Teachers' Influence on Students' Science Career Choices

Gheorghita M Faitar, PhD
Assistant Professor
Education Department
D'Youville College
320 Porter Ave., Buffalo, 14201, New York, USA

Silviu L. Faitar, PhD
Assistant Professor
Mathematics and Natural Sciences Department,
D'Youville College
320 Porter Ave., Buffalo, 14201, New York, USA

Abstract

The present study aims to understand to what extent is teachers' guidance responsible for helping minority students (according to race, gender, socio-economic status) choose to embrace fulfilling science oriented careers. According to the latest USA educational policy endeavors, the Science, Technology, Mathematics and Engineering (STEM) specializations are currently sought-after domains. To analyze the students' perception on the influence of teachers and counselors in their STEM career choice, a survey was given to undergraduate students enrolled in Mathematics and Natural Sciences, Physical Therapy, Nursing, and Physician Assistant programs. They were questioned in regard to tracking, and the support received during their high school years. The results clearly show that an early attention to students' skills and aptitudes, especially when dealing with minority and/or underprivileged ones, is critical in encouraging them to follow future STEM careers, and supports the hypothesis that teacher training needs to adapt to these new requirements.

Keywords: diversity, STEM orientation, science careers, teacher's influence

1. Introduction

In recent years the influence of tracking has been analyzed from multiple perspectives, especially for students interested in science careers. Starting with the concern for teachers' differentiated attention to boys and girls in the classroom, continuing with the implications of the course taking patterns in middle- and high-school years for students interested in science, and culminating with the importance of guided teaching and learning for most students, it is critical to understand the pursuit of a fair educational policy serving all students. It is reported that entering high school with lower levels of achievement and a history of less rigorous course taking is detrimental to minority students interested in embracing post-secondary education degrees (Faitar, 2012; Kelly, 2009; Entswisle, Alexander and Olson, 1997). Many of them do not even consider such careers when thinking about the future. Thus, it is important to determine all causes that determine this unfavorable outcome, and a coherent educational policy needs to be implemented in order to promote equal opportunities for all students that show the necessary skills for future careers in STEM disciplines.

2. Literature Review

In 2004, Kelly explained that by high-school years, whites are about twice as likely as are blacks, to be enrolled in advanced mathematics courses. Researchers through a concerted effort of understanding trends of disparity and achievement at a high professional level formulated the idea that the above disproportionate representation of minority (black) students in low-track courses could be a reflection of the within-school segregation (Mickelson, 2001a, 2001b). The scholarly research also acknowledges that within- school segregation is accountable for over half the total segregation in a district (Clotfelter, Ladd, and Vigdor, 2003).

In terms of quantifying gender based accomplishments, especially in science and mathematics, it is important to mention that the stereotype of boys performing better at core natural sciences and mathematics has been around for quite some time. Is there any truth of this stereotype and do actually boys outperform girls in science-oriented domains?! In 1983 Howard Gardner proposed the theory of multiple intelligences. Gardner's theory suggests that we have a wide range of cognitive abilities and human intelligence is based on a multiple ability range. This is an important theory in understanding girls/boys involvement in a science classroom. It does not explain the reasons why girls often perform more poorly than boys in mathematics and science, but nonetheless acknowledges the existence of multiple intelligences possibilities in an individual. Girls might be more prone to embracing careers reflective of their linguistic, natural, intra, or inter-intelligences rather than of the computational, bodily-kinesthetic ones.

The myth of low performance for girls' mathematics accomplishments might be deconstructed when analyzing factors of incipient knowledge formation. It may begin as soon as children entering school or some other structured learning environment. In 2004 Jacobs and Bleeker suggest that parents influence their children's mathematics ability in elementary school. This is a time when children develop their own interests but it is also a time when they want to discover their abilities. While in elementary school, parents, beside teachers (the other agents active in shaping students' interests) influence to a great extent their children's preoccupation and future career orientations. Parents are actually reproducing stereotypes present in the conscience of the general society when affirming that boys are better at practical, technological, logical structured activities than girls. They differentially structure the leisure time of their sons and daughters based on 'proper' activities for them. Toys like Lego and game boards for boys, and Barbie dolls for girls, clearly demonstrate differentiated gender structured roles.

Another study published in 2011 also discussed the role of parents in the development of girls' mathematical and science-oriented interests. In the article *Girls' Math Performance Under Stereotype Threat: The Moderating Role of Mothers Gender Stereotypes*, the authors Tomasetto, Alparone and Cadinu investigate whose role, mothers' or fathers' is more prevalent in influencing their daughters. According to them, the gender gap in mathematics could be derived from the idea of a stereotype threat. Along this line, "women's math performance is disrupted and under threat not because of insufficient talent in women, but because they feel threatened by the possibility that their performance will confirm the negative stereotype associated with their social group" (p.943). The authors researched girls' math ability but they also had parents fill out a questionnaire on how strongly they felt about the stereotype. The research found out that girls' math ability was lower when their mothers accepted the stereotype and they performed well when their mothers rejected the stereotype. A mother's attitude and support for girls' interest in mathematics is quintessential in their future science-oriented performance and careers.

As mentioned before, parents are not the only strong influence in choosing a science, technology or engineering oriented career in someone's future. The article *Female Teachers' Math Anxiety Affects Girls' Math Achievement* investigates if the fear and anxiety a teacher feels about math may influence a student's ability. According to Beilock, Gunderson, Ramirez and Levine (2009), "Not only do math-anxious people avoid math but they also perform more poorly than their abilities suggest when they are exposed to math" (p.5). Elementary school teachers may reflect their anxiety while practicing their teaching. The research tested the theory that the more anxious a female teacher was about math, the lower the students math performance would be. The conclusion of the research was that while at the beginning of the school year, boys and girls had similar math achievement, by the end of the year, the girls performed lower than boys when they had a teacher who was anxious about math. A general conclusion may be formulated along the lines that children emulate the behavior of the same-gender adults. The female teacher exhibiting math anxiety negatively impacted the mathematics performances of female students.

In a 2011 study, Cvencek, Meltzoff, and Greenwald investigated the idea that"Girls' weaker identification with math may derive from culturally communicated messages about math being more appropriate for boys than for girls" (p.766). The authors arrived at the conclusion that the aforementioned statement is paramount since "children have reduced interest in future academic courses and occupations that are incompatible with their academic performance" (p.767). Girls may conclude "I am a girl and math is not for me". They identify with the stereotype early in their life and this identification usually springs before math achievement differences occur.

The range of potential solutions for the remediation of the long-sustained perception of a girl's lower performance in math and natural sciences due to innate abilities has to address the need to develop a powerful curriculum during middle and high-school years. Several authors researched the possibility to build knowledge in various classroom dynamics. For example, Jennifer Shapka in 2009 offered one solution by promoting access to high professional knowledge in any classroom. Girls were offered the possibility to learn mathematics and science separately in an all-girl classroom in the ninth and tenth grades. Their performance was compared to that of girls at the same levels in the coed format. According to Shapka it has been proven that "female students who are taught in single-sex classrooms attained higher level performance on standardized math". It has been suggested, however, that" these benefits are gained at the cost of essential cross-sex socialization, thereby leaving adolescents ill-equipped to participate in a gender stratified society" (p.527). Although this is a viable solution, it may lead to some other socialization concerns. The alternative solution could be having female students allocated to smaller math unit teams where they can be individually taught. By doing this, while learning cross-socialization skills, the girls will not be separated from the entire math class, and will still be able to understand mathematics better.

When analyzing options for improving girls and/or minority performances in mathematics and science standardized tests, another proposed strategy comes to mind: the development of spatial skills in the targeted students. Many researchers believe that girls (and other specific minorities) lack the spatial, kinesthetic skills boys have, and as a consequence, this leads to lower math and science performances. According to a study by Ganley and Vasilyeva (2011), it is important that girls work and benefit from their teachers's help to increase their spatial, kinesthetic intelligences; nonetheless, this is highly beneficial only if corroborated with an improved attitude toward science.

An increased mathematics and science performance in class depends to a great extent on the attention and support teachers offer in the learning environment. In 2006, Beaman, Wheldall and Kemp studied the differential teacher attention to boys and girls in the classroom. They started with the previously known theory of Kelly (1988) who concluded that boys attract more attention than girls in all teacher-pupil interactions in a classroom. After a thorough analysis of the research performed on this topic, the authors concluded that some of the underlying statements on the issue of concern might be true:

1) If the educational achievement of boys is not keeping pace with that of girls in recent years, then there is a cause for real concern and for appropriate action;
2) If it can be demonstrated that there are real differences in the ways in which boys and girls respond to contemporary educational teaching contexts, then this warrants further analysis with a view to re-engineering such teaching contexts so as to make them equally effective learning environments for both boys and girls;
3) If it may reliably be replicated that it is a minority of male students who are identified as behaviorally troublesome, then the re-engineered teaching contexts referred to earlier must also be functionally inclusive of the special needs of such individuals;
4) If more inclusive, more positively orientated teacher interactional styles have been demonstrated to yield higher levels of class engagement, in turn leading to greater gains in academic achievement for both boys and girls, then such interactional styles might reasonably be considered as helping to shape the engineered teaching context. (pp 362-363).

The aforementioned findings are in agreement with previous studies on the topic. For example, in 1977, Persell explained how teachers' expectations for their students influenced the frequency of interactions teachers have with their students. For example, a teacher that has high expectations for a specific student, will closely observe, guide and support the student in his/her academic pursuit, and as a result, "high-expectancy students are taught more than low-expectancy students" (Persell, as mentioned in Banks and McGee Banks, 2011). Furthermore, "socially vulnerable students (i.e., younger, lower socio-economic class and minority students) seem to be more susceptible to lower teacher expectations" (Rosenthal and Jacobson, as mentioned in Banks and McGee Banks, 2011), and in the end, they will receive less support and guidance from their teachers.

Summing up, it is possible to analyze the current policies in both middle- and high-school, the practicing ability and curricular differentiation at these levels, differentiation that often impacts the school and career orientation of minority students, especially when corroborated with factors such as teachers' support and expectations.

3. Methodology and Results

An anonymous survey was distributed in the Department of Mathematics and Natural Sciences at an Upstate New York college, during the 2010-2011 academic year. The survey's content is presented in the Appendix. The results of the aforementioned survey were analyzed, quantified, and interpreted. The subsequent analysis demonstrates the importance of multiple school factors in choosing a professional career. The circumstances and challenges encountered in the process of preparation for rewarding careers depend on student's abilities, innate skills, interests, and on his/her direct collaboration, as well as support from teachers, counselors, administrators, parents, and not surprisingly, peers.

The questionnaire was applied to eighty students majoring in Biology, Pre-pharmacy, Chiropractic, Dietetics, and Sports and Exercise Studies. From the eighty surveyed students, the results deemed as important are the ones drawn from the minority groups interviewed. The female students and non-Caucasian male students constituted the basis of analysis for the present study.

Among the students majoring in Biology, the girls' results proved that they were tracked at the upper-level science disciplines. Moreover, one female student of Italian descent was offered support by her teachers both at the middle- and high-school levels. The minorities interviewed in the Pre-pharmacy program reported that they connect the success they have in school to both long hours of continuous preparation, and support from their teachers at the high-school level, especially in Chemistry and Biology disciplines. In interviewing students from the Dietetics program, a prevalent conclusion came forefront; all of the participating students were tracked at the average or upper-level knowledge in their middle, or high-school years. Among them, the female students, all Caucasian, were offered support from their instructors, for either Mathematics, Biology, or both. The Chiropractic students interviewed were mostly male, but not all of Caucasian descent. The Latino and Indian American students reported being successful due to personal interests and skills formed at the upper-level tracking in corroboration with hours of preparation and lessons offered by their teachers. The minority male students acknowledged the importance of being supported in their efforts by their teachers in the class preparation. The Sports and Exercise Studies students interviewed, including all minority female students, also acknowledged the importance of significant preparation time, as well as individual efforts guided by their Mathematics and Biology teachers. They were well aware of the importance of the support received, and the contribution their middle and high-school teachers had to their professional advancement.

4.Conclusion

For all survey respondents, regardless of the future career choice, there was a prevalent recognition of the individual effort that is necessary to achieve a high level of competency. All of the interviewed minority students, as illustrated by gender or race backgrounds, female students, or male of non-Caucasian descent, revealed the importance of having long hours of preparation in a well-structured environment of a science course, with teachers well–adjusted to supporting and offering pertinent guidance.

The levels of achievement and competitiveness necessary to be successful in today's job market are in direct correlation with the levels of preparation and collaboration with highly trained and dedicated teachers. Especially when analyzing the efforts promoted within education institutions for having highly qualified professionals, the needs of numerous minority students present in today's schools ought to be understood and addressed.

The qualitative analysis of the aforementioned study reinforces the previously discussed hypothesis: the individual choice for a science related career is determined by the parental support, individual efforts, courses taken in school, and also by the collaboration and support of the STEM teachers. The survey answers formulated by students also lead to the conclusion that a high level of expertise equating with the orientation towards science jobs in demand is to be sustained by both teachers and students at the onset of tracking, which in the US is at the middle-school level. A conscientious effort towards including teachers and administrators of minority background in the upper middle- and high-school tracking process will stimulate an increased attention toward minority students with abilities for STEM specializations, and could potentially facilitate their access to higher education opportunities and further on, to well-paying high-demand jobs.

References

Banks, J.A. & McGee, Banks, C. A. (2011). *Multicultural Education*. NJ, John Wiley & Sons, Inc.

Beaman, R., Wheldall, K., and Kemp, C. (2006, August). Differential teacher attention to boys and girls in the classroom. *Educational Review*, 58 (3), 339-366.

Beilock, S.L., Gunderson, E.A., Ramirez, G., & Levine, S.C. (2009). Female teachers' mathanxiety affects girls' math achievement. PNAS, 107, 1860-1863.

Clotfelter, C.T., Ladd, H.F., and Vidgor, J.L. (2003). Segregation and Resegregation in North Carolina's Public School Classroom. *North Carolina Law Review*, 81, 1464-1512.

Cvencek, D., Meltzoff, A.N., & Greenwald, A.G. (2011). Math-gender stereotypes in elementary school children. *Child Development*, 82, 766-779.

Entwisle, D.R., Karl, L.A., and Olson, L.S. (1997). Children, Schools and Inequality, Boulder CO, Westview Press Edts.

Faitar, G.M. & Faitar, S.L. (2012). The Influence of ability-tracking on the performances of minority learners. *Journal of Instructional Pedagogies*, 7, 1-9.

Ganley, C.M., & Vasilyeva, M. (2011). Sex differences in the relation between math performance, spatial skills, and attitudes. *Journal of Applied Development Psychology*, 32, 235-242.

Jacobs, J.E., & Bleeker, M.M. (2004). Girls' and boys' developing interests in math and science: Do parents matter? *New Directions for Child and Adolescent Development*, 106, 5-21.

Kelly, A. (1988). Gender differences in teacher-pupil interactions: a meta-analytic review. *Research in Education*, 39, 1-24.

Kelly, B. (2004). Do Increased Levels of Parental Involvement Account for the Social Class Difference in Track Placement? *Social Science Research*, 33, 626-59.___ (2009, January). The Black-White Gap in Mathematics Course Taking. *Sociology of Education*, 82, 47-69.

Mickelson, R.A. (2001a). Subverting Swann: First- Charlotte- and Second-generation segregation in the Charlotte-Mecklenbburg Schools. *American Educational Research Journal*, 38, 215-52.

Mickelson, R.A. (2001b). The Effects of Segregation and Desegregation on African American Middle School Students' Academic Achievement. Paper presented at the annual meeting of the American Educational Research Association, Seattle, WA.

Shapka, J. (2009). Trajectories of math achievement and perceived math competence over high school and postsecondary education: effects of an all-girl curriculum in high school. *Educational Research and Evaluation*, 6, 527-541.

Tomasetto, C., Alparone, F.R. &Cadinu, M. (2011). Girls' Math Performance Under Stereotype Threat: The Moderating Role of Mothers' Gender Stereotypes. *Developmental Psychology*, 47(4), 943-949.

Mathematics and Natural Sciences Survey

1. What is your gender? M F

2. Ethnicity Caucasian African Am. Asian Am. Native Am. Asian Other

3. Nationality

4. Age

5. Are you? Graduate Student Undergraduate Student

6. Major

7. How do you consider yourself in the following areas?

Mathematics	good	very good	average	less than average
Chemistry	good	very good	average	less than average
Biology	good	very good	average	less than average
Physics	good	very good	average	less than average
Medicine	good	very good	average	less than average
Environmental Sci.	good	very good	average	less than average
Engineering	good	very good	average	less than average

8. Who influenced the most your current academic career?

Teachers Parents Friends Myself

9. Undergraduate GPA Below 2 2-2.5 2.5-3 3-3.5 3.5-4

10. Graduate GPA Below 2 2-2.5 2.5-3 3-3.5 3.5-4 N/A

11. What is the major cause for your academic success?

Talent Luck Hours of preparation Lessons in class Courses previously taken

12. How many hours do you spend on average (weekly) for training?

0-3 3-6 6-9 9-12 12-15 15-18 18-20 More than 20

13. Are you better at: Theory Laboratories

14. What other activities were you part of in middle school when training for the following subjects?

	Tutoring	Gifted programs	Special Projects	Advanced Placement	College Prep.	After-school	Other* Explain
Mathematics							
Chemistry							
Biology							
Physics							
Medicine							
Environmental							
Engineering							

15. What other activities were you part of in high school when training for the following subjects?

	Tutoring	Gifted programs	Special Projects	Advanced Placement	College Prep.	After-school	Other* Explain
Mathematics							
Chemistry							
Biology							
Physics							
Medicine							
Environmental							
Engineering							

16. In middle school, what was usually your teacher's perception about your efficiency?

	Math	Chemistry	Biology	Physics	Medicine	Environmental Sciences	Engineering
Good							
Average							
Very good							

17. In high school, what was usually your teacher's perception about your efficiency?

	Math	Chemistry	Biology	Physics	Medicine	Environmental Sciences	Engineering
Good							
Average							
Very good							

18. In middle school, what was usually your teacher's attitude toward your interest in:

	Math	Chemistry	Biology	Physics	Medicine	Environmental Sciences	Engineering
Support							
Non-support							
Indifferent							

19. In high school, what was usually your teacher's attitude toward your interest in:

	Math	Chemistry	Biology	Physics	Medicine	Environmental Sciences	Engineering
Support							
Non-support							
Indifferent							

20. Were you tracked in middle-school?

Courses	Math	Chemistry	Biology	Physics	Medicine	Environmental Sciences	Engineering
Low-level							
Avg.-level							
High-level							

21. Were you tracked in high-school?

Courses	Math	Chemistry	Biology	Physics	Medicine	Environmental Sciences	Engineering
Low-level							
Avg. level							
High-level							