Mathematics Ability and Science Reasoning as Predictors of Science Achievement among African-American Students at a Historical Black College or University

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Abstract

This research focuses on the belief that the level of science achievement of students is dependent on each student's mathematical and science reasoning abilities. The American College Test (ACT) is an assessment tool that has been widely accepted as having the capability to assess mathematical and science reasoning abilities of students prior to entrance into institutions of higher learning (Barrons Regents, 2008).

Research participants were African-American students enrolled in Physical Science at a Historical Black Colleges and University (HBCU). Students enrolled were non-science majors of both genders, who were required to take a science option in fulfillment of degree and university graduation requirements.

This research was based on the hypothesis that the subscores of African-American students on the mathematical skills and science reasoning portions of the ACT would positively correlate with each student's individual Physical Science final grade. A Pearson correlation was conducted and positive correlations were observed. Although positive correlations were observed between math ACT and final grades, results were not significant, $r = .131$, $N=120$, $p = .155$. There was also a positive correlation between science reasoning ACT and final grades. These results were also not significant, $r = .109$, $N = 120$, $p = .237$. Being that the majority of students who participated in the study were from one state, had similar high school backgrounds, had similar majors, and were similar in age, the sample had more homogeneity than difference. This may be the most plausible explanation for the results found in this study.

Background

In a society driven by science and technology, many high school and college graduates have been reported as unknowledgeable about basic scientific concepts (Lee, 2002). The issue of science literacy has been the primary focus of Project 2061. Project 2061 is an initiative of the American Association for the Advancement of Science (AAAS) aimed at promoting science literacy in math, technology and science by the year 2061.

Project 2061 efforts were catapulted by the release of the report, "Science for All Americans", published in 1989. This report highlighted in detail the science performance and achievement of American school age children in comparison to their school age counterparts in other countries. School age children of the same grade level, from various countries, including the United States, were given the same test on the same science content. The results indicated a remarkable deficit among school age children from the United States in comparison to students from other countries. Following this, the ground work for standard based teaching and the Benchmarks for Science Literacy were incorporated into established goals for the promotion of science literacy in the United States. Furthermore, each state developed its own curriculum based on the benchmarks (AAAS, 2007).

The No Child Left Behind Act (NCLBA) in 2001 forced many school districts to revisit their own individual instructional strategies. Emphasis on test scores and achievement in science courses became a major focus. Previous research has shown that the development of science literacy is related to student achievement (Moore & Foy, 1998). A student's failure at school has been associated with later issues with substance abuse, violence and acts of criminal behavior (Goodstadt, 1989). Moreover, a student's failure in science courses and science related courses has been associated with low socio-economic status, low potential for employability and lower wages once employed (Geary & Hamson, 2007).

Theoretical Framework

The focus of this research was based on the assumption that a person's achievement in science and science related courses can be attributed to the individual's achievement in mathematics and ability to reason scientifically. Many studies have focused on the importance of science achievement (Beaton et al., 1996; Geary & Hamson, 2007; Harding & Parker, 1995, 1995; Mullis et al., 1998; Von Secker & Lissitz, 1999). The United States has been deemed as one of the wealthiest nations in the world. However, when it comes to science achievement, it is ranked very low when compared to other nations (Beaton et al., 1996; Forgione Jr., 1998; Geary & Hamson, 2007; Linn et al., 2000). In recent studies, United States 8th graders ranked 28th out of 41 nations (Geary & Hamson, 2007). Seventh graders, ranked 24th out of 39 nations (Geary & Hamson, 2007). Although the United States as a whole has performed poorly in science when compared to other nations; African American students tend to have more difficulty when compared to their Caucasian counterparts (AAAS, 2007; Alliance for Excellent Education, 2006; Ikpa, 2003; Jencks & Phillips, 1998; Lucas, 2000; Trent, 1997).

Previous literature argued that because equal opportunity to public education has been given to Caucasians as well as minorities an inadequacy in achievement must be the result of one of three factors. These factors include cultural practices, lack of desire to achieve and other inherent factors such as genes and environment (Hernstein & Murray, 1994; Thernstrom & Thernstrom,

2003). In contrast, the literature has also linked the difficulties that African Americans face to the disparity in resources within the community to improve the science and other related skills of not only African Americans but other minorities as well (Darling-Hammond, 1998; Ikpa, 2003; Johnson & Kritsonis, 2006).

Resources are often limited or in some cases nonexistent in communities that largely service minorities. This disparity has been associated with a lack of qualified teachers, materials, inadequate curriculum and curriculum resources (Darling-Hammond, 1998). According to current studies, fifty-five percent of science teachers in the United States are not knowledgeable about the field in which they teach due to a lack of a major or minor in a science subject area (Forgione Jr., 1998).

Recent literature cited the United States as the most unequal industrialized country in the world with race as a factor attributing to the different opportunities for learning. The United States differs from European and Asian countries because it bases opportunities on social class as well as race. Access to quality education was also associated with access to funding opportunities to support education (Darling-Hammond, 1998; Kozol, 1991).

Recent polls reported that minorities heavily reside in states in which the average household income is $48,371.30. These states included: Alabama, Arizona, Arkansas, Alaska, California, Georgia, Florida, Hawaii, Illinois, Louisiana, Massachusetts, Maryland, Michigan, Mississippi, New Mexico, North Carolina, New Jersey, Oklahoma, South Carolina, Texas, Utah, Virginia, and Washington, (United States Census Bureau, 2006; Williams, Morris & Furman, 2007). States with low minority populations had an average household income of $101,267.46 which was 2.09 times greater than the average household income of states in which minorities heavily resided. The states with low populations of minorities included: Colorado, Connecticut, Delaware, Idaho, Indiana, Iowa, Kansas, Kentucky, Maine, Minnesota, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New York, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island, South Dakota, Tennessee, Vermont, West Virginia, Wisconsin, and Wyoming. This difference in the overall average household income caused many minorities to be totally or partially dependent on financial aid, grants and scholarships in which resources are limited or simply not available (United States Census Bureau, 2006; Williams, Morris, & Furman, 2007). In addition, research has also shown that many minorities do not tend to leave their home state to pursue academic education in institutes of higher learning due to economic constraints (Guess, 2007; Williams, Morris, & Furman, 2007).

According to a recent article the need for math and science achievement was cited as imperative for the United States to remain a fierce competitor in the global marketplace (Alliance for Excellent Education, 2006; Geary & Hamson, 2007). The strength of the economy is based on skills that students obtain in math and science courses. Having skills in math and science increases the employability of an individual and gives that individual an socioeconomic advantage in a technologically driven society (Alliance for

Excellent Education, 2006; Center for Public Education, 2007; Geary & Hamson, 2007).

The United States Commission on National Security listed math and science achievement deficiencies as a greater threat to the security of the United States than any war we have ever seen or could possibly conceive (NCEE, A Nation at Risk, 1983). To remain fierce competitors in the global marketplace, investment in the future of American students is critical. American students would include all of the races represented in the United States population and both genders (Center for Public Education, 2007).

Many studies have focused on math achievement (Beaton et al., 1996; Ding & Davison, 2005; Lee, 2006; Marsh, 1986) and science achievement (Beaton et al., 1996; Harding & Parker, 1995; Mullis et al., 1998; Von Secker & Lissitz, 1999). These studies concluded that learning is a process that can be enhanced over time and that achievement levels in math and science could improve.

The Trends In Mathematics and Science Study (TIMSS) is a four year cycle international study that began in 1995 and has been repeated every four years since its initial launching. The last cycle was completed in 2007. TIMSS was developed by the International Association for the Evaluation of Educational Achievement (IEA). The assessment includes the science and mathematics content of 4th and 8th grade students by using benchmarks that are universally defined. The 4th grade assessment includes all of the science and mathematics knowledge prior to and including 4th grade. The eighth grade and the last year of high school were also assessed. The study began with forty-one nations participating and has since in recent studies added an additional 19 participating countries totaling 60 countries. These countries included: Algeria, Armenia, Australia, Austria, Bahrain, Bosnia and Herzegovina, Botswana, Bulgaria, Canada, Chinese Taipei, Colombia, Cyprus, Czech Republic, Denmark, Djibouti, Egypt, El Salvador, England, Georgia, Germany, Honduras, Hong Kong, Hungary, Indonesia, Iran, Israel, Italy, Japan, Jordan, Kuwait, Latvia, Lebanon, Lithuania, Malaysia, Malta, Mongolia, Morocco, Netherlands, New Zealand, Norway, Palestinian National Authority, Qatar, Romania, Russian Federation, Saudi Arabia, Scotland, Serbia, Singapore, Slovakia, Slovenia, South Africa, South Korea, Sweden, Syrian Arab Republic, Thailand, Tunisia , Turkey, Ukraine, United States and Uzbekistan. Unlike other countries, TIMSS research in the United States is conducted by the National Center for Education Statistics, an entity of the United States Department of Education (USDE).

Assessment is conducted in two parts. The first part consists of questionnaires that are given to the students, teachers, and schools. The student questionnaire asks questions regarding the student's attitude, perception, experiences at school in general and in the classroom as well as background information including the student's demographic information. The teacher and school questionnaire asks questions about the mathematics classes offered, science classes offered, student schedules, the educational level of the teacher, teacher opportunities for professional development, school policies and

procedures, and resources available for the both the student and the teacher. The second part of the assessment includes the actual test that is administered to each student. This test includes questions that range from minimum to increasing difficulty. TIMSS tests the math and science curriculum of schools around the world and whether or not the math and science curriculum taught actually works. Whether or not a curriculum works is based on the achievement level of students who participate in the study.

Setting

This study was conducted at a historical black college or university in the southeastern portion of the United States. The research population consisted of African-American students enrolled in Physical Science.

Physical Science is a science option for students who are not majoring in science or a science-related discipline. Occasionally other science options such as Astronomy and General Science are offered. The other science options are offered based on student interest and faculty availability. According to the Institutions of Higher Learning, all students must have a science course in order to receive a college degree. This assures that all college students have some level of science literacy upon graduating from an accredited university. Students taking Physical Science were required to purchase the same Physical Science textbook. A standardized syllabus was given to each student taking Physical Science that outlines the course requirements. A department designated officer, deemed the Coordinator of the Physical Science Classes, determined the content of what was taught in Physical Science Classes at the research HBCU. The Physical Science class taught was not based solely in Chemistry. However, the course covered certain principles used in Chemistry such as the study of physical and chemical changes, the states of matter and the study of elements. The course also incorporated the basic principles of Meteorology, Geology, Astronomy and Physics. There were nine sections of Physical Science during the semester in which the research was conducted. However if a greater need develops such as increased enrollment, other sections generally are added to fill the need. Seven of the nine sections participated in the study. Classes met once a week for a two hour lecture and one hour a week for laboratory activities. Evening classes met once a week for four hours, which included laboratory activities.

Participants

The participants in this study were students enrolled in Physical Science classes at the same university. The participants in this study were all African-American. Both genders participated in the study. The classroom size ranged between 15-35 students per class. The number included in the study was 120 from different course sections of Physical Science. Each student that participated in the study was asked to take a survey.

Research Design

The ACT was developed in 1959 as an alternate standardized college admissions test. Prior to its development, the SAT was the only accepted test for admissions to universities and colleges. Although both the SAT and ACT have undergone several revisions, each remains a very important means of assessing the academic achievement levels of students prior to college. The ACT originally consisted of four subtests until 2005, in which a writing component was added to the English, Mathematics, Reading Comprehension, and Science Reasoning subtests. In this study the English, Reading Comprehension, and Writing portions were not investigated because the reviewed literature showed more of a positive correlation to the chosen predictors involved in this study.

The results of the ACT were used to measure the student's academic performance from two of the five subtests included in the ACT. The subtests included were Mathematics and Science Reasoning. ACT scores were submitted as part of the application process for prospective undergraduates at the research HBCU. In order to gain admission to the research HBCU under regular admissions, students are granted four options. The first option is to complete a college preparatory curriculum with a minimum 3.2 grade point average (GPA) on a 4.0 scale. The second option granted is to complete the college preparatory curriculum with a minimum 2.5GPA or in the 50th percentile in class rank with a minimum ACT score of 16 or SAT equivalent. The third option granted to students is to complete the college preparatory curriculum with a minimum 2.0GPA and an 18 on the ACT or SAT equivalent. The fourth option under regular admissions granted is to satisfy the National College Athletic Association Requirements. Students under this option are considered as "full qualifiers" under the Division I Guidelines. These guidelines require that students must have a 2.5GPA on the college preparatory curriculum and have a minimum ACT score of 17 or SAT equivalent. Students who do not meet the regular admissions requirements must participate in a screening test called the "Accuplacer Test". If students pass this test, regular admission is granted. If students do not pass the Accuplacer Test, a summer remediation program is required to obtain admission. The summer remediation program is a nine week program from June through August. In addition, students must actively participate in a year long support program. If students do not pass the summer remediation program, they are advised to pursue other educational options.

Students were asked for permission to obtain the ACT scores submitted to the admissions office as part of the undergraduate application process at the research HBCU. Students were informed that the scores would be used only for the purpose of this study and that information would remain confidential. In addition, students were made aware that participation was on a voluntary basis and would not affect their individual class grade. The researcher obtained written consent, presented the purpose of the study orally and answered any questions directed from the students. Also, students were asked to complete a personal data survey sheet (Appendix A) and informed that there were not any right or wrong answers. Physical Science teachers were asked to submit

midterm and final grades at the end of the study. Three Physical Science instructors participated in the study, with students from seven different sections. Two instructors that participated in the study taught two sections of Physical Science and the third instructor taught three sections.

Results

The ACT subtests scores of the 120 participants revealed that the majority of participants, scored between 16-19 on the math portion of the ACT. Student majority also scored between 16-19 on the science reasoning portion of the ACT. The distribution of ACT subtests scores, in relationship to frequency, can be seen in Figure 1. The national average for the ACT subtests including math and science reasoning for the years 2002-2006 was 21 (ACT Incorporated, 2007). Therefore, the majority of students scored below the national average at the research HBCU. In light of this data, the researcher found it necessary to investigate other factors that might affect science achievement based on the personal data information sheet (Appendix A). These factors included the age of the student, the number of hours the student studies per week for the college level Physical Science course, if the student had children, if the student was employed and grade expected in the college level Physical Science course. Other factors investigated were midterm and final grades. A Pearson correlation was conducted to analyze this data. The results did not reveal any significant correlations. These results can be seen in Table I and Figure I, respectively. Figure I also indicate student grade expectations along with actual midterm and final grades received.

The research hypothesis was based on the belief that the ACT mathematical skills and science reasoning scores would positively correlate with each student's individual Physical Science final grade.

A Pearson correlation was conducted and positive correlations were observed. Although positive correlations were observed between math ACT and final grades, results were not significant, $r = .131$, $N=120$, $p = .155$. There was also a positive correlation between science reasoning ACT and final grades. These results were also not significant, $r = .109$, $N = 120$, $p = .237$. These findings can best be explained based on the information indicated on the personal data information sheet, Appendix A, Figure IV, Table III and Table II. Figure III shows the home state of participants and indicates that the majority of participants came from the state of Mississippi. Table II shows the math classes students had taken in high school. Table III indicates the science classes students had taken in high school. In addition, Figure II lists the majors of participants. Tables II, III and Figure IV all show that students in the study had similar backgrounds. Other marked similarities were noted in Appendix A. Therefore, it can be concluded that the sample may have had more homogeneity than difference.

Conclusion

The idea behind this research was to find a means of improving the achievement level of African American non-science majors enrolled in college level Physical Science courses at the research university, an HBCU. The purpose of this research was to collect data that could help identify some of the factors that influence African-American achievement in science. The results of this research would enable science educators and researchers to design programs that could build the science reasoning and mathematic skills of college level students. The improvement of these skills could help students succeed in science as well as graduate school programs.

Previous studies have focused on the science achievement levels of students (Beaton et al., 1996; Harding & Parker, 1995; Mullis et al., 1998; Von Secker & Lissitz, 1999). These studies have found a correlation between achievement and success in life. It has also been well documented the struggles African Americans have, due to an insufficient knowledge of math and science (Darling-Hammond, 1998; Ikpa, 2003; Johnson & Kritsonis, 2006).

Lack of achievement in math and science impacts the future of African Americans. As the population of the United States increases, the graduation rates of minorities steadily decline (Alliance for Excellent Education, 2006). The ability to understand and improve science achievement would therefore increase the presence of African Americans in the fields of science and technology (Williams, 2008).

The promotion of global competitiveness through science literacy depends on being able to identify those factors that could positively affect science achievement in Physical Science courses at historical black universities and colleges. Furthermore, the findings of this research, could also help increase the presence of African Americans in science careers and emphasize the importance of steadfast mentoring, tutoring and educating of African Americans regarding possible career choices in science and science-related disciplines. This paper focused on the assumption that a lack of success in science has strong economic and societal consequences (Alliance for Excellent Education, 2006; Geary & Hamson, 2007).

Table I
Other Factors Affecting Performance

	Final Grade
Number of Study Hours per Week	
Pearson Correlation	.056
Sig. (2-tailed)	.546
Student Has Children	
Pearson Correlation	.049
Sig. (2-tailed)	.593
Employment	
Pearson Correlation	-.072
Sig. (2-tailed)	.432
Number of Science Classes	
Pearson Correlation	.099
Sig. (2-tailed)	.283
Age	
Pearson Correlation	.088
Sig. (2-tailed)	.343

Table II
Math Classes Taken In High School

	Count	Percent
Algebra 1		
No	12	10
Yes	108	90
Algebra 2		
No	26	21.7
Yes	94	78.3
Geometry		
No	12	10
Yes	108	90
Trigonometry		
No	81	67.5
Yes	18	15
Calculus		
No	102	85
Yes	18	15
Took Other Math Classes		
No	102	85
Yes	18	15

Table III
Science Classes Taken in High School

	Count	Percent
Biology		
No	5	4.2
Yes	115	95.8
Chemistry		
No	34	28.3
Yes	86	71.7
Physics		
No	101	84.2
Yes	19	15.8
Physical Science		
No	51	42.5
Yes	69	57.5
Took Other Science Courses		
No	93	77.5
Yes	27	22.5
Number of Science Courses Taken		
1	6	5
2	8	6.7
3	55	45.8
4	51	42.5

Figure I. Distribution of expected grades, midterm grades and final grades

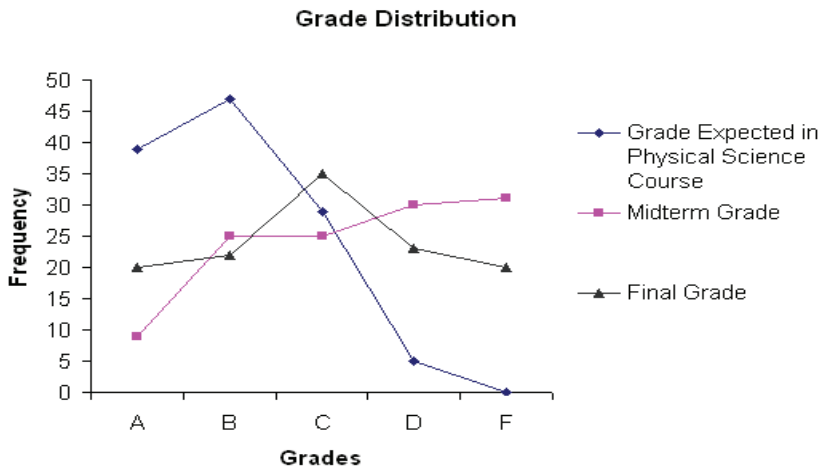


Figure II. Majors of Participants

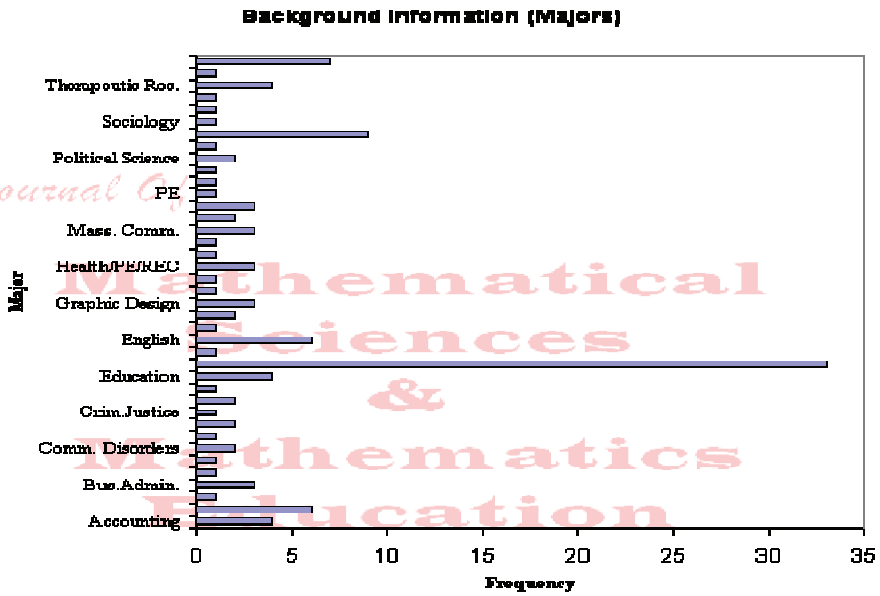


Figure III. Distribution of the ACT Subtests

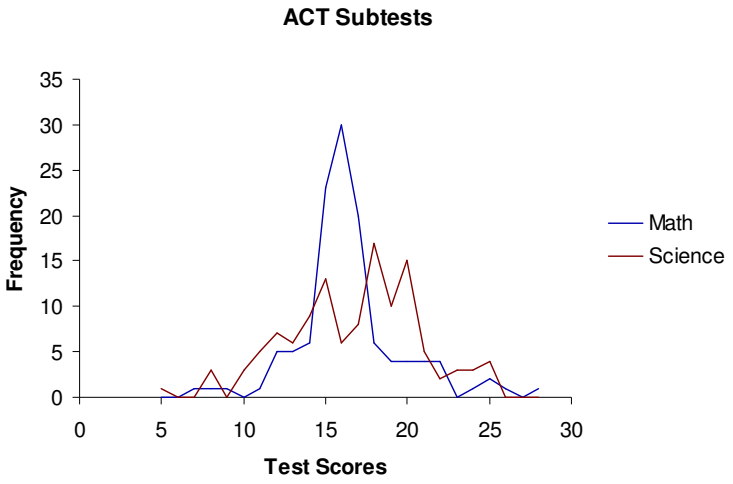
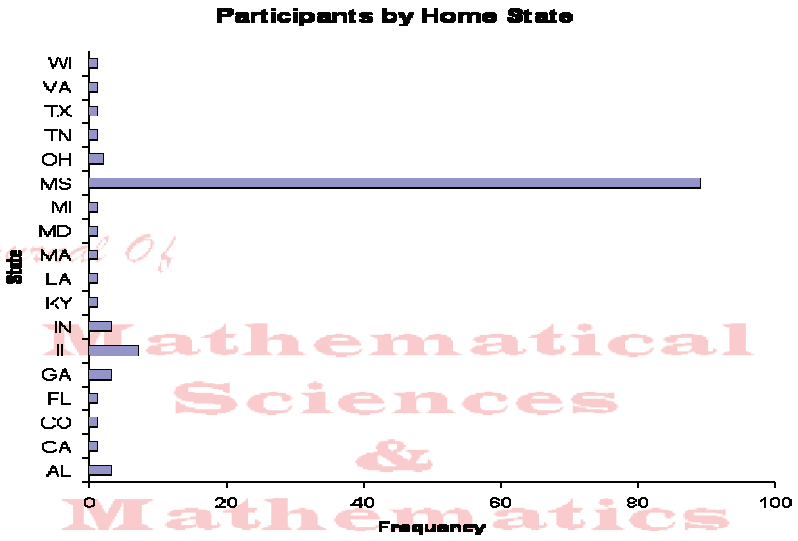


Figure IV. Participants by Home State



APPENDIX A

Personal Data Information Sheet

Instructions: Circle the most appropriate response

Sex: Male Female

Race: African-American White Asian Hispanic Other

Current Age: 18-19 20-21 22-23 24-25 Other

Major: Science Non-science

In which state did you attend high school?

High School: Public Private

If private, was the school religious based? Yes No

High School: Urban Suburban Rural

High School Size: Under 100 101-500 501-1000 Over 1000

Number of science courses taken: 1 2 3 4 or more

Grade you expect to earn in Physical Science: A B C D F

Circle all math courses that you took in high school:

Algebra I Algebra II Geometry Trigonometry Calculus Other

Circle all science courses that you took in high school:

Biology Chemistry Physics Physical Science Other

Circle all Language Arts courses that you took in high school:

Literature Journalism Learning Strategies English (how many parts)__

Other__

Employment: Full-time Part-time Student Worker None

Do you have children? Yes No

On average, how many hours per week do you study Physical Science?

Less than 1 hour 1 to 2 hours More than 2 hours

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