

T-TESTS FOR GROUPS I AND II

FOR SIX STUDENT CHARACTERISTIC DIFFERENCES

VARIABLE	F'	DF	p	variance	T	DF	p
CAPVERB	1.15	(23,44)	.678	equal	-2.035	67.0	.046*
CAPQUAN	1.12	(44,23)	.789	equal	-1.758	67.0	.083
CAPNONV	1.36	(23,44)	.376	equal	-1.174	67.0	.245
TAPSCI	1.45	(23,44)	.283	equal	0.656	67.0	.514
GPA	2.22	(22,44)	.024	unequal	-0.938	32.4	.357
ACTSCI	1.05	(44,23)	.924	equal	-1.711	67.0	.092

for variance: $p > .05$ variance is equal

$p < .05$ variance is unequal

* for T: $p < .05$ is significant

To further evaluate the importance of variables on ACTSCI scores, several analyses of covariance determinations were made. For comparisons between Groups I and II, since the correlation analysis indicated that both groups were not influenced by any variable in common, an analysis was run for the most significant variable affecting Group II. This analysis of covariance shows whether the group membership has an effect on ACTSCI scores after the effect due to TAPSCI is removed from the data. Results of this analysis are shown in Table 7.

TABLE 7

ANALYSIS OF COVARIANCE OF GROUPS I AND II
DEPENDENT VARIABLE - ACTSCI
COVARIATES - TAPSCI AND GROUP MEMBERSHIP

Source	DF	F	p
TAPSCI	39	0.93	0.587
Group	1	2.53	0.123

Group	TAPSCI Mean	ACTSCI Mean	Adjusted ACTSCI Mean	Standard Error
I	48.2	17.1	16.8	0.7
II	44.2	18.4	19.1	0.9

The data set consisted of 69 observations and had 2 levels of group membership and 40 levels of TAPSCI. A Type III Sum of Squares analysis was used since group sizes were unequal. The degrees of freedom in the denominator was 28. Initial analysis testing the slopes of TAPSCI and group covariates produced a F value of 1.17, $p=.3585$. Since $p<.05$, the slopes were parallel and the analysis could be completed. The resulting TAPSCI data, $F(39,28) = 0.93$, $p>.05$, indicate that TAPSCI scores were not a significant factor in predicting ACTSCI scores. In a similar manner group membership, $F(1,28) = 2.53$, $p>.05$, indicated that group membership was also not significant.

Pearson correlation data from Groups III, IV and V indicated that GPA and CAPVERB scores showed significant relationships in all three groups to ACTSCI scores. For that reason, these were tested along with group membership using analysis of covariance. In each test, ACTSCI was the dependent variable, group membership was one covariate and GPA or CAPVERB was the other covariate.

The analysis using GPA included 140 observations. Initial testing of the covariates yielded a F value of 0.30, $p=0.739$. This indicated that the slopes of the covariates were equal since $p>.05$. Completing the analysis utilized 136 as the degrees of freedom in the

demoninator. Results, in Table 8, show that GPA, $F(1,136) = 19.32, p < .05$, was significant in influencing ACTSCI scores. The group membership was not significant, $F(2,136) = 0.34, p > .05$.

Table 8

ANALYSIS OF COVARIANCE OF GROUPS III, IV AND V
DEPENDENT VARIABLE - ACTSCI
COVARIATES - GPA AND GROUP MEMBERSHIP

Source	DF	F	p
GPA	1	19.32	0.0001
Group	2	0.34	0.7125

Group	TAPSCI Mean	ACTSCI Mean	Adjusted ACTSCI Mean	Standard Error
III	67.43	19.64	19.26	0.48
IV	61.23	19.25	19.84	0.54
V	68.27	19.54	19.28	0.80

The analysis using CAPVERB included 141 observations. Initial testing of the covariates yielded a F value of 0.81, $p=0.447$. This indicated that the slopes of the covariates were equal since $p>.05$. Completing the analysis utilized 136 as the degrees of freedom in the denominator. Results, in Table 9, show that CAPVERB, $F(1,136) = 24.32$, $p<.05$, was significant in predicting the ACTSCI score. The group membership was not significant, $F(2,136) = 0.07$, $p>.05$.

TABLE 9

ANALYSIS OF COVARIANCE IN GROUPS III, IV AND V
DEPENDENT VARIABLE - ACTSCI
COVARIATES - CAPVERB AND GROUP MEMBERSHIP

Source	DF	F	P
CAPVERB	1	24.32	0.0001
Group	2	0.07	0.9340

Group	TAPSCI Mean	ACTSCI Mean	Adjusted ACTSCI Mean	Standard Error
III	67.43	19.64	19.61	0.47
IV	61.23	19.25	19.35	0.52
V	68.27	19.54	19.48	0.77

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Data for 304 students of six graduating classes from Springboro High School were collected and statistics derived to characterize and evaluate a general chemistry course. Implementation of the course provided students with science course options for the third year of high school and was hoped by the school to increase science achievement of particular student groups. This research project's goal was to generate statistical data on students choosing various course-taking patterns and to evaluate general chemistry's effectiveness in increasing student achievement. The null hypothesis that group membership would not affect achievement scores was tested.

Statistical Conclusions

Students completing a general biology course during their sophomore year had two options for their junior year. Students choosing to enroll in general chemistry comprised Group I, and students choosing not to enroll in a chemistry course comprised Group II. Statistical analysis of data from these two groups showed that the only significant difference in student characteristic

variables, included in this study, was that CAP verbal ability scores were higher in Group II. In evaluating factors important in influencing ACT science scores a Pearson correlation analysis found that none of the studied variables affected Group I ACT science scores, but CAP verbal ability scores, TAP science achievement scores and grade point averages all showed significant correlations to the ACT science scores. An analysis of covariance, removing the effect of CAP verbal ability scores, did not disprove the null hypothesis that group membership would show no effect on achievement scores.

Students who completed a college preparatory biology class their sophomore year were placed in groups based on which of three science options they chose for their Junior year. Group III was composed of students choosing to take college preparatory chemistry, Group IV of students choosing general chemistry, and Group V of students choosing to take no science class. Of these students, analysis focused on ones who had grade point averages of less than 3.3 and earned a B- or lower in college preparatory biology. The rationale for targeting this group for analysis was that these students realistically had three options from which to choose. It was felt that higher achieving students would definitely enroll in college preparatory chemistry, and 83% (72 of 87) did.

Analysis of data from Groups III, IV and V indicated that although several student characteristic variables showed correlations with ACT science scores, group membership itself did not show a significant relationship to ACT science scores. Therefore, the null hypothesis that group membership would have no influence on achievement held up in tests and was not rejected. All three groups had significant correlations between CAP verbal ability scores and ACT science scores. Grade point averages had significant correlations in Groups III and IV with ACT science scores. The ACT scores were also significantly correlated in Group V with CAP quantitative ability scores and in Group III with TAP science achievement scores.

Discussion

This study's null hypothesis that student course choices between college preparatory chemistry, general chemistry and no chemistry their junior year does not affect achievement was not rejected. Based on collected data, including ACT science scores as the achievement indicator, statistical analysis did not show course selection affecting achievement scores. Analysis of covariance in both sets of groups found group membership as not being significant. This result leads to two possible lines of thought: Course-taking

patterns truly make no difference, or the ACT subscore used does not illustrate achievement gains by chemistry students.

If course-taking patterns analyzed truly make no difference in science achievement, this should be an area of great concern. That college preparatory chemistry and general chemistry do not show achievement differences from each other could be acceptable, but for no chemistry to show similar achievement to that of the two courses is certainly troublesome.

The ACT science subscore was chosen as an achievement indicator because it was available in student high school records and because it is the only science-related section of commonly used college admission tests. It is surprising that no relationship was found between course-taking patterns and the ACT score. This might be due to the nature of this test subsection. It is essentially composed of reading sections on science processes and information topics with questions that require careful analytical thinking. Despite the usefulness of being familiar with the science topics and scientific processes included, possibly the most important criteria related to high scores on this test is verbal ability. In four of the five groups analyzed, CAP verbal ability scores showed significant correlations with ACT science scores. So, in reality, this ACT subscore may be more

of a reading and critical thinking test than a science test.

Even though the ACT science test may not be an acceptable achievement test for chemistry classes, it may be an indicator of students' training to think scientifically about reading passages on science topics. If high school courses accept a goal of preparing students to do well on college admission tests, this research seems to indicate a lack of achieving that goal.

Another interesting observation of this project's results is that in only one group does TAP science achievement scores show a significant correlation to ACT science scores. This is additional evidence that the two science achievement tests measure very different aspects of science.

Recommendations

This study has resulted in issues of concern. These could be investigated in future projects. First, the lack of achievement differences between the various course-taking patterns suggests a need for additional study. Before concluding that truly no differences exist, more data should be collected. A more appropriate testing tool to judge the effectiveness of different courses could be utilized. One possibility

for an alternative tool might be the Ohio twelfth grade proficiency test in science which is scheduled to be first given during the 1995-1996 school year. This research does not provide an answer as to which chemistry course is more effective in increasing achievement of the different student groups. For the purpose of advising students making decisions on junior year science classes, this type of information would be helpful.

An additional concern is that the science courses in this study do not seem to influence ACT science subscores. A close review of the subtest might provide information which could suggest activities and methods to be used in science classes to more adequately prepare students for this test.

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