AC 2009-517: FACTORS INFLUENCING HIGH-SCHOOL STUDENTS' CAREER CONSIDERATIONS IN STEM FIELDS

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Factors Influencing High School Students Career Considerations in STEM Fields

Abstract

While sporadic gains have been made in recent years in attracting minority and female students to STEM (science, technology, engineering and math) fields, there yet remains a significant underrepresentation of females and minorities who pursue academic degrees in these areas. This study assessed different variables that could influence high school students to consider STEM career options. Ninety-four high school students (43 male and 51 female; 52 African American and 42 Caucasian) attending a summer technology academy participated in the study. These students were nominated by their respective high schools as demonstrating potential in STEM academic areas but, due to inhibiting factors (gender, minority status, and/or financial issues), might not choose to pursue these academic and careers options as young adults. During the course of the program, students were asked to provide information on factors such as peer influences, family, school, and media that they felt were influential in their consideration of viable careers. While several areas assessed were consistent across gender and race, notable differences were identified. This paper highlights the importance of better understanding of influences in career considerations as crucial to help guide interventions to improve STEM career selection for women and minorities.

Representation Issues and Career Choices in STEM Fields

Although STEM field populations have grown, this pace has not keeping up with the overall labor market.[1] In 2006, STEM professionals accounted for 5 percent of all the employment in the United States; this was down from 5.6 percent from 2001. This decline mirrored post secondary enrollment in STEM degree fields.[2] While the actual enrollment in STEM degree fields increased from 519,000 students in 1994-1995 to 578,000 students in 2003-2004, the proportion of undergraduate degrees awarded in STEM fields actually declined from 32 percent to 27 percent of all degrees awarded. This decline has significant economic implications[3] since the U.S. needs to produce more graduates in the STEM fields to maintain America's competitive advantage in technology areas.

The demographics of the U.S. will change dramatically over the next few decades.[3] It is predicted that the current Caucasian majority will cease to be the majority of the total population by 2050.[3,4] The African American population over this same time frame will double in size and the Hispanic-Latino population will quadruple. This increase, however, does not necessarily mean that many of these individuals will choose careers in science and engineering unless major changes are seen. These individuals present a strong, albeit largely untapped, resource for building the nation's scientific workforce.[5]

African Americans and Hispanics-Latinos compromised only six percent of the science and engineering labor force in 1993. From 1995 to 2005, non-Hispanic minorities showed no increases in proportion to undergraduate engineering enrollment and Hispanics made minimal gains from seven percent to nine percent.[4] With these demographic trends in mind, the National

Science Foundation (NSF) stated that more efforts are needed to attract minorities, especially underrepresented minorities, to the STEM fields.[5]

Women are also underrepresented in STEM fields.[2, 6, 7, 8, 9] Although women make up 50.8% of the U.S. population, they are significantly underrepresented in STEM fields.[2, 4] As long as women choose other careers, the STEM areas are losing a substantial number of intelligent, talented individuals who could make important contributions to science and engineering.[8]

Factors and Influences in STEM Career Choice

Numerous factors and influences inhibit women and minorities from choosing academic degrees and professions in STEM related fields. Clewell[5] cites four barriers that impede minority student choice of math and science careers: 1) negative attitudes toward math and science; 2) lack of information about careers in math and science; 3) poor math and science scores; and 4) failure to take higher level math and science courses.

Minority students may also face additional challenges. In a report by the NSF, minority postdoctoral fellows stated that African Americans are sometimes steered towards athletics rather than academics, and teachers and guidance counselors unknowingly provide negative reinforcement towards careers in science.[4] The report indicates that the exceptional African American students are usually steered towards areas such as law or medicine rather than STEM fields. The report recommends that teachers make science relevant to the student's lives, teachers receive multicultural awareness training, parents become involved in the students' educational choices, and teachers demonstrate high expectations of all students. A 2007 study shows minorities who took high level math and science courses are as likely to pursue a STEM degree as non-minority students.[10]

Women also face factors and influences that affect their decisions regarding the selection of academic programs and careers. A 2006 study reports that, while most females had a low interest in science, they do not possess lesser ability in science.[7] Blickenstaff[8] proposes explanations regarding why women do not pursue STEM careers and these include: academic preparation for a science major/career; poor attitude toward science and lack of positive experiences with science in childhood; the absence of female scientists/engineers role models; and science curricula which do not interest female students. Adya and Kasiser[6] state that the access to technology resources both at school and home has increased and will have a positive impact on female choices of careers.

Although many studies have examined challenges confronting minorities and women pursuing STEM careers, there are very few studies documenting tools for positive changes in stimulating interest in STEM fields. This study examines students attending a summer academy which targeted building career interest in STEM fields. It assesses various factors among these students that may lead them to consider career options. Of particular interest are possible differences reported by female and minority students with regard to these influences. As a starting point, the next section examines the curricular approach of the academy.

The Summer Academy

The Academy was developed as a key component of a NSF ITEST (Innovative Technology Experiences for Students and Teachers) grant which targeted integration of an applications orientation into mathematics and science classes in rural high schools. In general, the NSF ITEST program was a response to the concern about shortages in the U.S. of future professionals in the field of technology. The ITEST program was designed to increase the opportunities for students and teachers to learn about, experience, and use applied technologies within the context of STEM education areas. The project's aim was to assist high school mathematics and science teachers in integrating STEM topical investigations into their classroom instruction and, thereby, stimulate students' interests in these academic pursuits and careers.

The academy was comprised of two primary components: the Information Technology Academy for Teachers (ITAT) and the Information Technology Academy for Students (ITAS). The ITAS high school students experienced mathematics and science curriculum through investigations in STEM problem-solving in robotics, biomechanics, solid modeling, and Microsoft Excel over a three-week period during the summer on-site at a university. Additionally, students were provided information regarding post secondary education and careers in STEM fields. The program provided a rich learning environment centered on problem-solving, understanding of the integration and interrelatedness of STEM fields, and an understanding of fulfilling state curriculum standards in mathematics and science through hands-on projects and investigations in STEM topics.

Affective Instructional Environments

In developing the curricular plan for the summer academy, the participating faculty strongly supported an integrated curriculum conjoining the areas of mathematics, science, and technology.[11] The traditional disjointedness of mathematics, science, and technology instruction echoes an unrealistic view of the world. Today, interdisciplinary understanding is needed to solve technical problems. Students best realize this when they engage in learning activities that cause them to apply their knowledge of mathematics, science, and technology concepts while seeking solutions to real-world problems.[12] The scientific, technological, and academic communities have a vital role to play in reaching out to education reform efforts and encouraging young people to study and pursue STEM careers the by employing best curricular practices.[13,14]

Research indicates that when teachers employ interdisciplinary or integrated curricula, students are provided opportunities for more relevant, less fragmented, and more stimulating learning experiences in STEM areas.[15, 16, 17] By nature, instructional environments, which employ real-world problem-solving, stimulate student inquiry, enthusiasm, and participation. When real-world problem-solving environments are accentuated with integrated curricula, these environments further serve to inform the student regarding the nature of work in STEM careers. Altogether, learning in these environments can greatly affect student interest in STEM careers.

Survey Development and Participant Overview

The summer academy experience provided a unique opportunity for investigating the question of factors influencing students entering STEM academic fields and careers along with examining whether gender and racial/ethnic differences existed among students in regard to factors that influenced their consideration of STEM career options. The survey was divided into two parts. Part one asked students to rate the degree of influence ten factors (such as peers, teachers and parents) exerted on their career considerations, employing a five-point Likert scale rating system (1 no influence to 5 very strong influence). The second part of the questionnaire asked students to rate how important five factors (such as friends with same interest and someone in their family who was working in a particular field) were in developing the career interests they currently have with 1 not important to 5 very important.

High School Participants

One hundred thirty-two high school students ranging in age from 12 to 18 (mean age of 14.6) were extended invitations to attend the ITAS Academy and ranged in grade from freshman to senior (61 students for summer of 2007 and 71 students for summer of 2008). Seven students were unable to attend after accepting the invitation, and six students left prior to the end of the three-week academy. One hundred nineteen students were in actual attendance for the entire three weeks of the academy. One male student failed to complete the survey leaving a sample size of 118 students - 63 (53.4%) female students and 55 (46.6%) male students. The race/ethnicity of the students was as follows: American Indian 2 (1.7%), African American 52 (43.7%), Pacific Islander 1 (0.6%), Asian 2 (1.7%), Hispanic/Latino 15 (12.6%), Caucasian 42 (35.3%) and other 5 (4.2%). Only African American and Caucasian students had a large enough response set for both male and female students to perform analyses on gender and racial factors influencing career choice options. Therefore, the study was based upon survey responses for 51 African American students (20 male and 31 female students) and 42 Caucasian students (22 male and 20 female students).

Students were chosen from six rural school systems in eastern North Carolina. One focus of the academy was to attract students from lower socioeconomic status (SES) backgrounds who exhibited talent in math and/or science, but who might not have had opportunities to explore career options in the STEM areas. SES status was estimated based on eligibility for reduced or free lunch programs through the various schools. While there are limitations to using free or reduced lunch to assess SES, it did provide a marker that could be utilized without intrusion into families' personal finances. It should also be noted that many families may actually qualify for free or reduced lunches but may choose not to apply and would not be identified by this method. Seventy-six percent of the participating students attending the academy were on free or reduced lunch programs with a range of 56% to 100% of participants on free or reduced lunches for the participating school systems. Overall the academy was successful in its goal to attract students from lower SES backgrounds as participants.

Survey Results- Influences on Career Considerations

As noted above, the first questionnaire section asked students to rate ten factors that might influence their thinking on career choice and results (mean and standard deviation of the responses) are presented in Table 1.

Table 1 Summary of Influences on Thinking about Career Options

Please rate the following in terms of how much you feel they have influenced your thinking about future career options using the following rating scale: 5 = very strong influence, 4 = strong influence, 3 =somewhat important influence, 2 = minor influence, or 1 = no influence					
	African Americans		Caucasians		
Influence	Males (n=20)	Females (n=31)	Males(n=22)	Females(n=20)	Total
Friends	3.00 (1.03)	3.00 (1.15)	3.09 (1.51)	3.20 (1.15)	3.06 (1.21)
Parents	**4.45 (0.99)**	**4.29 (1.01)**	**4.00 (1.07)**	**4.35 (0.75)**	4.27 (0.97)
Teacher	4.05 (1.15)	4.06 (1.03)	3.45 (1.01)	**4.25 (0.79)**	3.96 (1.03)
Negative Influence of Teacher	2.20 (1.06)	1.94 (1.18)	2.19 (1.18)	1.80 (0.69)	2.02 (1.06)
Cost of Degree	4.25 (0.85)	3.39 (1.41)	3.18 (1.05)	3.30 (1.46)	3.51 (1.28)
Time to Degree	3.60 (1.19)	3.19 (1.45)	2.64 (1.22)	2.80 (1.06)	3.06 (1.29)
Earning Potential	**4.25 (0.85)**	**4.39 (0.99)**	**3.59 (1.26)**	3.70 (1.08)	4.02 (1.09)
Interest in area	**4.85 (0.37**	**4.58 (0.89)**	**4.50 (0.59)**	**4.65 (0.59)**	4.63 (0.67)
Stay in Region	2.50 (1.19)	2.48 (1.46)	2.59 (1.37	2.60 (1.46)	2.54 (1.36)
Media	3.25 (1.29)	2.61 (1.23)	2.45 (1.01)	2.65 (1.18)	2.72 (1.20)

The three highest rated influences are highlighted in bold for each of the survey segments. Several noteworthy factors are evident: in Table 1:

- Earning potential was highly rated for all groups. It was rated among the top three influences with the exception of Caucasian females who rated teachers as their third highest influence.
- Across racial and gender lines, parents and general interest in a career area are two highly rated career choice influences.
- African American male students were more concerned about the cost of a degree than the other survey segments.
- Time to complete the degree was also more important to African American male students than the other survey segments.

Table 2 summarizes the two way ANOVA results evaluating statistically significant differences between the ratings of the influences by the response groups. Statistically significant differences at 90% confidence or higher are highlighted in bold. The results this two-way ANOVA include tests of three null hypotheses:

1) Means of observations grouped by one factor (gender) are the same;
2) Means of observations grouped by the other factor (race) are the same;
3) There is no interaction between the two factors (race and gender). The interaction test examines whether the effects of one factor depend on the other factor. For example, an

interaction effect would occur in a case where Caucasian and African American females have about the same rating of an influence, while African American males rated the factor much lower than Caucasian males.

Table 2 ANOVA p-values for Career Influences.

	Gender	Race	Gender by Race	Conclusion
Friends	.83	.57	.83	No significant differences in ratings
Parents	.64	.34	.22	No significant differences in ratings
Teacher	**.05**	.34	**.07**	Gender ratings significantly different, Interaction significant at 93% confidence
Negative teacher	.16	.73	.79	No significant differences in ratings
Cost of degree	.16	**.03**	**.06**	Race ratings significantly different, Interaction significant at 94% confidence
Time to degree	.65	**.01**	.29	Significant response difference based on race
Earning potential	.58	**.00**	.95	Significant response difference based on race
Interests in area	.67	.32	.14	No significant differences in ratings
Stay in region	.99	.72	.97	No significant differences in ratings
Media	.38	.13	**.09**	Significant differences based on gender by race. Interaction significant at 91% confidence

The following noteworthy differences in ratings are seen: in Table 2:

- Teachers: Rating differences for teacher influence was significant for gender. This appears to stem from the fact that Caucasian females rated these influence very high and Caucasian male students lower. African American males and females were consistent in this rating. As evidence of this complex rating, the gender- race interaction term was significant at a level above 90%.
- Cost of degree: Financial considerations were found to be significant for race but not gender, as a result of the high importance rating from African American male students. Once again, due to the rating mixture, the interaction term is significant at a level above 94%.
- Time to degree: African American survey participants rated time to degree as significantly more important than Caucasian participants.
- Earning potential: Ratings of importance of this factor was significantly different based on race with African American students rating this factor higher than their Caucasian counterparts.
- Media: A significant gender by race interaction was found for media. African American male participants rated this higher than African American females or Caucasian participants.
- Other factors: Personal interest in a career field, and being able to stay in region were not significant for gender or race. Interest was rated as a high influence by all groups while staying in the region was rated somewhat low. African-American males did tend to rate media higher than their counterparts, but this was not significant.

It is interesting to note that all three factors related to financial benefits of a career (cost, time, and salary) were rated significantly higher influences for future career considerations by African-American students in comparison to Caucasian students.

The second part of the questionnaire asked students how important five factors were with respect to their present career interests. Specifically this question was intended to move beyond influences to examine the factors students used to make their current career decisions. The average ratings (employing a 1-5 Likert scoring scale) are presented in Table 3 with the two highest rated factors for each of the survey participant groups highlighted in bold.

Table 3 Importance Ratings in Current Interests Held

How important are the following in the interests you have? 5= Very Important , 4= Important , 3= Somewhat Important , 2= Very little Importance , 1= Not Important					
	African Americans		Caucasians		
Factor	Males (n=20)	Females (n=31)	Males(n=22)	Females(n=20)	Total
Friend with same Interest	3.50 (1.28)	3.34 (1.08)	**3.36 (1.05)**	3.50 (0.89	3.42 (1.07)
Interest of Same Sex Friend	3.15 (1.18	3.14 (1.09)	2.91 (0.97)	3.15 (1.14)	3.09 (1.08)
Occupation of Family Member in Field	3.55 (1.19)	3.07 (1.36)	2.73 (1.16)	3.15 (0.99)	3.11 (1.22)
Teacher Encouraging Field	**4.00 (1.03)**	**4.14 (0.87)**	3.14 (1.04)	**3.80 (1.19)**	3.79 (1.08)
Knowledge of School Personnel about Field	**4.30 (0.98)**	**4.48 (0.91)**	**3.55 (1.06)**	**4.25 (1.02)**	4.16 (1.04)

Table 3 indicates that:

- All four survey groups rated knowledge of school personnel about the field as most important in developing current interests.
- African American males and females and Caucasian females rated teacher encouragement as the second most important factor.
- Caucasian males rated friend with the same interest as the second most important factor. While it was the second highest rating for Caucasian males, their mean rating of this factor was still lower than the mean ratings for Caucasian females or African American males.

ANOVA was again employed to identify statistically significant differences in scores and results are summarized in Table 4. Statistically significant differences at 90% confidence or higher are highlighted in bold.

Table 4 ANOVA p-values for Career Decision Factors

How important are the following in the interests you have? 5= Very Important , 4= Important , 3= Somewhat Important , 2= Very little Importance , 1= Not Important				
	Gender	Race	Gender by Race	Conclusion
Friends with Same Interest	.97	.97	.53	No significant differences in ratings
Interest of Same Sex Friend	.62	.62	.59	No significant differences in ratings
Occupation of Family Member in Field	.91	.15	**.08**	No significant differences in ratings. Interaction significant at 92% confidence
Teacher Encouraging Field	**.07**	**.00**	.23	Race ratings significantly different at near 100% confidence and gender ratings different at 93% confidence
Knowledge of School Personnel about Fields	**.04**	**.02**	.22	Both race and gender responses significantly different at over 95% confidence

Important results contained in Table 4 include:

- Interest of friends in career field: No gender or racial differences were found for the importance of having a friend with similar interests, or a same-sex friend with similar interest
- Occupation of family member in a particular field: No significant gender or racial differences were identified. There was, however, a significant interaction effect for race by gender at the 92% level. African American males rated this higher in terms of influence than the other groups.
- Teacher encouragement of a particular career: Significant for race at near 100% with higher ratings from African Americans than Caucasian respondents. Gender significance was 93%. The low rating of importance of this influence by Caucasian males may play a role in each of these results.
- Career knowledge of school personnel: Significant for both gender and race. Again, students rated this as high importance overall, but it seemed to be especially important for female students and minority students.

Discussion

In order to attract more students to the STEM fields, especially women and minority students, it is important to know what factors influence career considerations. It is also critical to know if there are gender or minority differences in how these influences are perceived. This paper has contributed to this body of knowledge and has identified several critical issues for marketing and recruitment for STEM careers.

In general, the influence of parents and teachers is critical for STEM career decisions. However, parents are the more important influence across all groups. In addition, students indicated that their interest in a career field is a very crucial factor. The message from this is clear. To increase selection of STEM careers, we must make sure that parents understand the quality and potential of these life opportunities with their sons and daughters. In addition, we must be sure that students are presented with a positive image of STEM careers through high school curricula so they can develop an interest in these fields.

As far as gender based differences, teachers are more influential for female students, in particular Caucasian females. School personnel are also more important for female than male students. While African American and Caucasian female students rated this factor higher than their male counterparts, African American males also saw this factor as being very important to their interest in considering a career option. Clearly to attract more women and minority students, we must do better at developing a STEM career interest and also improve STEM understanding of parents and school personnel.

The study found significant differences in career influences with respect to race. The financial cost of getting a degree, the time to obtain a degree, and the future earning potential of a degree were all rated as significantly more important for African American students than Caucasian students. The knowledge of school personnel about career fields was also a significant differentiator for race as well as gender as noted above. The current study was limited to African American and Caucasian students. It is also important to continue this line of research to determine how these factors relate to future career choices and interests in other groups.

There are several limitations of the current study that should be noted. The sample represents a relatively small group of students in rural, eastern North Carolina and generalizations to other populations needs to be made with caution. The focus of the current study was on students from lower SES background as well as rural school systems that may also limit generalizations. However, it should also be noted that the students participating in this study represent young adolescents who were identified by their respective schools as having the ability to do well in the STEM fields and were nominated by their schools to attend the academy. These students reflect a potential, but often overlooked, resource for recruitment in science and technology fields. The surveys in the study are also self-report, and there is a question as to whether or not high school students are always aware of the factors that are influencing their career considerations. Follow-up research is needed to help determine what additional courses these students actually take as part of their high school career as well as their subsequent majors in college/career choices.

As noted above, students in this study came from rural schools with limited funds for innovative technologies in the classroom. Future research also needs to focus on how to better assist rural school system in engaging talented students in science and mathematics. These students are part of a largely untapped resource that we cannot afford to ignore if we are to remain competitive in the world marketplace.

The path forward to improving student selection of science and engineering careers must focus on solid, consistent effort to increase comprehensive awareness and understanding of STEM fields. This is not a simple task but one which must be embraced by STEM educators and must include compelling information about earning potential and satisfaction with STEM careers. Some of the influences assessed in this study were consistent across groups (i.e., interest in area, parents), but there were also some interesting differences. Caucasian female and African American male students report strong influence by teachers in encouraging them to consider a STEM field. This indicates that the educational system has a strong influence in directing or encouraging students to consider a STEM education and career. Without encouragement from the educational system, many talented students may not fully consider these career options as a possibility. The study also found that the cost of a degree, time to complete the degree, and the earning potential of a STEM degree are major considerations for African American students. Other external influences were of a lesser consideration. An underlying factor in this effort is the long term importance and impact of programs such as ITEST which provided the context and impetus for this study. Programs such as this provide a foundation for the career exposure and information which are essential to make progress in attracting and retaining future STEM professionals.

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