Seeding future engineers

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Abstract

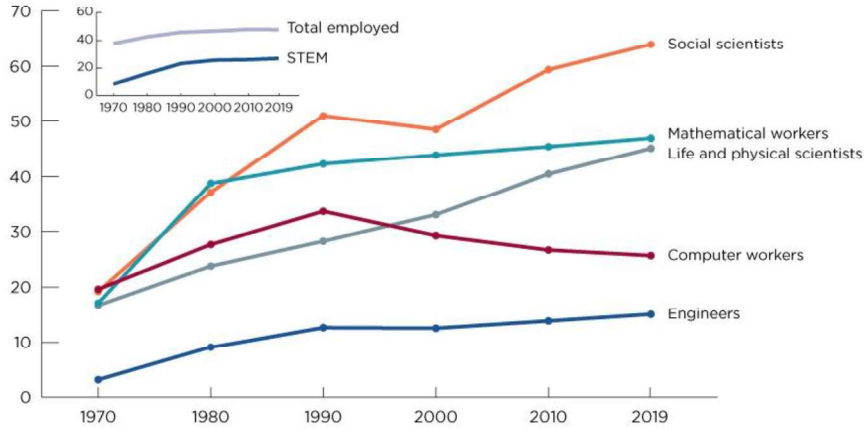
How to motivate female students to progress in the Engineering course? This question was the motivation for this work, which aimed to introduce some women who have revolutionized the world around Exact Sciences to female students attending the Engineering course at the University of Brasilia. This paper presents personal and professional bibliographic results of four extraordinary women scientists in exact sciences: Ada Lovelace, Katherine Johnson, Marie Curie, and Hedy Lamarr and, reports the results of the experience of this work developed in which it concludes benefits of self-esteem, overcoming, courage and appreciation of the female gender, promoting the planting of female engineers.

Keywords: Women Scientists; Female Gender; Motivation; Exact Sciences.

1 Introduction

When we think of physics and mathematics, we remember physicists Galileo Galilei and Albert Einstein, and mathematicians Leonhard Euler and Gottfried Leibniz, for example. In engineering we remember Leonardo da Vinci and Gustave Eiffel. What do they all have in common? They are men in exact sciences. Where are the women in this field? Historical accounts register that it was unusual to have women in the Exact Sciences, because they were prepared to dedicate themselves to domestic chores and were not suitable for this training; and those who had the opportunity to study in this area were because they had family financial support, but the merit of their achievements was not attributed.

Figure 1 presents global statistical data of the most employment sectors for women from 1970 to 2019 (before the start of the COVID-19 pandemic). In 1970, women made up 38% workers and 8% representatives in the STEM fields (Science, Technology, Engineering and Mathematics). By 2019, the STEM proportion had increased to 27% and women made up 48% of all workers, on what women also made up nearly half of those in all math (47%) and life and physical science (45%) occupations.



Source: U.S. Census Bureau, 1970, 1980, 1990 and 2000 Censuses; 2010 and 2019 American Community Surveys, 1-Year Estimates.

Figure 1. Porcentage of women in STEM jobs: 1970-2019.

Currently, there has been an increase in the number of female scientists, but they are still a minority and are still not valued in some fields. Why is this? Because career choice is due to cultural factors acquired in childhood and adulthood rather than biological factors (Reis & Silva & Carvalhaes, 2016). For example, toys discriminated by gender, that is, dolls for girls and cars for boys, generating less contact for them in parental activities that have social culture linked to technological and exact themes (Mascarenhas, 2019).

In the studies by Matusovich & Streveler & Miller (2010), they show that the motivation for choosing an engineering course is due to emotional values, acquired beliefs and discovery of personal identity, especially for female students. On the other hand, intrinsic and social motivations are the motivational factors to attract students to engineering education and in addition, women are significantly influenced by their mentors (Kolmos, & Mejlgaard, & Haase & Holgaard, 2013).

Given this situation, the idea arose to expose to the female students of the Engineering course at the University of Brasilia (UnB) some female scientists who revolutionized the world of Exact Sciences with their research, because inspirations come from examples, right?

Thus, the objective of this article is to expose the personal and professional bibliographies of four women scientists (Ada Lovelace, Marie Curie, Hedy Lamarr, and Katherine Johnson) and to report the motivational experience of this exposition for the students of the Engineering course at UnB.

Initially, we will make a documental presentation of these researchers in chronological order. Next, we will report the characteristics of the students involved in the Engineering course, where the work was developed. Finally, we will show the results obtained and the conclusions.

2 Four women who changed the world of exact sciences

In the old days, restrictions on women's access to education were customary and the rare ones who had admission to education could not publish their work because they were expected to be groomed to be only good wives and good mothers and supported by their husbands and furthermore, society labeled that woman were not talented in the exact field like men (Ygnotofsky, 2016). The four women in this article broke rules, learned to listen to themselves and follow their dreams.

2.1 Ada Lovelace

On December 10, 1815, Augusta Ada Byron was born in England-UK, the daughter of poet George Gordon Byron and mathematician Anne Isabella ("Anabella") Milbake - known as the princess of parallelograms. Her parents divorced when she turned one year old. Thus, she lost the paternal bond and started living only with her mother, who was responsible for her education by hiring excellent tutors and for influencing her in exacts. When she was 8, her father passed away, leaving poetry as her second passion, as numbers became her great admiration.

At 17, Ada met the old scientist Charles Baggage who was amazed by her intelligence. At the time he had created the analytical machine (a device like a large clock full of gears for adding and subtracting numbers). He became her mentor and thus began the emergence of the great mathematician Ada Lovelace.

In July 1935, at the age of 20, Ada married William 8th Baron King, Earl of Lovelace, and became known as Ada Lovelace. They had three children, but at the age of 36 due to uterine cancer, she died and at his request, was buried next to her father in Nottinghamshire, a county in England situated in the East Midlands.

After one hundred years of her loss, the poetic scientist's notes on Baggage's analytical machinery have been recognized as a description of a computer and software, i.e., she is the first person to create a computer program that took as its inspiration the punched cards used in mechanical looms at the time.

In her honor and in her recognition around exact sciences, in 1980 the U.S. Department of Defense created the ADA programming language, and since 2009, every second Tuesday in October is celebrated as Ada Lovelace Day, whose goal is to highlight women in science, technology, engineering and mathematics.

Figure 2. Image of Ada Lovelace (Source: https://pt.wikipedia.org/wiki/Ada_Lovelace).

2.2 Marie Curie

Marie Salomea Skłodowska was born on November 7, 1867, in Warsaw-Poland in a period when her country was under Russian rule. From an early age the words "How does this work? What is it? Why is it here? I have an idea" became her jargon. With the death of her mother, at the age of 10, and three years later with the loss of her older sister, she began to dedicate herself more to her studies and to science, which she was fascinated with, but a hidden learning, since women were not allowed to attend universities.

In 1891, at the age of 24, Marie gathered money to attend the Sorbonne University in Paris and it was during this period that she met the scientist Pierre Curie, in which they married in 1895 and became recognized as Marie Curie and had two daughters. They were a couple with a passion for research and together they formed a brilliant team. In the year 1903, they won the Nobel Prize in Physics for the discovery of radiation, which made Marie the first woman to be awarded this prize.

The Curies knew that the effect of the radioactivity was making them ill, yet they did not give up scientific work. In 1906, Pierre died in a carriage accident, and despite great sadness at the loss of her husband, she continued research with the radioactive materials they had discovered: polonium and radium, named after the country of Poland and the sun, respectively. These discoveries led Marie to receive her second Nobel Prize in Chemistry in 1911, making her the first person to have two Nobel Prizes in different fields.

During World War I in 1914, she served as a volunteer nurse driving x-ray trucks to save and help wounded French soldiers. In addition, she proved that radium is a powerful material for cancer treatment. She died of leukemia at the age of 66, leaving great inspirations of courage and fraternity for scientists today.

Figure 3. Image of Marie Curie (Source: https://pt.wikipedia.org/wiki/Marie_Curie).

2.3 Hedy Lamarr

Hedy Lamarr is the stage name of Hedwig Eva Maria Kiesler, an Austrian born on November 9, 1914.

From an early age, her beauty was admirable, which made her win several beauty contests and start her artistic career at the age of 16. She had a very controversial personal life, was married six times, and had two children with her third husband, John Loder. In addition, most of her husbands were wealthy and influential politicians, for example, her first husband, Friedrich Mandi, in which she attended his meetings with researchers and scientists that awakened and revived her interest in technological research.

In 1940, during World War II, Lamarr patented her first invention: a radio interference device to alter Nazi torpedoes; the idea for which came about together with composer and friend George Antheil. This work was

the basis for the creation of wi-fi, Bluetooth, GPS, and military communication, i.e., she co-invented the technology to use frequency hopping spectral scattering (FHSS).

In the last years of her life, she lived alone and did not like visitors, died at the age of 85 residing in Florida-USA, received several awards in life and fourteen after her death, in 2014, entered the National Inventors Hall of Fame.

Figure 4. Image of Hedy Lamarr (Source: https://pt.wikipedia.org/wiki/Hedy_Lamarr).

2.4 Katherine Johnson

On August 26, 1918, African American Katherine Coleman was born in the small town of White Sulphur Springs, USA. Due to the racial segregation of the time, she had many prejudices and difficulties in accessing education, but this did not hinder her dedication to her studies.

At 15, she entered the university and was tutored by W. W. Schieffelin Claytor, the third African American to earn a PhD in Mathematics. In 1939, Katherine at age 18 finished her undergraduate degree and was the first black woman to complete a college degree.

In 1929, she interrupted her professional career to devote herself to her marriage and the three daughters she had with her first husband James Francis Goble. In 1956, Katherine was widowed and, remarried in 1959 to Lieutenant Colonel James A. Johnson, and became known as Katherine Johnson.

She returned to research in 1953 working for the U.S. Aerospace Department (now the National Aeronautics and Space Administration - NASA), where she was responsible for man's flight to the moon in 1962. He then dedicated himself to space work for NASA and retired in 1986, after 33 years of dedication to mathematics for aerospace engineering. He received several awards and honors before he passed away on February 24, 2020, at the age of 101, including the Presidential Medal of Freedom.

Figure 5. Image of Katherine Johnson (Source: https://pt.wikipedia.org/wiki/Katherine_Johnson).

3 Description of the experience

In 2021, the idea of planting, sowing, and motivating female students emerged from the author's concern with their demotivation in dropping out of the Engineering course at Faculdade do Gama (FGA), during the period of the pandemic caused by COVID-19. FGA is an extension of the University of Brasilia (UnB) of Brazil, in which it offers five engineering courses: aerospace, automotive, electronics, energy and software.

For this reason, an extension project entitled "Mathematical café for future female engineers" was created, which took place in the period from May to December 2021 with weekly meetings in virtual format with the participation of 50 students, in which the themes were directed:

- A bibliographical exposition of personal and professional women who have made historical contributions and revolutionized the significant role in the engineering courses offered at FGA.

- The presentation of curious historical facts in the world of Exact Sciences.
- Emotional themes to mitigate the period of social isolation due to the COVID-19 pandemic, such as: anxiety, depression, phobia, nostalgia, fear, etc.

Figure 6. Logo of the extension project Math Café for future female engineers.

4 Results and Analysis

To collect data from the extension project presented, the female students who participated in this activity answered a brief questionnaire (voluntarily) that addressed the following questions:

(i) Did the presentation of women who shone in exact sciences motivate you to continue in the Engineering course?

(ii) Did your perception of the Engineering course change positively with the exposure of the female scientists of the project?

(iii) Were your emotional problems arising in the isolation period because of the COVID-19 pandemic successfully alleviated?

(iv) Did you enjoy participating in the project?

(v) Among the four scientists studied, which one did you like the most? Why?

In addition, the questionnaire had a space for open answers so that the students could give their opinion, suggest and/or criticize. Thus, the scale dimensions ranged from 1 (strongly disagree) to 4 (strongly agree).

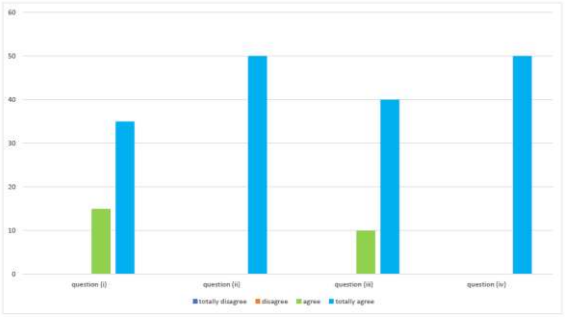


Figure 7. Questionnaire response - questions (i) to (iv).

Based on Figure 7, it can be concluded that most of the students considered that the exemplification of outstanding women in exact sciences motivated them to continue in the course (35 votes = 70%) and that their perceptions/notions of the Engineering course became clearer and more motivating (100%). The emotional themes worked on helped overcome the period of isolation experienced by the COVID-19 pandemic (40 votes = 80%) and unanimously, all participants enjoyed participating in the project (100%).

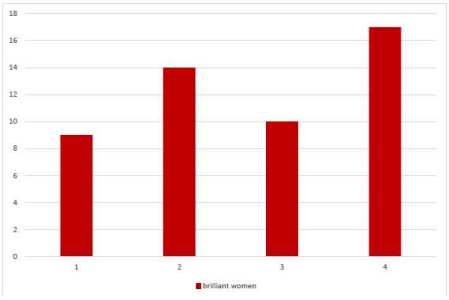


Figure 8. Answer to question (v).

Figure 8 presents the scientists favored by the participants. Thus, listed in descending order were Katherine Johnson (17 votes = 34%); Marie Curie (14 votes = 28%); Hedy Lamarr (10 votes = 20%) and Ada Lovelace (9 votes = 18%), respectively, the justifications were: example of race and courage; example of fraternity and love for science; example of beauty and intelligence; example of achievement and conquest.

Below are four randomly open responses from some participants:

- Student 1: *"The participation in this project was a great motivation for me to keep in my Engineering course. In particular, highlight the example of scientist Marie Curie who encouraged me to study what I love and not be afraid to always research what I don't know."*
- Student 2: *"The project brought me a different perspective on women's skill in Exacts. I had my hope renewed and my emotional worth. In addition, meeting all these women scientists are certainly great motivational examples to attend the Engineering course."*
- Student 3: "*Katherine Johnson and Hedy Hamarr were the scientists who motivated me the most, as they were distinct examples of economic class and race, but both had courage and fought for their dreams. Exacts are also for women!*"
- Student 4: "*The women scientists studied in this project improve my conception of myself, that is, my values, my beliefs and my goals. In addition, the stories of these great women motivated me to have courage in my choices and find the strength to never give up on my dreams*."

According to the data presented, it can be concluded that the personal and professional bibliographic study of women scientists in the Exact Sciences was a great motivator for the permanence of female students in the Engineering course, because women scientists were sources of inspiration and intrinsic motivation, which converges with the results of Kolmos, & Mejlgaard, & Haase & Holgaard (2013). In particular, it is highlighted that the values (captured from the brilliant women scientists studied): autonomy, mastery, purpose, courage, achievement, perseverance and creativity, were sown, planted and will certainly always be cultivated by the students participating project.

Therefore, it is concluded that real inspirations from women scientists who made history and shone in the field of exact sciences can successfully attract women and/or young people to engineering with female empowerment.

5 Conclusions

With the results obtained in this study, it was possible to observe that the students were motivated and excited to stay in the Engineering courses at FGA, due to the many real-life accounts of female scientists who revolutionized the area of Exact Sciences. The approach presented cleared up doubts and exposed curiosities in the universe of exact sciences that stimulated the participants' curiosity. The emotional themes brought emotional comfort for the period of isolation due to the 2021 pandemic of COVID-19.

The scientists presented mirrored in the students the joy of fundamental discovery, awakening the feminine touch of each within themselves (Swaby, 2015). As such, it is believed that exemplifying women in exacta enables a great benefit to plant and sow fruits of motivation, self-esteem, courage, overcoming, female empowerment, and confidence so that SHE can follow the brilliant paths that these pioneers once explored.

For future activities, it is intended to carry out a local and global statistical survey on factors that are capable of awakening more women in the exact sciences, especially in engineering.

Acknowledgements

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