PROJECT REPORT

The STEM Gender Gap: Outreach Activities from Two Higher Education Institutions in Oklahoma

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Abstract

Studies have shown that one of the best ways to include a greater number of girls in STEM (Science, Technology, Engineering, and Mathematics) is to influence them from an early age, starting at the elementary or middle school level. In the past 15 years, the Department of Chemistry, Physics, and Engineering at Cameron University (CU) has been involved in several outreach activities, including the hosting of a one-week summer academy for middle school girls, Women in Leadership and STEM conferences, and several workshops involving middle and high school girls. Tulsa Community College (TCC) recently inaugurated its high school summer academy to encourage more girls to gravitate toward STEM and to provide positive reinforcement. We believe our outreach programs have been very helpful to female students, particularly to students who are in underserved rural and metropolitan schools throughout the state of Oklahoma.

Introduction

Even in the 21st century the number of women in science and engineering, especially in the upper level of those professions, is very low. In the area of physics and engineering, only 20% of bachelor's degree holders are women. This trend continues to graduate-level degrees and the transition into the workplace. Various research findings show that social and environmental factors

contribute most to the underrepresentation of women in STEM, particularly in physics and engineering. While the gender gap in those areas is shrinking in cities and urban areas, it is still very prevalent in rural areas. A role model for a career in STEM—a teacher, parent, or family member—can encourage a girl's interests in math and science, and, especially at the middle school level, can inspire her desire to explore a STEM career. Creating an environment to influence girls at this age will increase their likelihood of having an interest in science and math. In recent years, girls across the world have shown their excellence in mathematics skills, proving that the classical assumptions of men's excellence in mathematics and women's excellence in language skills are wrong. As a society, we need to pay careful attention to the creation of a STEM-encouraging environment for girls in classrooms and in the workplace. From a young age, school children are familiarized with several well-known male scientists like Einstein, Newton, Galileo, Faraday, Gauss, and Darwin, but usually with only one female scientist, Marie Curie. Even the famous discovery of the composition of stars by Cecilia Payne is still not known among young girls.

The stereotypical belief that math and science are male-dominated career choices affects young minds and leads to future career choices. A study conducted by Cheryan et al. (2013) showed that stereotypes of academic fields influence who chooses to participate in these fields. For example, the depiction of women in computer science in the media can influence the recruiting of more women in this field. Nosek et al. (2009) suggested that widespread, implicit stereotyping is correlated with gender inequality in science and math. They further suggested that changing implicit stereotyping requires the consideration of social realities that unintentionally shape minds. To understand the factors affecting the gender gap, we need to know the difference in performance of boys and girls in math from the elementary to the high school level. The data on standard math tests like the National Assessment of Educational Progress (NAEP) in the United States or the Trends in International Mathematics and Science Study (TIMSS) do not show trends of better performance by boys than by girls (Kahn & Ginther, 2017). A recent global education monitoring report by UNESCO covering data from 120 countries shows that in some countries like Malaysia, Cambodia, Congo, and the Philippines, the gender gap for math performance is reversed by a few points (Batel et al., 2022). Breda et al. (2023) studied PISA (Program for International Student Assessment) 2012 data on 251,120 15-year-old boys and girls in 61 countries to analyzed math-related career studies as a function of math performance. They found that boys have a stronger positive correlation between a math-related career and math performance than girls. Having a community and peer mentoring can contribute significantly to women's success in STEM fields. These could be in the form of tutor groups, club activities, and other research-focused mentoring (Atkins et al., 2020; Whitten et al., 2003; Winterer et al., 2020). Colbert and Hill (2015) suggested that the lack of computing education in K–12 schools can contribute to a gender gap in those areas at the professional level. Research found that during the adolescent years (middle school), students are more likely to gravitate toward in-group activities in order to have influence in peer groups. Goodwin (2013) stated that most girls lose interest in STEM-related topics between the ages of nine and twelve. Introducing more STEM-related activities to this group of girls can provide a sense of belonging and motivation. Reinking and Martin (2018) also stated that one of the theories about the STEM gender gap is "Gender Socialization." A report published in Harvard Business Review mentioned that 40% of women who earn engineering degrees either quit or never enter the profession (Sibley, 2016). The author also suggested that to prevent higher numbers of women from leaving the engineering profession, engineering programs need to avoid gender-based tasking and expectations in class work and at internship sites. A recent review published in the *Magazine of the Society of Women Engineers* (Meiksins, 2023) suggested that work/family conflict and lack of personal development are among the various causes of female engineers leaving the profession. They suggested that a program like NSF-ADVANCE, which emphasized research-based institutional transformation, could be created, focusing on industry's need to improve women's employment experiences.

FIGURE 1A: PhD Degrees Received in the US by Men and Women, 2014-2019

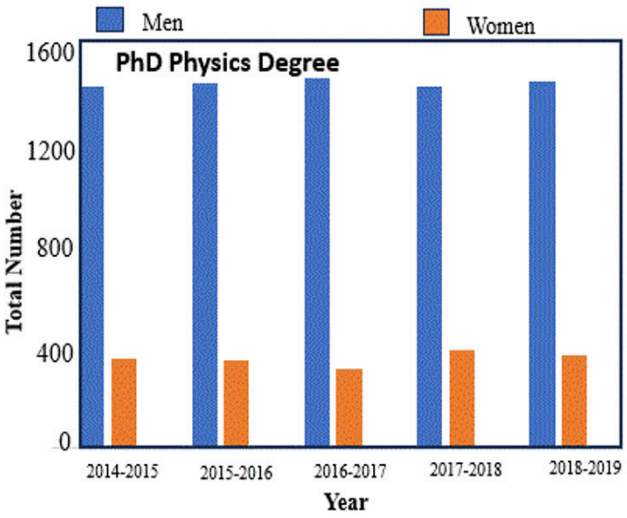
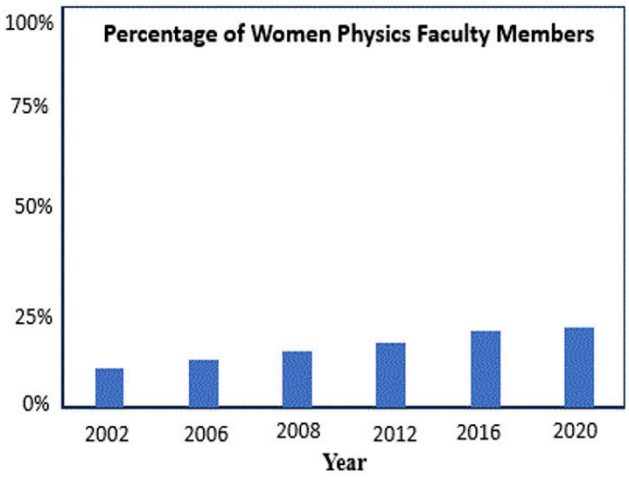


FIGURE 1B: Percentage of Women Faculty Members in Physics, 2002-2020



Data from American Institute of Physics Statistical Research Center

The Engineering and Physics Career Gender Gap

Within STEM fields like the biological sciences, women are no longer underrepresented. It is time to focus more on math-intensive STEM areas like physical science, engineering, and computer science. A report published in *Scientific American* in 2022 mentions that only 22% of computer science undergraduate degrees are awarded to women. Data published by the National Girls Collaborative Project show that fewer than 20% of professionals in computer and mathematical science are women. The field of engineering also has fewer than 20% women professionals. Figure 1 plots the data from the American Institute of Physics Statistical Research Center, which shows that fewer than 30% of physics doctorates were earned by women in the years 2015–2019. Data show that during past 20 years, only 20% of university physics faculty are women. There is, however, a slow increase of about 10% over the last 20 years. In the period from 1980 to 2019, the percentage of women earning a Ph.D. degree increased less than 15%.

STEM Education in Oklahoma

The National Science Foundation (NSF) and other nonprofit organizations fund programs to encourage young people to prepare for a STEM profession. Some of these are Girls Who Code, Letters to a Pre-Scientist, and programs offered by the Society of Women Engineers, the Association for Women in Science, the Special Section in the APS (American Physical Society) and ACS (American Chemical Society) for Women in STEM, National Girls Collaborative Project, and various outreach programs from NASA. Even though there are a number of programs at the national level to encourage more girls to study physics and engineering, in rural area schools girls are still not aware of those initiatives. States like Oklahoma, which ranked 45th in education in 2022, need more initiatives to promote STEM education for young students. At the eighth-grade level, 84% of Oklahoma students are not proficient in math, and the National Assessment of Educational Progress (NAEP) shows that Oklahoma's eighth grade students are 10% below the national level. This score is lower than in our neighboring states, Kansas, Missouri, and Arkansas. Data from the NSF on science and engineering show that Oklahoma has had a consistently lower percentage of bachelor's degrees in STEM in the past 20 years. Figures 2a and b display those data. There is a great need in Oklahoma for STEM education and for more people with STEM degrees. K–12-level STEM outreach programs from universities or community colleges could be extremely helpful.

FIGURE 2A: Percentage of STEM Degrees in Oklahoma

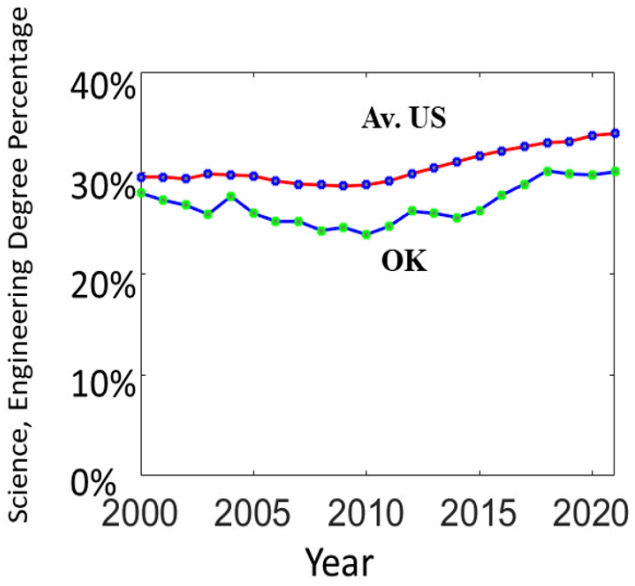
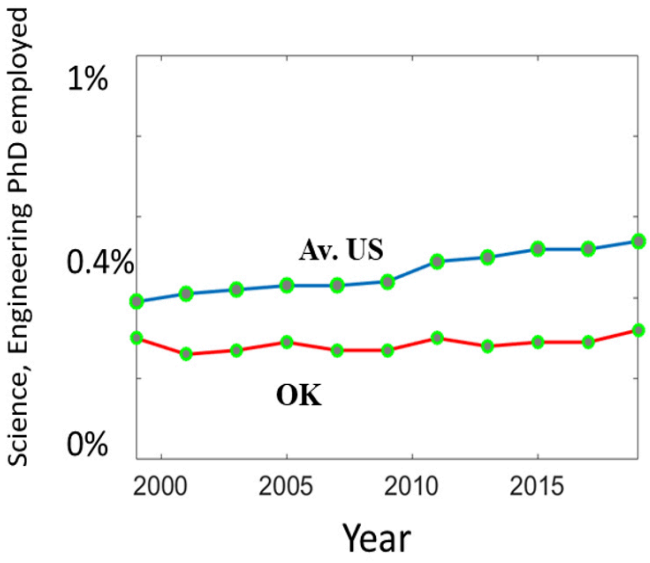


FIGURE 2B: STEM PhDs Employed, Compared to US National



Initiative from Cameron University:
Aerospace Engineering and Applied Mathematics for Middle School Girls

Cameron University is located in the southwestern region of the State of Oklahoma. It is a regional university with about 3500 students. The Department of Chemistry, Physics, and Engineering has been actively involved in promoting STEM activities in the community. It has been hosting a free summer camp, Aerospace Engineering and Applied Mathematics for Middle School Girls, for the past 10 years. Every year 10–12 middle school girls (grades 6–8) participate in this summer academy. It has been a one-week residential camp except when there were COVID restrictions. This academy has been very popular in southwestern Oklahoma. Various factors like school district, race, GPA, and a recommendation letter from the teacher are included in the selection process so that there is diversity among the participants. Every year we have two or three undergraduate students from the department serve as camp councilors to help the students along with the university faculty. We also include two or three local middle/high school science teachers to assist with the setup and management of the camp. We include a wide range of physics and engineering topics related to aerospace. Students are provided with breakfast, two snack breaks, and a lunch break during day camp. All materials, food, and drinks are provided free of charge for the participants. The main objective of this academy is to encourage the students in applied mathematics and to demonstrate how it is used in the areas of science and technology.

We include the following learning objectives for the students participating in the camp:

1. Demonstrate basic physics experiments related to kinematics.
2. Communicate effectively about the broader application of physics of motion.
3. Show teamwork by participating in group activities.
4. Earn an Aerospace Academy Camp badge.

FIGURE 3: Middle School Summer Academy Team in Summer 2021

TABLE 1. Brief Schedule of Activities for the Five-Day Camp, Summer 2021

DAY 1	· Keynote speaker (a women scientist) · Q& A session for the girls with keynote speaker · Lesson in physics of motion utilizing cart, motion sensor, photogate sensors, PhET simulation, and tracker simulation
DAY 2	· Physics of motion and gravity · Incline plane · Learn plotting motion data using LoggerPro software
DAY 3	· G force · Bernoulli's equation · Foil simulation · Build model F-15 plane from cardboard paper following NASA instructions
DAY 4	· Hands-on activity on hot air balloon · Foam rocket launch. Analyze data from foam rocket activity in terms of distance, angle, and time · Construct water bottle rocket
DAY 5	· Quiz bowl · Build a rocket using a standard kit · Closing ceremony with families

Cameron University (CU) Women in Leadership and STEM Conference

For the past seven years, the Department of Chemistry, Physics, and Engineering has been hosting a CU Empowering Women in Leadership and STEM Conference. The primary purpose for this project is to empower Cameron University undergraduate/graduate women, community members, and area high school women to seek their full potential in leadership roles within their chosen fields. This conference is geared toward giving students access to professional development, industry insight, and current research in the field of organizational leadership. The seminar is designed to be a one-day opportunity for students and local women in leadership positions to explore the skills that create a successful executive/leader. The leadership panel continues to bridge the gap between CU students who are about to begin their careers and local women who have found success in theirs. In addition to the panel sharing their personal experiences, students are encouraged to submit questions before the panel discussion that address their specific concerns. An impromptu question and answer session ends the panel. The evening culminates with a mixer to encourage participants to network and build further connections with local women in leadership and with one another.

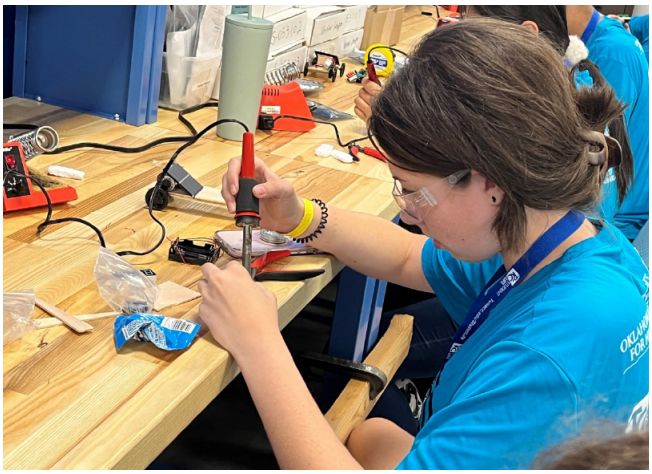
This project also includes the selection of students to attend the Annual Oklahoma Women in Leadership Conference. Although its high registration cost may prevent a typical CU student from attending, this conference provides a useful experience for students and can help prepare our students to be successful business leaders by showing them how important trust and impactful leadership are for the success of a business. A *Forbes* article (Graham, 2020) surveyed 2200 chief financial officers and found that the most common mistakes people make when networking are "not asking for help, failing to keep in touch or reaching out only when they need something, failing to connect with the right people, not thanking contacts when they provide help, and not helping others." By learning about these strategies to establish trust and fulfillment in their relationships, Cameron students will be empowered to act as leaders within their community.

Tulsa Community College Summer STEM Academy for High School Students

TCC's residential Summer STEM Academy provides STEM career exploration in a stimulating, engaging, and fun learning environment via hands-on instruction and experimentation. Students actively engage in project-based learning activities in math, engineering, and physics related to the design and building of a roller coaster, going into detail beyond lessons learned in everyday secondary STEM courses. The program served a total of 30 students, 28 first-time participants and two junior counselors who were interested in STEM in grades 9–12. Over 50% of the student participants recruited were female and approximately 40% were from other underrepresented groups.

FIGURE 4A: Junior Counselor Atriya Nourbakhsh Interviewed by Local News Media

FIGURE 4B: Southwest Oklahoma High School Student at a Summer Academy at Tulsa Community College



The focus of recruitment was building a diverse population of students, recruited with the assistance of tribal nations, local secondary schools, churches, community organizations, and outreach programs, meeting Board of Regents target populations. This academy serves as a supporting or reinforcing initiative to the introductory initiatives listed above with the middle school girls. We believe providing follow-up opportunities throughout that state will solidify STEM confidence and interest in female students. Figure 4a shows a student who attended the CU Summer Academy in Lawton, Oklahoma and then later was able to serve as a junior counselor at the HS TCC STEM Academy. Figure 4b depicts a southwest Oklahoma student who traveled to Tulsa to participate in the summer academy. As with the middle school girls academy, all costs are covered by external and internal grants and industry sponsorships. This allows the academy to be accessible for all students across the state.

Women in Science Conference, Science Sessions for Local Schools, Girl Scouts

Faculty from Chemistry, Physics, and Engineering have been participating with groups of female students at a Women in Science conference in Oklahoma for the past several years. We have been demonstrating physics, chemistry, and engineering activities to about 1500 middle school and high school girls from all over Oklahoma each year. We do electromagnetics, optics, and mechanics

FIGURE 5: Faculty and Students from Cameron University

demonstrations in physics, and chemistry demonstrations like chromatography and making slime. Engineering demonstrations such as making a bounce cart are also offered. Our students and faculty enjoy this rewarding experience. In addition, our faculty host science sessions every semester for local schools and Girl Scout groups. These sessions are in high demand from our local community. Figure 5 shows Cameron University's diverse group of faculty and students who participated in a recent Women in Science conference.

Conclusion

Aerospace Summer Camp offered many fun-filled activities for the students. Parents and guardians also enjoyed the students' rocket launching and were very happy to

see their enthusiasm. We encourage the students to keep in touch with us for future mentoring and to share their progress. Participating in a wide range of activities in this camp emphasizes teamwork among students, opportunities for active participation, and effective communication. This prepares students for professional success and helps to develop a desire for lifelong learning in science. This camp also gives undergraduate students from our department opportunities to get involved in STEM outreach activities with young girls, for example by helping them do lab setup and record data and by responding to their questions. This type of learning engagement gives students confidence to move forward in their careers and prepares the students to become professionals in their selected fields of study. In the future, we are planning to include camps with other topics like observational astronomy, space weather, and applied optics. We are also planning to include a mentorship program in physics, engineering, and astronomy, where our faculty could give high school girls the opportunity to do job shadowing and demonstrate frequent activities in science and math. By participating in these high-impact learning experiences like CU Women in STEM and Leadership conferences, our students come to understand the different leadership opportunities they can create, in a set discipline or for a specific company, once they complete their degree. This experience will motivate students to stay steadfast in their program and by doing so, will enhance their academic experience and their ability to become leaders in their field. These students will also use what they experience during this seminar along with their academic courses to actively engage in leadership experiences on campus. After students have actively participated during the one-day leadership and business seminar in Oklahoma City, they are encouraged to participate in an online evaluation and are prompted to provide details about the most beneficial aspects of this seminar. Ultimately, this project enhances student learning by facilitating their development of a long-term professional vision. The event provides students with a game plan to better navigate the networking process and highlights strategies for tapping into the network they already have, building connections within the university and with the community.

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