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The Effects of High School Mathematics and Science Classes on Wages

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I. INTRODUCTION

The popular press is filled with claims that the world is becoming a more technological place, and that mathematical and scientific knowledge is becoming a necessity. Carol Wynn, chairwoman of a chamber of commerce education group, projects by the year 2000 almost all new jobs will be technical in nature (Louka 1993, p. 1). According to Barbara Behrendt (1993, p. 1), education is also moving in that direction; many people feel pursuing more math or science oriented classes will pay off financially.

People are often unaware how frequently they use their mathematical and scientific skills. For example, mathematics subtly confronts us every day, often in the form of routine computational tasks. Poor mathematics skills could cost companies a great deal of money by the errors their employees make. A study by Francisco Rivera-Batiz (1992, p. 314) did show that quantitative skills increase productivity in the workplace. Thus, employers might select employees partially on their mathematical ability. Yet despite the claims about the importance of mathematics and science classes, surprisingly little empirical research has been done to show the effect these classes have on later wages. Therefore, this study attempts to fill that gap and test if there is a positive correlation between taking an abundance of mathematics and science classes in high school and wages later in life.

I use the Human Capital Model as my theoretical framework. An individual's human capital consists of his or her acquired productive skills, talents, ability, and knowledge. Human capitalists believe that schooling enhances productivity, which in turn, increases wages. If mathematics and science classes are really essential, then they should increase productivity and wages even more so than other classes. My research looks for evidence of this.

My results show that the human capital factors of previous work experience and age positively affect wages. Further, demographic variables such as having children present in the home or being male also increase wages. However, the results fail to support the claims that high school mathematics and science classes are more beneficial than other classes. None of my variables that measured the number of classes are significant. My paper concludes by suggesting possible reasons why my results did not support these claims.

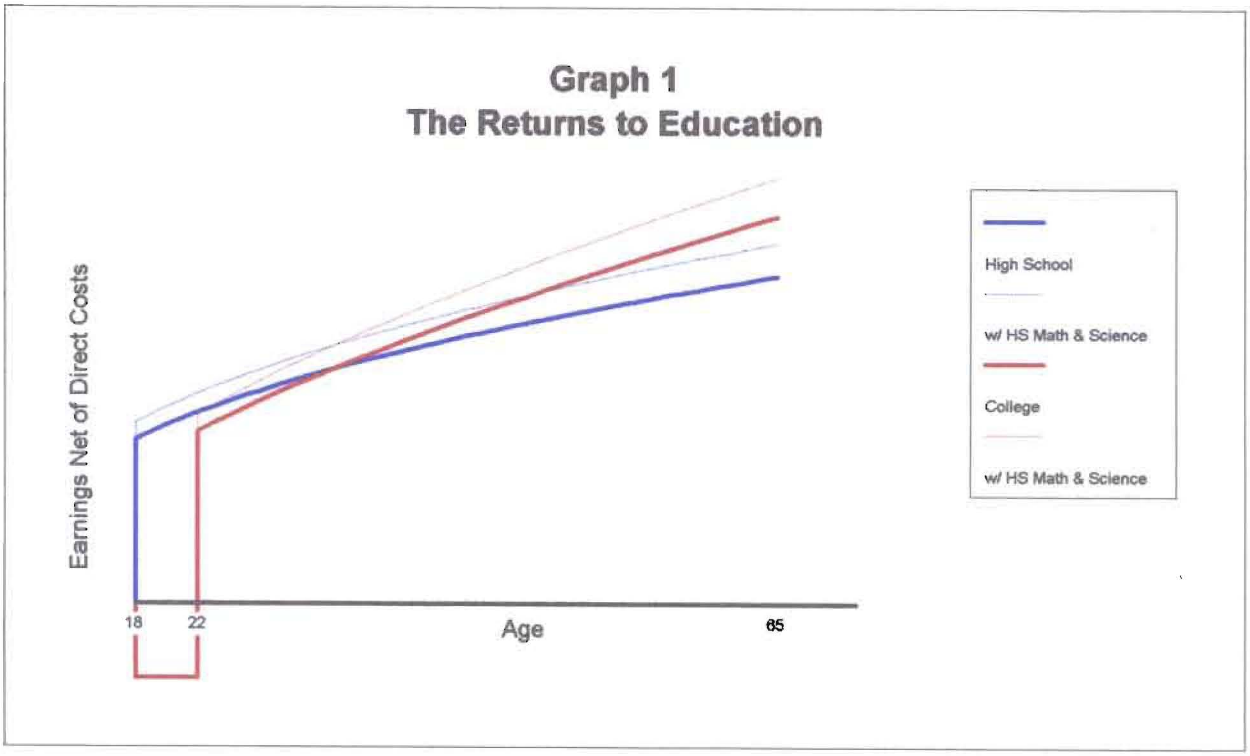
II. THEORY

A. Human Capital Theory

Alfred Marshall stated, "The most valuable of all capital is that invested in human beings" (Becker 1975, p. 14). The investment in human capital, an individual's acquired productive skills, talents, ability, and knowledge, is a widely researched economic topic. Human Capital theory states that individuals bear costs to acquire human capital if they expect the returns from that human capital to surpass the expenses. Thus, human capital expenditures are considered as "investments" (Hornbeck and Salamon 1991, p.3). The knowledge and skills that a worker possesses constitutes a "stock" of productive capital. The "value" of this "stock" is derived from the wage these skills can earn in the labor market (Ehrenberg and Smith 1994, p. 280). Specifically in my study, I want to examine the "value" that individuals receive as they "rent out" their quantitative skills to employers.

Schooling is an investment in human capital. Many human capitalists believe that schooling enhances productivity, thus increasing wages. They note that education teaches a wide variety of skills and increases knowledge that may partially be used on the job. The investment in educational human capital has costs upfront. First, there is the direct cost of books, tuition, fees, or unusual

transportation costs. Second, there is an indirect cost in the income a student forgoes while in school. Thus, a college student bears costs in the early years, but has higher returns in the future as a result. This is shown in Graph 1 which is adapted from Blau and Ferber (1986, p.147). The graph shows as schooling is increased, the age-earnings profile also increases. Thus, we see that the future benefits compensate for the early costs.



Further, the type of schooling may also affect the earnings. The claims I am testing are, in essence, that mathematical and science skills are especially valuable in enhancing productivity. If so, one would expect to see investment in mathematics and science education leading to higher wages. As seen in Graph 1, I test to see if individuals with more mathematics and science classes (the dotted lines) earn more than people with less.

The incentive to expand or improve one's resources depends on the present value of some monetary amount--which depends on the amount of earnings increase per time period and the length of work-life. The present value of some monetary amount is defined to be

$$\text{Present Value} = B_1/(1+r) + B_2/(1+r)^2 + B_3/(1+r)^3 + \ldots + B_T/(1+r)^T$$

where B_i is the yearly benefit, T is time, and r is the interest rate. If the individual expects to work for many years, the total return is higher than if he or she does not. This is because the person with the longer life span has more time to utilize the acquired capital. Generally, younger people have a greater incentive to invest in schooling because there are many years over which they can collect the return (Becker 1975, p. 72). I test to see if B_i is higher for those who pursue mathematics and science classes.

Although the yearly benefits should increase for both men and women with additional education, the total return may differ between gender. Women tend to be in the labor force for a shorter duration of time than men. Comparing educated men and women at age twenty-five, men tend to work in the labor force for approximately eight years more than women (Ehrenberg and Smith 1994, p. 300). This results from women often dropping out of the labor force during their childbearing years. As a result, women may have less of an incentive to invest in market skills and may receive lower benefits from a given investment.

Of course there are other factors that affect wages. The amount of experience in the workplace is another form of human capital that should positively affect wages. Age can also be considered as a proxy for experience and wisdom. As one gets older (to a point) one's productive skills, knowledge, and abilities should naturally increase.

Various demographics should also affect wages. Having children present at home may force a woman to stay home since she often is the main care-giver,

or may force a man to look for higher wages in order to support the child. Marriage may encourage specialization within the family where one spouse may concentrate on work at home, and the other may focus on the labor market. Or, marriage may have the same affect on men and women--it may encourage both sexes to seek higher wages in order to support their family. Finally, natural ability cannot be overlooked. A person with higher ability will most likely be more productive in the workplace.

While the analysis of education as investment in human capital is useful, it does have its limitations. Human capital is different from physical capital in some important respects. First, human capital is affected by nonpecuniary considerations to a greater extent than physical capital. For example, one person may derive great pleasure from enrolling in a biology course whereas another may detest it. Or some may enjoy working alone while others need to be surrounded by people. Due to social conditioning, women may value the nonpecuniary aspects of mathematics and science less than men. Still, most human capital models deal solely with pecuniary aspects (Blau and Ferber 1986, p. 184).

In addition, human capital is an illiquid asset--it cannot be sold and it is poor collateral on a loan. There are many uncertainties that surround an investment in human capital. First, the number of years one will live is somewhat unpredictable. So, the number of years over which the return will be collected is in question. Second, people are often unaware of their abilities. Thus, they will be uncertain as to how much human capital they should invest in. Third, people, especially youth, are uninformed of alternate investment opportunities. Since youth are ignorant of other choices, they are more likely to make an error when selecting an investment. Thus, for these reasons it is often difficult to determine if

an investment will be beneficial. Recognizing these limitations, the Human Capital Model is still valuable.

B. Human Capital Theoretical Model

Few papers have tried to determine the effect of quantitative skills in the workplace. However, in 1992 Rivera-Batiz examined the effect of quantitative skills on the likelihood of full-time employment of young adults in the United States. He found that these skills are a major determinant of full-time employment (Rivera-Batiz 1992, p.325), most likely because quantitative skills are found to increase productivity. So employers may use quantitative skills as a criteria for employment.

Further, in 1974, Lucy Sells studied the link between mathematics and vocational opportunities. She believed that knowledge of Algebra and Geometry divides unskilled and clerical jobs from better-paying, upwardly mobile positions. The mastery of algebra can increase scores on one's civil service or industrial entrance exams, thus immediately moving one to a higher level. Sells found, "just one more year of high school math could make the difference between a starting salary of $8,000 and one of $11,000 [in 1974]" (Tobias 1978, p. 26). Students regarded as non-college material are often steered from pre-college mathematics and pushed toward general mathematics or business mathematics. However, Sells showed the importance of these students enrolling in classes such as Algebra and Geometry. Sells also provided useful ideas on how to distinguish upper level mathematics classes from lower level mathematics classes: upper level mathematics classes are denoted as classes including and above Algebra, and lower level mathematics classes are those such as business mathematics and general mathematics.

Rivera-Batiz also included other demographic variables in his model. Specifically, he included the presence of children and marital status. He believed that both having a child or being married will affect employment, but in different ways for men and women. Thus, it is necessary to control for gender. He found the effect of marriage to be negligible for females, but strongly positive for the probability of male employment. Further, the presence of a child greatly decreased the likelihood of employment for women but it had an insignificant effect on males.

There are other reasons as to why males' and females' wages differ. Alexander and Eckland (1974) examined sex differences in the educational attainment process. They determined that women are less likely to enroll in college preparatory classes, and thus, women attain less education than men of comparable academic ability. Even after controlling for a number of variables, the effect of sex on educational attainment surpasses the effects of aptitude, background status, educational expectations, and other variables. Further, status influences affect the amount of education attained for women more than for men. Ability has a greater affect on the amount of education a male will attain than the it does on the amount females obtain.

It is important to control for ability because it is a factor in determining the education one will receive. Ability is also related to earnings. A study in the late 1980's determined that scores on the Armed Forces Qualification Test (a general test which focuses on problem-solving aptitude and trainability), of youth aged 18 to 24, are positively correlated with earnings and being employed (Rivera-Batiz 1992, p. 314). Rivera-Batiz cites another study that determined there is a strong, positive relationship between general intellectual achievement and earnings (1992, p. 314).

Alexander, Cook, and McDill (1978) found that socioeconomic characteristics affect curriculum enrollment of students, but mostly through their achievements and goals. The importance of curriculum placement in students' junior and senior years is very significant. Curriculum tracking, whether it be a college track or a non-college track, consistently affects educational goals, achievements, and goal-oriented behaviors (Alexander, Cook, and McDill 1978, p. 62). The authors believe that the way students are "sorted" within high school affects their socioeconomic attainment. Placement in a college track does enhance achievement, goals, and greatly increases the probability of application and acceptance to college. So, the benefits are cumulative in this case. College track classes are courses such as upper level mathematics and science classes, the classes I am looking at. Thus, enrollment in these classes may affect socioeconomic attainment.

Together, the studies examined above suggest that wages are a function of human capital measures such as education--both the overall level and the amount of mathematics and science--and experience. They suggest that demographic variables--family structure and gender also matter. And they suggest that ability matters too.

III. THE EMPIRICAL MODEL

My empirical model follows directly from the preceding theory.

$$\begin{aligned} LN(WAGE) = {} & \beta_0 + \beta_1(HIMATH) + \beta_2(LOWMATH) + \beta_3(SCIENCE) + \beta_4(EXPER) + \\ & \beta_5(AGE) + \beta_6(AFQT) + \beta_7(MARRY) + \beta_8(CHILD) + \beta_9(FEMALE) \end{aligned}$$

A person's wage (in 1989) is hypothesized to depend on the amount of mathematics and science he or she took in high school (about nine to twelve

years earlier), as well as his or her age, work experience, ability, family status and gender.

Often human capital literature uses the log-linear model, which uses the natural logarithm of earnings or wages as the dependent variable (Ramanathan 1995, p. 272). The log transformation means that the coefficients can be interpreted as percentage rates of return. For example, β_1 (x100) is the percentage return to an additional HIMATH course, and β_4 (x100) is the percentage return to an additional hour of work experience.

I utilize the National Longitudinal Survey of Youth (NLSY) database. The NLSY is a national sample of 12,686 men and women born between 1957 and 1965. The survey originated in 1979 with personal interviews; it still continues with yearly interviews. The database has an overrepresentation of minorities and economically disadvantage youth, but it is possible to select a representative sample from the total. I start with the representative sample. However, the high school transcript study was done in 1981. Thus, I restrict this sample to individuals, born in 1957 through 1959, who had earned their high school diplomas by 1980. Moreover, for reasons explained below, I include only individuals with exactly twelve or sixteen years of education, who worked more than zero hours in 1989. Table 1 describes the variables.

Dependent Variable

I use the natural log of wages as my dependent variable. This variable was created by dividing the total 1989 wages, salary, and tips by the number of hours worked in 1989. This is why members of my sample had to work more than zero hours in 1989, because dividing by zero is impermissible. Also, since I want to determine how classes affect wages, it is difficult to examine the effects if they are not working.

Table 1: Variable Definitions and Summary Statistics

VARIABLE	MEAN	STANDARD DEVIATION	DESCRIPTION	EXP. SIGN
12LN(WAGE)	2.12	.69	Ln of hourly wage in 1989	
16LN(WAGE)	2.54	.58	Ln of hourly wage in 1989	
12HIMATH	.81	1.10	Number of high mathematics classes	(+)
16HIMATH	2.06	1.41	Number of high mathematics classes	(+)
12LOWMATH	.88	.99	Number of low mathematics classes	(+)
16LOWMATH	.57	.84	Number of low mathematics classes	(--)
12SCIENCE	1.49	1.10	Number of science classes	(+)
16SCIENCE	2.39	1.48	Number of science classes	(+)
12EXPER	20,682.73	7,259.35	Total number of hours worked in 1978-1988	(+)
16EXPER	19,624.98	4,915.88	Total number of hours worked in 1978-1988	(+)
12AGE	31.00	.84	Age in 1989	(+)
16AGE	30.96	.80	Age in 1989	(+)
12AFQT	46.25	24.68	AFQT percentile score	(+)
16AFQT	76.54	18.11	AFQT percentile score	(+)
12MARRY	.68	.47	1 if married, 0 otherwise	(+)
16MARRY	.63	.48	1 if married, 0 otherwise	(+)
12CHILD	1.27	1.20	Number of own children at home	(?)
16CHILD	.77	1.13	Number of own children at home	(?)
12FEMALE	.47	.50	1 if female, 0 if male	(--)
16FEMALE	.50	.50	1 if female, 0 if male	(--)

Education

Because the entire pattern of earnings over time varies with the years invested in education (recall Graph 1 above), combining people with different years of education might obscure the patterns. Therefore, I concentrate on just two important groups--those with exactly twelve, and those with exactly sixteen years of education--and analyze each regression separately.

HIMATH is defined as the number of high level mathematics classes the respondent took and received credit for while in high school. The classes include Algebra, Geometry, Trigonometry, Calculus, and special topics such as Logic, Statistics, and Probability. According to the claims cited earlier, for the value of mathematics education in particular, upper level mathematics courses should

increase productivity and thus wages. In Graph 1, it is shown that for both groups, an abundance of mathematics and science courses should increase earnings. Thus, HIMATH should be directly related to wages.

The number of low level high school mathematics classes in which credit was received, (including topics of Arithmetic, Remedial Math, and Vocational Math) is the variable LOWMATH. For the group that had twelve years of education, I test the claim that these classes should also increase quantitative skills, and increase wages. However, for the individuals with sixteen years of education, I project LOWMATH to have a negative coefficient. This is because a college-bound student taking classes such as Remedial Math may indicate a greater problem.

SCIENCE is defined to be the number science classes that one received credit for in high school. Science classes should also increase quantitative skills. These quantitative skills should increase productivity, thus increasing wages. For the same reasons as HIMATH, a direct relationship is expected for both groups.

Experience Variables

Experience and age are also used as human capital variables. Looking at Graph 1 again, one can see as age and experience increase, earnings also increase. To measure experience, I create a variable, EXPER, which is the total number of hours the respondent worked from 1978 through 1988. Second, I have a variable, AGE, which is the respondent's age in 1989. Age is a proxy for a person's experience and wisdom accumulated over his or her lifetime.

Ability

Ability cannot be ignored. It is plausible to believe that ability affects wages to some extent. To measure this I use actual percentage scores on the

Armed Forces Qualification Test (AFQT). However, this may be an imperfect measure. Since the High School Transcript survey was done in 1981, I select students who had completed high school by 1980. The AFQT test was administered in 1980, so the mathematics classes the respondents took in high school may have affected AFQT scores. If AFQT reflects achievement as well as ability, it could bias estimates of the effects of mathematics classes. This is my best approximation though, so AFQT is included in the regression.

Family Structure

It is important to look at family structure when examining wages. It was previously noted that marriage may encourage both men and women to seek higher wages in order to provide for their family. Thus, I include a dummy variable, MARRY, that states whether the person is married or not. Next, CHILD denotes the number of own children in the household. The presence of children in the home may affect wages, but differently for men and women. Women may need to accept lower wages to obtain better conditions in which to remain the primary care-giver. Children, like marriage, may force men to search for higher wages in order to be the main bread-winner of the family. Since my sample has both men and women, it is difficult to predict the effect of this variable. The last variable, FEMALE, is a dummy variable denoting sex. Men and women are often paid differently due to discrimination and other factors, so a gender variable will control for this.

Limitations of the Data

There are limitations to my data. I am limited by a three year span, about ten years after the respondents graduated from high school. The effects of mathematics or science classes might have not shown up yet, or they might have

already worn off. Next, the number of mathematics and science classes may be too crude of a measure of mathematical and scientific knowledge. It is obvious that classes differ between high schools. A mathematics course in inner-city Chicago will most likely be quite different from a mathematics class in the suburbs.

The doubts about AFQT as an ability measure are previously noted. Also, mathematics and science education may interact with ability. A person with greater ability may attain more from an upper level mathematics class than a person of lower ability.

IV. RESULTS

Table 2 presents the results of the three regression analyses. Looking first at high school graduates (column A), the non-education human capital measures--age and experience--have the expected positive signs, and are at least somewhat significant statistically. The same is true for ability, as measured by AFQT. Of the family structure variables marriage is insignificant; having a child present has a strong positive affect. And, as predicted, being female has a negative affect.

The main focus of this study, of course, is to determine whether mathematical and scientific training has a differential effect. And, in fact, none of the mathematics and science variables are even close to being significant. There is no evidence here that mathematics and science courses have any differential impact.

Next, in column B, the base model is tested using only respondents that had exactly sixteen years of education. Surprisingly the human capital variable of experience is insignificant. Age is significant, but only at the ten percent level. Ability is insignificant along with the family structure variables of marriage and the

Table 2
REGRESSION ANALYSIS
Dependent Variable--LN(WAGE)

Independent Variable	A Grade 12	B Grade 16	C Grade 12	D Grade 16	E Grade 12	F Grade 16
HIMATH	0.0065	-0.0183	0.0772	-0.1270	0.0346	-0.0141
	(.166)	(.488)	(.873)	(.853)	(.903)	(.377)
LOWMATH	-0.0104	-0.0276	-0.0087	-0.0320	-0.0273	-0.0409
	(.252)	(.487)	(.211)	(.564)	(.660)	(.742)
SCIENCE	-0.0114	-0.0097	-0.0139	-0.0123	0.0025	-0.0042
	(.299)	(.276)	(.366)	(.347)	(.065)	(.122)
EXPER	.00002	.000008	.00002	.000008	.00002	.000006
	(4.234)***	(.761)	(4.210)***	(.771)	(4.568)***	(.624)
AGE	0.0620	0.0715	0.0587	0.0700	0.0763	0.0729
	(1.570)*	(1.325)*	(1.480)*	(1.294)*	(1.924)**	(1.351)*
AFQT	0.0045	0.0024	0.0053	0.0003		
	(2.982)***	(1.014)	(2.990)***	(.069)		
HIMATH*AFQT			-0.0012	0.0014		
			(.891)	(.754)		
MARRY	0.0659	0.1013	0.0699	0.0957	0.0823	0.1053
	(.814)	(1.025)	(.863)	(.964)	(1.008)	(1.066)
CHILD	0.0777	-0.0508	.0770	-0.0491	0.0856	-0.0496
	(2.352)**	(1.223)	(2.303)**	(1.178)	(2.541)**	(1.195)
FEMALE	-0.276	-0.2889	-0.2791	-0.2979	-0.2816	-0.2997
	(3.632)***	(3.071)***	(3.666)***	(3.137)***	(3.666)***	(3.207)***
CONSTANT	-0.4574	0.2313	-0.3897	0.4493	-0.7750	0.3897
ADJ. R2	0.1802	0.0737	0.1798	0.0711	0.1623	0.0736
SAMPLE	370	163	370	163	370	163

Absolute t-statistics in parentheses
* indicates significance at 10 percent level
** indicates significance at 5 percent level
*** indicates significance at 1 percent level

presence of children. However, once again, being female negatively affects wages.

Again, the human capital variables that represent mathematics and science courses are extremely insignificant. Thus, it is impossible from my results to state that mathematics and science courses are more beneficial than other classes.

One plausible explanation for the statistically insignificant coefficients on the mathematics and science classes may be that their effects depend on natural ability. Therefore, I added a variable, HIMATH*AFQT, to allow for the interaction between mathematics and ability. This interaction variable is the individual's number of high mathematics classes times their AFQT score. I project this variable to have a positive coefficient. This is because people of greater ability should benefit and receive more from their high level mathematics classes. Thus, the next two regressions contain this new variable.

Column C and column D are the regressions with the new interaction variable. As one can see, the significance levels changed very little from the previous regressions. Further, HIMATH*AFQT has a negative, insignificant coefficient. This obviously did not help my results.

In my final regressions, I also eliminated AFQT. As previously noted, AFQT may be an imperfect measure of ability. Column E and column F list the results for the two groups. Once again, the results changed very little.

V. CONCLUSIONS

Generally, my results are quite robust. Throughout the three regressions I ran for each group, when dropping or adding variables, the equations fluctuated very little. Overall, I found that the general human capital measures of experience and age positively affect wages. Also, demographic variables such

as gender or marital status also affect wages. I found no evidence that mathematics and science classes in high school have a differential effect on wages.

I noted my uncertainty about AFQT as a measure of ability. While it was significant for grade twelve, it was dropped in the final equations. As a result, the third equations then fail to control for ability. Further research could include finding a better approximation for ability.

Along with that data limitation, I believe that a better measure for mathematical and scientific knowledge is a necessity. Obviously there is a difference between a person receiving an "A" or a "D" in a Geometry class, but I did not want to include grades since they are not standardized across America. Yet another avenue for research would be to locate a variable that more accurately denotes this knowledge.

Another explanation as to the insignificant class variables could be that many of the positions in 1989 did not utilize an abundance of mathematics and science. Recall the popular press claims state that jobs are moving in this direction. This study may prove useful in the future in studying jobs in the year 2000.

On the other hand, these results could be correct. My results fail to support the claims about the importance of mathematics and science classes. While I have not found that mathematics and science are unimportant, I have found that they do not have a differential affect on wages. So it is possible that taking a wide variety of classes in high school, not an overabundance of mathematics and science, would be just as beneficial.

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