PROJECT REPORT

Women in STEM: A Civic Issue with an Interdisciplinary Approach

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Abstract

Fewer women major in STEM than in liberal arts and social sciences. How do family background and cultural issues impact upon and help shape students' career choices and majors? Using a civic engagement approach, our transdepartmental collaboration (Mathematics, Natural Sciences, and Liberal Arts) in a community college allowed 80 students to become aware of the invisibility of women in STEM. This paper discusses the outcomes of this collaboration in terms of understanding family and cultural influences on students' career choices and motivation to major in STEM, while raising the issue of women's absence in STEM. The data supporting the research are based on conclusions drawn from analyzing students' responses to surveys and contributions to class discussions, as well as homework and writing assignments. We also present a sample of student work in an effort to assess whether the instructional objectives of our interdisciplinary civic collaboration were met.

Introduction

Despite efforts to increase the representation of women in STEM fields, the gender gap in fields such as physics and engineering still persists (American Association of University Women 1998; Brickhouse 2001; Brotman and Moore, 2008). This gap is observed in both undergraduate education and in the workplace (Brickhouse 2001).

The need to recruit a more diverse workforce in the STEM fields dates back to the Sputnik crisis and America's response to the perceived technological disparity between the U.S. and rival nations in the 1950s. Today a serious lack of workers in STEM areas is exacerbated by the underrepresentation of women entering such fields. Increasing participation in STEM areas will invigorate society's efforts to innovate and design solutions for complex technological problems in the future. Clearly, ignoring a whole cohort of potential STEM workers when there is a natural shortage of people in the field does not alleviate the problem. Furthermore, increased

female participation in STEM fields may yield a more equitable society.

Within this context, the current paper involves a transdepartmental collaboration in a Community College setting. Three professors from different departments conducted action research to investigate the question of why there is a paucity of women in STEM- related fields. Data to investigate the student perspective were collected from multiple sources; surveys, assignments and class discussions, in order to strengthen the reliability of the data. The data were analyzed in order to understand the student perspective concerning the research question and to devise theories or approaches to address the problem. Throughout the project period, regular interaction and discussion among the three faculty members provided scope for reflective practices and for the refinement and improvement of subsequent stages of the project.

Contextualization, Civic Engagement, and Women in STEM: Literature Review

There is a significant body of literature focused on enhancing student interest in the STEM fields, as well as addressing the underrepresentation of women in several areas of STEM. For instance, the incorporation of real-world issues into mathematics classes has proven to be successful and meaningful for students, as is illustrated by the example of Roosevelt University, where González-Arevalo and Pivarski (2013) demonstrated the strong validity of integrating real-life, everyday connections as well as civic issues into semester-long class projects for an advanced Calculus II course. They found that students appreciated gaining an understanding of civic connections, so that they could view math not as an isolated subject, but as one that can be exploited to acquire deeper insights into real-world issues, such as the spread of HIV/Aids, levels of Greenhouse Gas emissions, wealth distribution, and population growth. The incorporation of SENCER principles (Science Education for New Civic Engagements and Responsibilities) into the course allowed students to critically explore key civic issues of local, national, and global concern from a multidisciplinary perspective.

The underrepresentation of women in the STEM sector has become a major civic issue at many hierarchical levels, including government and educational establishments (Report to the President 2010). For example, the Obama administration recently established an Educate to Innovate (2013) enterprise, comprising a partnership between the public and private sector and committed to broadening the participation of underrepresented groups in the STEM fields, particularly women and minorities, to enhance the diversity of the talent pool in this area (U.S. Executive Office of the President 2013). From the academic perspective, several studies have been conducted to explore the paucity of women and other minorities in the STEM fields, the reasons for such gender discrimination, and the obstacles women face, in order to promote strategies to overcome the diagnosed impediments. A recent study has shown that gender biases exist in science, particularly in academia. Science faculty from research universities, regardless of their gender, were found to exhibit unintentional biases towards male students (Moss-Racusin et al. 2012). This may stem from cultural stereotypes (Devine 1989).

In the 1980s and the 1990s, many scholars brought to light feminist pedagogies and feminist epistemologies (Hekman 1990; Keller 1985; Martin 1991; Pagano 1998). These pedagogies had a direct impact on course curricula and in the teaching of biology, chemistry, and physics (Barad 1995; Barton 1997; Rosser 1986; Whatley 1985). It is important to note that different majors provide different cultural environments. For instance, the humanities field is characterized by discussions and questions in classes, whereas science classes are dominated by a culture of acquiring specific skills to solve problems (Knight et al. 2011).

When looking for the roots of the underrepresentation of women in certain STEM fields, such as physics and engineering, several angles have been examined. Catsambis (1995) explored the achievement gap and science attitudes and achievements of a multi-ethnic sample of eighth grade students and found that girls' achievements were at equal levels compared to the boys, but that they had more negative attitudes towards science. Miller et al. (2006) examined gender differences in students' perceptions about science among high-school students and found that girls liked biology and health-oriented fields. However, girls often perceived science in general as uninteresting. Furthermore, the

underrepresentation of women in some undergraduate STEM fields can lead to feelings of isolation and to lower self-esteem compared to the males (Seymour 1995).

Two of the authors of the current article are faculty in STEM fields where women are underrepresented. A project to understand the gender perceptions of their students came to light when they were approached by a faculty member from the Education and Language Acquisition (ELA) department, who teaches a liberal arts capstone course.

The authors' focus is on the perceptions of gender inequalities in the science and technology areas—as related to the attitudes, feelings, and behaviors that a given culture associates with a person's biological sex—from the viewpoint of students at LaGuardia Community College. We also explore student perspectives on whether they believe that such gender inequality barriers will impede their development in specific sectors of STEM.

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LaGuardia's Mathematics, Engineering and Computer Science (MEC) department has extensively invested in contextualizing mathematics using civic engagement. In this connection, MEC faculty initiated Project Quantum Leap (PQL) as an evolution of the SENCER approach, in order to teach math topics within the context of pertinent civic issues to students in remedial and entry-level mathematics classes in a municipal two-year community college (Betne 2010). This project has yielded many faculty-developed projects during its three-year funded period, including those from a cohort of non-math faculty participants. Although not all the remedial and introductory math courses in which PQL was implemented were impacted equally, the overall outcomes showed positive effects on students' critical literacy skills and quantitative reasoning. As an illustration, the MEC faculty involved infusing an introductory college algebra course with PQL projects (Jaafar 2012). These projects focused on topics of civic relevance pertaining to the environment, health, and finance in order to enhance student engagement with the course material and allow students the opportunity to gain deeper insights into critical real-world issues by applying quantitative mathematical reasoning and interpretation. Student feedback from qualitative surveys was found to be overall very positive. For example, in a project related to debt and student loans, most participants said that their understanding of debt, interest rates, and repayments had improved considerably through participation in this work (Jaafar 2012).

"SENCERizing mathematics" is not unique to the PQL projects detailed above, which have been integrated into remedial and introductory mathematics classes. For advanced mathematics, González-Arevalo and Pivarski (2013) implemented semester-long projects in capstone Calculus 2 classes that yielded many diverse student research projects. Kasi Jackson and Caldwell (2011) applied feminist pedagogies (Hekman 1990; Keller 1985; Martin 1991; Pagano 1998) to the non-science-major introductory Biology 101 classroom, but in a limited manner. The aim behind the work was to integrate scientific knowledge with topics of civic importance so that students could improve their skills in applying science concepts to real-world issues that they are familiar with from everyday life. In assignments, students were asked to identify differences between science writing and the popular reporting of science, evaluate the content of a scientific news article, and discuss the flow of information between scientists and the media. From conducting surveys, the authors observed improved student confidence in the application of their scientific knowledge to social issues and enhanced interest in the course topics, although there appeared to be little change in students' desire to take more science courses (Kasi Jackson and Caldwell 2011).

Inspired by the successes of these "SENCERized" STEM-based courses, the three faculty from MEC, Natural Sciences (NS), and ELA teamed to create assignments about a non-traditional civic issue related to the underrepresentation of women in STEM. Gender equalities and the gender gap are current and critical societal concerns (Educate to Innovate 2013; Report to the President 2010), and, as discussed in the Introduction, the paucity of women in the STEM sector has increased significantly in recent years in terms of education, degrees earned, and employment in the STEM sector (De Welde et al. 2007; NSF 2012a; NSF 2012b). With regard to employment, women are outnumbered in STEM fields in industry, business, and government, although, interestingly, in institutions with lower salaries and status, such as K-12 schools and two-year community colleges, there are often more women than men in the majority of STEM areas

(De Welde et al. 2007). A number of reasons have been proposed for the dearth of women in STEM: lack of role models and encouragement, cultural bias and discrimination, poor salaries and status, and the balancing of work-life issues (De Welde et al. 2007; Pollack 2013). Hence, the issue of women's underrepresentation in STEM must be tackled from multiple perspectives and angles. We decided to explore women in STEM as a civic issue from diverse perspectives using a contextualized, student-focused, connected-learning, SENCER-based approach.

The Participants

The students who participated in the study come from diverse backgrounds and have attained different levels of academic skills through their distinct academic and social experiences. Eighty students participated in the study. Fifty-six of these students were taking either a remedial mathematics or an introductory college algebra course, and the remaining twenty-four students were enrolled in the LIB200 capstone course. The students in the mathematics classes were in the early stages of their journey at LaGuardia, whereas students in LIB200 were close to graduation.

The capstone course was fully dedicated to discussing women's issues from an anthropological perspective. It focused on women and the sciences, and students were assigned articles and data on women's involvement or lack of involvement in the sciences and then asked to write research papers on this key issue. MEC and NS faculty participants provided some of the supporting data and articles pertaining to the theme. They also visited the LIB200 class twice separately and took charge of the discussion of one of the master readings. The NS faculty member supervised two research papers in LIB200 on two famous figures in the sciences.

Students in the two targeted mathematics courses were also assigned reading and writing material, but to a lesser extent. In addition, they were assigned mathematical content that was included in the syllabus. (The details of the materials are described in the section "Infusing Remedial Mathematics Topics with Women in STEM" and in Appendices C and D). Surveys were also conducted in the two mathematics and LIB200 classes in order to explore the perspectives, ideas, and understanding of students related to the paucity of women in the STEM field.

Our purpose is to shed light on how, through this unique transdepartmental collaboration, we integrated civic and educational principles to our course content. The paper discusses the outcomes of this collaboration in terms of how to (1) better understand the process through which our students' major and career choices are influenced by their family background and cultural biases; (2) strengthen the motivation of students, particularly women, to major in STEM; and (3) raise awareness about women's absence from the STEM field. The data supporting our research are based on conclusions drawn from analyzing students' responses to surveys conducted in the two mathematics classes and in LIB200. We also analyzed the content of a sample of student work from specific assignments in an effort to assess whether the instructional objectives of our interdisciplinary civic collaboration were met.

Methodology

In order to address the civic and interdisciplinary aspects of women in the STEM fields, several methodologies were employed, with a focus on pedagogical approaches to engage students. We combined content and thematic analysis to examine students' work and identify common patterns in students' responses to both the surveys and assignments (Savin-Baden and Howell Major 2013). First, various student surveys were conducted. A demographic survey was administered that helped us better understand the diverse backgrounds of the students. A subsequent questionnaire survey focused on other key aspects, such as the reasons for students' major and career choices and the importance of women in STEM (Appendix E). The development of these surveys was based on discussions that took place in the LIB200 and mathematics classes as well as the students' responses to assigned readings. We have not used any internal method of validation of the surveys. The research was built into the LIB200 assignments: by signing up for the course, students agreed to engage in the readings about Women in STEM and participate in the two surveys. Within this framework, the authors believed it was not necessary to estimate the

percentage of students responding or to test for biases in the response frequency. Both surveys were administered to all students enrolled in the liberal arts capstone course and in the remedial and college-level mathematics courses.

Secondly, several assignments were designed in which students were given specific reading materials and relevant data as well as sets of guided questions. Using these elements, students were then asked to write appropriate essays based on the contextualized issues under consideration in this research. By "appropriate," we mean essays relevant to the topic of women in STEM, using the concepts of gender inequalities and biases and fulfilling the requirements of a capstone course. The final appropriate aspect of the essays is a result of a scaffolding approach that enables students to gradually grasp the course concepts and write a relevant final research paper, having worked through both low stakes and high stakes assignments and using ePortfolio to document their progress.

The issue of women in STEM has not previously been tackled from such an interdisciplinary and civic angle. As stated in previous work, a true interdisciplinary study involves a synthesis of at least two different disciplines or fields (Dykes et al. 2008; Lattuca 2001; Wall and Shankar 2008). The issue of women in STEM has typically been explored only from the perspective of students majoring in STEM. Our research is unique in that we are attempting to assess the benefits of a collaborative multidisciplinary approach to bring awareness to the issue of women in STEM, in the context of a liberal arts capstone course as well as in remedial and introductory mathematics courses for a predominantly non-STEM-major student population.

As we will show, each of these classes addresses in its unique way the civic issue of women in STEM using different assignments and methods. The goal of the research was to raise the awareness of all students in the classes about the underrepresentation of women in some STEM fields, rather than to target the women specifically. In this respect, the readings and discussion topics were enriched by the contrasting and diverse views of the whole group of students in the classes. We measured the impact of such an approach by the involvement of students in the class discussions and by their response or lack of response to the concerns of female students that were raised by their increased awareness of the women in STEM issue.

LIB200: Reflection on Cultural Impediments to Recruiting in STEM

The Liberal Arts Seminar explores aspects of the relationship between humanism and science and technology, and draws on texts from the humanities, arts, social sciences, and sciences. Students are required to reflect on the responsibilities of citizenship in a diverse society. The course is designated as writing intensive and, as a capstone, it offers a culminating experience for students' education at this community college.

LIB200 challenges students to demonstrate competencies in two areas: Critical Literacy requires students to understand and think about the world around them and encourages them to investigate and interrogate societal institutions and issues; Oral Communication comprises interpretation, composition, and presentation of information, ideas, and values through verbal communication. The particular LIB200 section that contributed to this research was fully dedicated to women and gender issues. The principal aim of this section was to help students acquire an awareness and a deep understanding of gender biases, and to encourage them to question and apply critical thinking to culturally constructed gender categories. The concepts studied in the course allowed students to further elaborate on the obstacles women face when they desire to enter and succeed in the STEM domain.

In terms of course content, the section analyzed theoretical literature on gender and explored various perspectives concerning women's lives from a cross-cultural standpoint that requires a multicultural approach. The multicultural aspect helped students to understand, accept, and value the cultural differences between groups, "with the ultimate goal of reaping the benefits of diversity" (Burn 2010, 8). Furthermore, relevant examples were drawn from a variety of different contexts and disciplines that are related to gender issues. For instance, the course stressed the main differences and commonalities of women cross-culturally. In this context, the Oral Communication component comprising discussions on women in STEM fits into the course unit designated as

"Women and Work." This unit covered issues related to cultural and social impediments to women's recruitment and promotion (such as the gender pay gap, the glass ceiling, etc.) as well as cultural factors that hinder women's involvement in educational and professional fields perceived as being male dominated. The social constraints in selecting a major and a job were also debated.

The interdepartmental collaboration for this project resulted in several assignments designed by the MEC and NS faculty and conducted with the LIB200 students. This collaboration did not involve team-teaching. The LIB200 instructor provided the platform for this collaboration because her class was well suited to the implementation of the research project. Although the LIB200 course elaborates extensively on gender-expansiveness (Understanding Gender 2015) and on the diversity of gender experiences across cultures, this collaborative project was designed to reflect the full spectrum of gender definition.

The collaboration encompassed the three disciplines represented by the faculty involved: the math and natural sciences instructors provided suggestions for reading material for the LIB200 students, which formed the basis for the class assignments, and also supervised the class discussions on this material. In addition, the natural sciences instructor supervised the research papers of two students enrolled in LIB200. The LIB200 instructor contributed to elaborating, supervising, and analyzing the questionnaire survey administered to the LIB200 students.

In the readings assigned for the class, critical references were made to gender inequalities, social construction of gender roles, family expectations, and social impediments in order to help explain the paucity of women in STEM. The assignments focused on (1) the general context of women and science, and (2) the life and contributions of specific women in the scientific arena. As stated earlier, the data for this research project were collected from the questionnaire survey (Appendix E), students' assignments based on the readings, and class discussions. Most of the emerging themes came from class discussions, which helped in the generation and refinement of the questionnaires. Time restrictions did not allow for any class observations or focus groups to further explore the themes. Our approach is based upon action research in that it involved selecting a focus, clarifying theories, identifying research questions, collecting and analyzing data, reporting results, and taking informed action by suggesting some measures (Kayaoglu 2015).

The questionnaire survey results are reported in "Survey Results & Assessment" below. Here we address one of the important issues for this research project: the lack of awareness regarding the presence of women in the sciences. For instance, to the question: "Could you mention the name of a female scientist?" only three students taking the mathematics classes and three students in LIB200 were able to provide an answer. In reaction to this lack of knowledge of female scientists, the NS professor designed an assignment for the LIB200 class that involved writing an essay dedicated to the contributions and life of a specific woman in science. The main aim of this assignment was for the students to explore the scientific career and accomplishments of the chosen woman and, importantly, to consider and acquire insights into the background, life, and culture of the woman, including any gender-related barriers and difficulties she may have experienced.

Further details of the assignments are given below and in the Appendices. Table 1 summarizes the different courses where the assignments in the Appendices were given.

Women and Science

TABLE 1. The Assignments in the Appendix. The X indicates the course in which the assignment was given.

	Appendix A	Appendix B	Appendix C	Appendix D
Remedial Mathematics	X		X	
College Algebra	X			X
LIB200	X	X		

This assignment was devised by the MEC faculty member.

Learning Goals: To understand the issues and factors related to the underrepresentation of women in STEM fields, to relate these issues to ones' personal circumstances and background.

Approach: Students were required to read an article entitled: "Why Are There Still So Few Women in Science?" (Pollack 2013). They were then asked to write a one-page essay based on the following questions:

1. Given your own culture, to what extent do you see the article's title statement applicable to you?
2. Suggest new ways of including women in the field of science. Provide explanations for your suggestions.

In a subsequent LIB200 class , the NS faculty led a discussion of students' opinions on the issues raised in the article. See Appendix A for more details of the assignment and samples of student output. This assignment was also completed by the students in the two mathematics classes. The MEC faculty member also introduced several other assignments that focused on more quantitative aspects of women in STEM. Some of these assignments were targeted for the remedial mathematics students, others for the college algebra group. We describe the assignments within the relevant course context below.

Specific Woman in Science

This assignment was devised by the NS faculty member.

Learning Goals: To familiarize students with the contributions of a specific woman to her scientific field, to expose students to the social issues and obstacles the woman faced at the time, to consider whether the same obstacles still exist today.

Approach: Students were asked to write a Research Paper of approximately 800–1200 words based on the contributions and accomplishments of a specific woman in science. This work exposed students to the scientific work and discoveries of the chosen woman, as well as to the social issues and obstacles the woman faced. The research paper also represented an opportunity for students to explore an area of their own academic or professional interest. See Appendix B for more details of the assignment and samples of the output of the two LIB200 students who worked on this assignment.

Infusing Remedial Mathematics: Topics with Women in STEM

At LaGuardia Community College, many students attend college part-time, have children and full-time jobs, and are often placed in remedial (also known as developmental) mathematics classes. In any given semester, approximately 7000 students enroll in a mathematics class, with forty-one percent of enrollees taking remedial mathematics. The majority of the students in developmental mathematics had negative experiences in previous mathematics classes, which has likely contributed to a low level of self-confidence, poor motivation, and/or high anxiety towards the subject (Hammerman and Goldberg 2003). Teaching remedial mathematics using a contextualized approach that invokes real-life problems in the mathematics setting can help the students engage with the subject and enhance their critical literacy skills.

The specific assignment designed by the MEC faculty member for this collaborative project is detailed below.

Learning Goals: To explain the concepts of ratio and percent using a civic issue as the contextualized medium, to master conversion from ratio to percent, to understand the meaning of a percent. The assignment reflects the interdisciplinary approach adopted in this project in that it draws its content from a gender-focused perspective. If it were not for this collaborative work, the instructor would have used examples stemming from a variety of fields (political, economic, biological…), all equally relevant to students.

Approach: This assignment comprised both in-class and out-of-class activities. The in-class activity involved students working in groups of three or four. In teaching ratios and proportions, data were used that were provided by the National Science Foundation and pertained to the

employment status and median salary of 2008 and 2009 science, engineering, and health doctoral degree recipients, in terms of broad field of doctorate and sex (NSF 2010a). First, students were required to look at the table and explain the meaning of the data. Students were then required to answer several questions about ratios of males to females in the biological sciences and in the mathematical sciences. In this respect, they needed to critically interpret ratios in context. Appendix C details the assignment.

The students were also provided with a second table that represented the number of Science and Engineering (S&E) doctoral degrees by sex and by selected country (NSF 2010c). Using these data, they were asked to identify their own country of origin in the table in order to find the percent of females in S&E fields and in Non-S&E fields. They were also required to choose another country, and again find the percent of females in S&E fields and in Non-S&E fields. Finally they were asked to compare and speculate on the reasons for those percentages and any observed differences.

LaGuardia's students hail from over 150 countries. To bring a "taste of home" to the assignments, it was important for our students to learn about the status of women in science in their country of origin and compare it with the United States. Native U.S. citizens were asked to consider a country of their choosing.

The out-of-class activity comprised two components. First, students were asked to write a one-page essay explaining their own career choice, and whether it is in a STEM or non-STEM field. They were also asked to relate data from the tables discussed in class to their career choice and to consider whether the underrepresentation of women in science impacts on the societal status of women. For the second component, students were assigned to read an article entitled "Why the Status of Women in STEM Fields Needs to Change" (Thomas 2013). The article not only describes why there are few women pursuing STEM fields but also argues why the status quo needs to change. Students were asked to write a one-page essay revolving around the following statement in the article: "As a culture, we don't particularly encourage girls to play with mechanical objects which can develop both comfort and interest." They were required to critically consider whether the statement is applicable to them and to suggest new strategies for enhancing the participation of women in the sciences. The same idea was also implemented in a college algebra class, with different learning goals. The reading assignment was the same but the essay was structured differently.

Infusing College Algebra: Topics with Women in STEM

Exploiting the real-world context of Women in STEM, this assignment was designed for an introductory college algebra class in order to improve the quantitative reasoning and critical literacy skills of the students. The specific assignment is detailed below.

Learning Goals: To understand Linear Modeling, to find and interpret the meaning of the slope.

Approach: Students were presented with a table about earned bachelor's degrees by sex and field for the years 2000–2011 (NSF 2010b). They started working on this mini-project during class time but were required to complete it on their own outside of class. Details of the project are listed in Appendix D. Several questions were assigned that required students to focus on the trends in bachelor's degrees awarded to males and females in both Psychology and Engineering. First, students were asked to calculate the percent of males who earned bachelor's degrees in Engineering in the years 2000 and 2011 and the percent of females who earned bachelor's degrees in Engineering in the same years. The aim of these questions is to show that, although the number of females earning a bachelor's degree in Engineering has increased from 12,206 to 14,656 over the eleven-year period, this represents only a twenty percent increase compared with thirty-four percent for male Engineering degree holders over the same period of time. To enhance their quantitative reasoning skills, the students were then asked to interpret the calculated percentages in the context of women in science and to identify any trends that the data revealed.

To further improve students' technological literacy, they were also required to use Excel to graph the number of males who earned bachelor's degrees in Psychology versus the year (starting in 2001) and the number of males who earned bachelor's degrees in Engineering versus the

year. For both graphs, students were required to find the best linear fit, interpret the meaning of the slope, and use the model to predict future values. Similar questions were asked using the number of females who earned bachelor's degrees in Psychology versus the year, and students were asked to compare the graphs. Psychology was chosen at random from among the five most popular majors in the U.S. An equally relevant data set could have been drawn from another of the five fields (U.S. Department of Education, National Center for Education Statistics 2015).

The aim of the mini-project was to depict the contrasting trends for female and male Psychology degree holders on the one hand, and for male Psychology and male Engineering degree holders on the other hand. Students were also required to interpret the meaning of the slopes and to rationalize the trends with a critical eye in order to answer a set of questions.

In their essays based on the assignment in Appendix A, students effectively related their personal career choice with what the article stated. The essays contained on average 800 words. Students used data from the table provided by the NSF, along with quantitative information they had calculated, such as the slope, to support their argument and thereby enhance their critical literacy skills.

Survey Results and Assessment

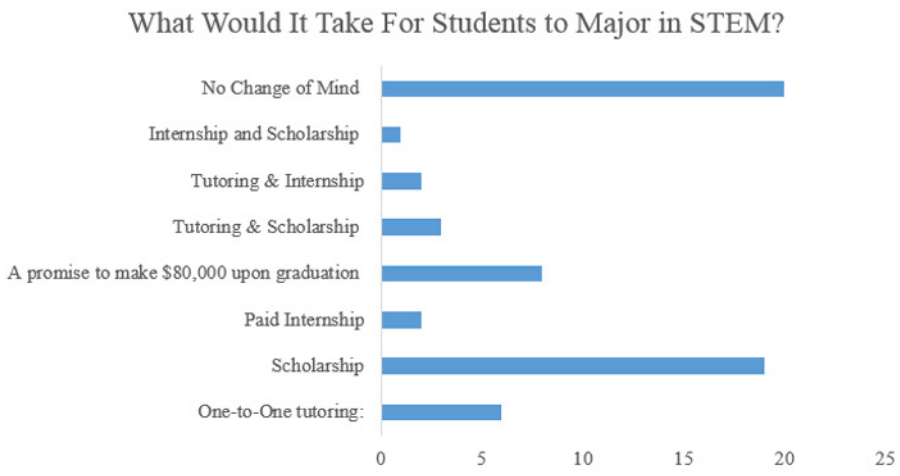
In this section, we analyze the results of the questionnaire survey detailed in Appendix E. Twenty-one students in LIB200 and forty students in the remedial and college algebra mathematics classes participated in an anonymous questionnaire survey after receiving approval from the institution's review board (IRB) to participate in this project (see Appendix E). The IRB also permitted us to conduct the qualitative research, with or without textual analysis. In terms of gender, sixty-five percent of participants in the mathematics classes and sixty-two percent in LIB200 were identified as females. In the mathematics classes thirty percent of students were found to be first-generation college-goers, compared with fifty percent for LIB200. In terms of majors, forty-three percent of participants in the mathematics classes intend to major in a STEM-related field, including nursing and health related areas, with the same percentage for LIB200.

Only thirty-six percent of all participants were aware of the status of women in the sciences prior to taking the class. This was an open-ended Yes/No answer question (see Appendix E, Question 13) and it was left to each student to individually interpret the meaning of "aware." Furthermore, only six students were able to name even one female scientist. Overall, the outcomes of the survey emphasize the value of the civic engagement aspects of this research, which serve to augment the critical understanding of the societal issue of the lack of women in the sciences and calls for both qualitative and quantitative reasoning skills. The survey also provides scope for students to reflect and critically think about STEM-related fields and why they chose their major and to evaluate their experiences, performance, and problem-solving skills at LaGuardia. It also encourages them to consider whether these skills and experiences are transferable to other subjects and to their future careers. The outcomes of some of the key survey questions are considered below.

How to encourage students to major in STEM

When trying to assess what it would take for students to major in STEM (survey Question 6), students' responses varied from a scholarship, to the promise of a

FIGURE 1. What would it take for students to major in STEM?



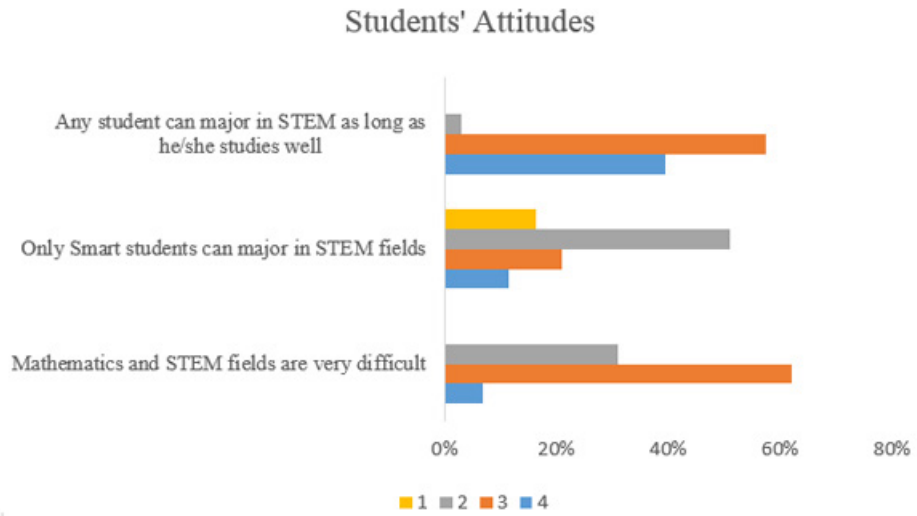
substantial living upon graduation, to the conviction that no incentive would make them change their mind (see Figure 1).

Students' attitudes

On a scale of 1 to 4, where 1 means strongly agree and 4 means strongly disagree, a majority of students (sixty-nine percent) believe that STEM-related fields are difficult majors. However, the same percentage of students do not necessarily believe that only smart students can pursue STEM fields, and almost all students agree that anyone can major in STEM fields as long as they study well (see Figure 2). This positive attitude is an indication of the maturity of the students: they all recognize that STEM fields can be difficult but that hard work can lead to success.

The next section highlights some excerpts from students' essays. Interestingly, they do not corroborate our assumption that family background plays the major role in students' career choices. Instead, there appear to be several factors that influence the major and career choices of the students.

FIGURE 2. Students attitudes towards majoring in STEM.



Who Chooses the Career Path? Excerpts from Students' Essays

To what extent do social norms, family, and gender expectation determine students' career choices? We found that our students' responses were mixed. Family background does have an impact on the career choice of some students, but for others, different factors exert the major influence, such as individual ideas and ambitions, culture (based on societal or geographical background, not just family background), and role models (or the lack of them where women in STEM are concerned). Interestingly, some students also referred to the changing of stereotypes, which are providing more opportunities for women. The males in the class also felt the influence of family and culture in their major and professional career choices but did not experience any stigma or barriers to entering the STEM field, beyond the perception of the difficulty of such subjects. A sample of students' responses is presented below.

The excerpts are taken from the LIB200 class.

One student wrote:

> My parents always told me to choose whatever career I wanted to do, they never decided for me. When I got to college I didn't know what I was going to study, but just like my parents I was thinking of doing business administration.

Another student stated:

> The culture that I am part of has brainwashed women to believing that they should just stick to the simple jobs or just play the role of a housewife. However, despite this deeming [sic] stereotype, women are challenging themselves and wanting to make changes to show that we are equally or even better qualified than men.

A student from the Caribbean Islands stated:

> ... given my own culture in the Caribbean girls are not subjected to this stigma; girls' schools allow them to select whatever they feel would give them adequate contentment in terms of career choice. Students who grow up in such settings end up not encountering difficulties in their own studies compared to those of combined schools

where both genders study together faced by discouragement.

In her research paper, a student wrote about the importance of analyzing the number of males and females in the STEM field:

> We can track inequalities cross-culturally in many different aspects; one way is to take a look at specific careers and the number of females in the field, vs. the number of males in the field. Science and engineering are fields mostly occupied by males, where typically they are respected and given gratification when deserved.

This clearly relates to the assignment conducted by students in the mathematics classes.

The excerpts below are taken from student essays in the college algebra class. Overall, the essays show that students have an appreciation of how to interpret the numerical data in the papers they were given, and they reference the lack of role models to encourage women to enter the STEM field. After each quote below, a deeper textual analysis is provided within the context of the current research question.

One student wrote

> I don't think culture influenced my career choice but rather it was inspiration and passion.... As the calculation showed, which was to find the percentage of women and men who got their bachelor's in engineering from 2000 to 2011. I found that there was and is a huge gap, for males there was a 34% increase in earned bachelor's degrees from 2000 to 2011 while for females the increase was just 20% in earned bachelor's degrees for engineering. Furthermore my calculation showed that there was a decrease of women getting their degrees in engineering while for males there was in an increase. In 2000 79.5% of males earned their bachelor's degree in engineering, while 20.5% of females got theirs. And in 2011 81.2% of males got their degrees in engineering, while 18.2% of females got theirs, this shows that more and more females are quitting the STEM field. But one of the things that surprised was the difference of earned psychology degrees for females and males; there are more females earning their bachelor's degrees in psychology than males. As the graph showed on my project, the value of slope for the females earning their bachelor's degrees is 1984, while the graph for males earning their bachelor's degrees in psychology shows a slope value of 662, that means that the increase of earned psychology degrees for females is 1984 each year while for males the increase is 662 each year. Why is it female presence in engineering is decreasing, while for psychology it is increasing?"

By "this shows that more and more females are quitting the STEM field," the student meant to say that although the number of female degree holders in some STEM fields has increased, this increase is much lower percentage-wise than the corresponding increase of male STEM degree holders. Within the framework of the research question, the data provided encourages students to interpret numbers in their context, a point discussed in class as a follow-up.

Another student related her experience to the data analyzed in a similar manner.

> Now that I am planning to transfer to a four-year school I meet with my counselor every month to discuss the career path I may choose. Just like her, she constantly recommends me to choose psychology. She never mentioned to me to consider science. She is a female who did psychology and I think she believes that it is better for me as a female to do psychology too. In the table of earned bachelor's from 2000 to 2011 it is clear that more females than males are more likely to pursue a degree in psychology. The average of females who earned bachelor's degrees in psychology per year is 1,984 while the average of males is 662.

It is clear from the essays that students mastered the use of trends and numbers in their context. In qualitative terms, most students were able to generate appropriate percentages and linear slopes from the data and interpret these values in the context of gender issues and stereotypes in the STEM field. It was also interesting to note that the female counselor did not recommend that her female student major in the sciences. What is the bias

playing against both of them? This testimony is a clear indication that a lack of awareness of cultural biases against women in the sciences could not only reinforce gender stereotypes in terms of career choices and majors, but also hinder the efforts to bring more females to STEM.

The absence of female figures who could act as role models to advocate for a more female-inclusive approach was brought up by students in the college algebra class:

> The trends of fewer women entering the field of engineering has obviously impacted their status in society in several ways. If there are fewer women in the STEM world, women will have less influence and power to encourage other women in society to pursue science degrees and careers.

This remark is corroborated by a statement made by an LIB200 student, who dedicated her research paper to the iconic figure in genetic mutations, Barbara McClintock:

> For women the fields of science and engineering can be a lonely and obstacle- filled career path. We often forget the remarkable achievement of women and barely give them recognition where is due. Too often do we ignore and forget female role models.

Conclusion

As evidenced by class discussions and students' assignments and responses to surveys, the instructional objectives of our interdisciplinary civic collaboration have been thoroughly explored. Our first objective was to determine family influence on majoring in STEM and choosing a career. The surveys provided the answer that perhaps cultural biases and the lack of female role models in the sciences were stronger influences. In fact, a significant number of students argued that family had no influence on their choices. Overall, there was no single influence that stood out as the most critical in the students' decision-making process.

Although we acknowledge that students' decisions exhibit a level of agency, we believe that their perceptions reflect a lack awareness of how deeply decisions and choices are embedded in culture. This leads to our second objective: to bring awareness to women's absence in STEM. Students discussed this issue at length with the three of us. They had specific assignments on the topic, and two students dedicated their research paper to specific women scientists.

Within the action research format, the assignments and the interactions that LIB200 students had with the three professors led to deep class discussions on the detrimental factors that prevent women from fully embracing STEM majors and careers. Contributions from students ranged from cultural issues, whether things are changing now or will change in the foreseeable future, and what we can do to encourage more women into the sciences. The NS faculty member was particularly inspired by several very personal comments from students in the class regarding not only the impact on the research question from the culture of their country of origin, but also from their specific family backgrounds. He thought these students were extremely brave to air such perspectives in "public" and found the whole session very rewarding and thoroughly enjoyed the experience.

Based on such class discussions in the MEC and LIB200 classes, it appears that students lack exposure to literature about women in STEM. We therefore call for educating students in order to bring awareness to this civic issue. However, the education of students in this context goes hand in hand with educating faculty, who may also be unaware of this situation. Indeed, a student testimony shared with us how, surprisingly, a female college counselor deterred her from pursuing a major in STEM and guided her into majoring in her own field, i.e. psychology. This leads us to wonder: to what extent is higher education reinforcing gender stereotypes when it comes to career choices? These biases bear close similarity to those portrayed in Pollack's New York Times article (Pollack 2013). A relevant future study would be to explore whether infusing higher education with appropriate role models would successfully influence students' future academic and professional choices.

In order to address the above matter, we suggest that increasing exposure to women in STEM should be done across curricula by having an open discussion about the problem and by suggesting readings in freshman seminars focused on the issue. Another solution would be to

provide students, especially female students, with female role models who could act as mentors. Research shows that lack of mentoring limits women's career opportunities, particularly in STEM areas. The aim of the mentoring system is to help guide the career of a junior member of the organization by sharing knowledge about how to succeed (Burn 2010). Mentoring is important in that it helps the junior employee to have access to promotions, career mobility, and better compensation (Ragins 1999). Advocacy for providing young women with personal support, job-related information, and career developmental support from their supervisors is backed by research (Bhatnagar 1988; Cianni and Romberger 1995; Noe 1988). Our collaborative research project shows that with the appropriate sensibilization to the situation and context, students took interest in the field of women in the sciences, as evidenced by class discussions, assignments, and research papers dedicated to the topic.

About the Authors

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Reem Jaafar holds a Ph.D. in theoretical physics from the CUNY Graduate School (2010). In 2010, she joined the Math, Engineering, and Computer Science Department at LaGuardia Community College as an assistant professor and was promoted to associate professor in 2013. During her tenure at LaGuardia, she has been the recipient of three grants, cofounded the Math Society, and invested in students' excellence at LaGuardia by training them to compete in regional and national mathematics competitions and by organizing STEM talks and workshops. She has coauthored thirteen papers in peer-reviewed journals and has presented her work in theoretical physics and mathematics pedagogy at over fourteen conferences.

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APPENDIX A

Write a one-page essay explaining the influence of culture on your career choice and whether you think it might have impacted your decision to major or not to major in science. In your essay, relate this statement to the statistics discussed in class and in the assignments, and explain how the presence of fewer women in science would impact the status of women in society.

Read the article: Why Are There Still So Few Women in Science?
By EILEEN POLLACK
The article can be found at:
http://www.nytimes.com/2013/10/06/magazine/why-are-there-still-so-few-women-in-science.html?pagewanted=all

Towards the end, the article states:
"As so many studies have demonstrated, success in math and the hard sciences, far from being a matter of gender, is almost entirely dependent on culture—a culture that teaches girls math isn't cool and no one will date them if they excel in physics; a culture in which professors rarely encourage their female students to continue on for advanced degrees; a culture in which success in graduate school is a matter of isolation, competition and ridiculously long hours in the lab; a culture in which female scientists are hired less frequently than men, earn less money and are allotted fewer resources."

(1) Given your own culture, to what extent do you see the statement applicable to you?

(2) Explain your position and suggest new ways of including women in the field of science.
(Write a one-page essay)

In-Class Discussion with NS Faculty
A very interesting and fascinating discussion ensued about the NY Times Women in Science article.

APPENDIX B

LIB200 Research Paper: WOMEN IN SCIENCE

The purpose of this Research Paper is to familiarize you with some of the contributions of women in science. This will expose you to the scientific work and discoveries of these women, and also to the social issues and obstacles they faced at the time. The research paper also represents an opportunity for you to explore an area of your own academic or professional interest.
Overall Format: Approximately 800–1200 words, double spaced and with a 12-pt. Times Roman font.

Report Format

The paper is in the form of a report and should include Headings and Sub-headings as described below.
The Research Paper should consist of the following sections:

(1) Title:
The title should present the name of the chosen woman and the scientific area in which she made a significant contribution. Please choose a woman you would like to write about and discuss it with your Instructor.

(2) Background information:
The background information should provide an overview of the life of the chosen woman. You could mention some details of her early life, her scientific career, and then her later life. This could also include some historical information that is relevant to the topic (e.g., a key historic moment, an important observation that led to a discovery, etc.). Here you can also establish the important contributions of the woman to her scientific field.

(3) Discussion:
This section forms the main body of the report. The Discussion should be divided into 2 parts:

i. Details of the key contributions of the chosen woman to science
This part describes the scientific area, what work the woman conducted, what her accomplishments were, and how they contributed to the field.

ii. Social issues face by the chosen woman
In this part, you should identify and discuss the social issues and barriers experienced by the woman at the time. What support did she receive? How did she overcome the obstacles? How did these experiences affect her scientific career and her life?

(4) Conclusions:
This section provides a summary of the previous sections. Discuss the legacy of the chosen woman in terms of scientific and/or social issues. Do you think women in science face similar barriers today?

Research Project Feedback

Two students in LIB200 conducted this Research Project. Their project papers are attached. They both put a great deal of effort into this assignment and produced very high quality and thoughtful papers, and it is hoped that they both enjoyed the experience.
The feedback and grades given by the NS Faculty to the two students are provided below.

Student 1
The student has chosen Woman in Science: Barbara McClintock.

This is a well-written paper. The Introduction and Background are excellent, and there is a good Discussion of the barriers overcome by Barbara McClintock, the support she received to succeed and her legacy. Student 1 also considered whether women face similar barriers today and included her own opinions on the causes of gender inequalities.

The only issues to improve the paper would have been to expand the discussion on her own opinions of gender inequalities, and more complete citation of references in the text.

Student 2
The student has chosen chosen Woman in Science: Marie Curie.

This is a very well written paper. The Introduction and Background are excellent, and there is a good Discussion of the scientific career of Marie Curie, the barriers she had to overcome and the support she received. Student 2 also considered whether women face similar barriers today in terms of the number of women in STEM fields and their salaries.

The only issues to improve the paper would be to give a little more detail of her own opinions and thoughts on the causes of gender inequalities. Also, Headings and Titles of subsections could have been used as suggested in the Guidelines document that was set (Background, Discussion, Conclusions). Finally, a list of references at the end is needed, and proper citation of them in the text as appropriate, particularly for the quotations that are used.

APPENDIX C

1. Fill out Table C1 below

Employment status by gender	Biological/ life sciences	Mathematical sciences	Physical and related sciences	Engineering
Total				
Female				
Male				
Male/Female				
Female/Total				
Percent of Females				
Percent of Males				

TABLE C1: Data taken from NSF (NSF 2010a).

2. Convert the ratio of females to the total into percent. Does your number agree with your calculation in the table?

3. From the table, what is the ratio of males to females in the biological sciences and in the mathematical sciences? Write down the ratio, and then explain the meaning of each ratio using your own words.

4. Read carefully the table http://www.nsf.gov/statistics/seind14/content/chapter-2/at02-40.pdf

a) What information does the table present?

b) Look for your country of origin in the table.

Find the percent of females in S&E fields and in non-S&E fields (S&E stands for Science & Engineering).

c) Choose another country, and find the percent of females in S&E fields and in non-S&E fields.

d) How do the two percentages compare to each other? Can you speculate why your country has the percent of women in science you found?

APPENDIX D

1. Fill out Table D1 below

Field and year	Engineering (2000)	Engineering (2011)	Psychology (2000)	Psychology (2011)
Total				
Female				
Male				

TABLE D1: Data provided by NSF (NSF 2010b).

2.

a) Calculate the percent increase in earned bachelor's degrees in Engineering for males between 2000 and 2011.

b) Calculate the percent increase in earned bachelor's degrees in Engineering for females between 2000 and 2011.

c) Which percent increase is higher?

3.

a) Calculate the percent of males who earned bachelor's degrees in Engineering in the year 2000 and percent of females who earned bachelor's degrees in Engineering in the year 2000.

b) Calculate the percent of males who earned bachelor's degrees in Engineering in the year 2011 and percent of females who earned bachelor's degrees in Engineering in the year 2011.

c) What trend do you notice between 2000 and 2011 for the female bachelor's degrees earners?

4.

a) Fill Table D2 below (be careful, start from 2001).

b) Using Excel, graph the number of males who earned bachelor's degrees in psychology versus the year (starting with year 0 in 2001 as indicated) and graph the number of males who earned bachelor's degrees in Engineering versus the year. For both graphs, find the best linear fit.

c) Write down the value of the slope for each graph, and explain what it means.

d) Which graph is increasing at a faster rate? Interpret it in terms of the slope.

e) Predict the number of male psychology and male engineering degree earners in 2020.

5.

a) Fill Table 3 (start from 2001).

b) Using Excel, graph the number of females who earned bachelor's degrees in psychology versus the year (starting with year 0 in 2001 as indicated). Find the best linear fit.

c) Write down the value of the slope for this graph and compare it with the slope of the graph that represents the number of male psychology degree earners (from question 5).

d) Which graph is increasing at a faster rate? Interpret the slope in c).

e) Predict the number of female psychology bachelor's degrees holders for the year 2020 and compare it with the expected number of male psychology bachelor's degrees holders for the year 2020.

6.

a) Fill Table D4 below.

b) Write the ratio of the number of female degree holders in engineering to the number of female degree holders in psychology for the years 2001 and 2011. Express the ratio as a percent.

c) What trend do you notice?

TABLE D2: Data provided by NSF (NSF 2010b).

Year	Earned bachelor's degrees in psychology (male)	Earned bachelor's degrees in engineering (male)
2001		
2002		
2003		
2004		
2005		
2006		
2007		
2008		
2009		
2010		
2011		

TABLE 3: Data provided by NSF (NSF 2010b).

Year	Males who earned bachelor's degrees in psychology	Females who earned bachelor's degrees in psychology
2001		
2002		
2003		
2004		
2005		
2006		
2007		
2008		
2009		
2010		
2011		

TABLE D4: Data provided by NSF (NSF 2010b).

Year	Females who earned bachelor's degrees in psychology	Females who earned bachelor's degrees in engineering
2001		
2004		
2007		
2011		

APPENDIX E

Anonymous Survey *Women in Science: Engaging Students in Liberal Arts Seminar and in Mathematics Classes*

1. I primarily Speak

i) English

ii) English and another language

iii) Another language

2. What is your gender?

i) Male

ii) Female

3. I am the first person in my immediate family to attend college

i) Yes

ii) No

4. My racial or ethnic identification is

i) Asian or Asian American

ii) Black or African American

iii) Hispanic or Latino

iv) Arab

v) White

5. My major is in a STEM field (Science, Technology, Engineering, and Mathematics)

i) Yes

ii) No

iii) Undecided

6. If you do not intend to major in STEM, what would it take to change your mind and major in STEM? Circle all that apply.

i) One-on-one tutoring

ii) Scholarship

iii) Paid internship

iv) Scholarship to attend a four-year college

v) A promise from someone that you will make $80,000 per year upon completing your bachelor's degree

iv) Other (Explain):_____

7. Is anyone in your family or extended family working (or graduated) in a STEM related field?

iv) Yes

v) No

8. What was the main reason why you decided attend college? (Check all that apply.)

i) My family wanted me to.

ii) I am interested in increasing my earning power by earning a college degree.

iii) I love to acquire new knowledge.

9. Did you intend to transfer to a four-year institution when you first joined LaGuardia?

i) Yes

ii) No

iii) Undecided

10. Were you good at mathematics in (circle ALL that apply):

i) Elementary school?

ii) Middle school?

iii) High school?

iv) I was never good at math.

11. What grade approximately did you earn in the last mathematics class you took at LaGuardia?

i) A

ii) B

iii) C

iv) D

v) F

12. How long did you spend studying for this course every week?

i) Less than three hours

ii) Three to six hours

iii) More than six hours

13. Prior to taking this course, were you aware of the status of women in the sciences?

i) Yes

ii) No

14. Can you name one or more famous female scientists?

_____

_____

_____

15. Do you think that what you learned in this course helped you understand your choice of major?

i) Yes

ii) No

iii) Somewhat yes

16. Indicate the extent to which you agree with the following statements:

	Strongly Agree	Agree	Disagree	Strongly Disagree
Mathematics and STEM fields are very difficult				
Only smart students can major in STEM fields				
Any student can major in STEM as long as he/she studies well				
I intend to major in a field I like, regardless of how easy it is				
I intend to major in a field I may not like just because it is easy				
I am a self-starter and self motivated				
I manage my time well and meet deadlines				
I know where to look for answers on problems I have difficulty with				
I know when to make judgments about the soundness of information and arguments				
The faculty and staff at LaGuardia care about me				
My experience at LaGuardia helped me change the way I see myself and life				
The skills and knowledge I acquired during my class this semester might help me succeed in other courses				

17. What were the biggest challenges you encountered in this course?