GENDER STEREOTYPES – A FRONTIER FOR WOMEN IN COMPUTER SCIENCE

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Abstract: *Modern society is still haunted by stereotypes, particularly when we talk about the field of Computer science. The number of female specialists in Computer science is increasing, but gender stereotypes and frustration still determine many girls nowadays to consider a less masculine profession in life.*

The present study starts from a historical presentation of the term STEM- a type of education developed in the USA in the 1970s and reaching the highest level of implementation in public schools after the year 2000, as well as its implications upon modern society. This part will set the ground for an understanding of the gender stereotypes and their impact on STEM related fields. At the same time, this part will create the link between an understanding of the educational profile of young women who pursue an academic path involving the field of computer science and a career in the field.

The purpose is to understand how mentalities can be changed, in a masculine world which is extremely competitive, where women can become counterparts of their male competitors. The final aim is to develop a set of cultural awareness skills, able to overcome gender stereotypes in the field of Computer science.

Keywords: *gender studies, Computer science, STEM education, Hofstede's dimensions of culture, masculinity vs. femininity*

1. Introduction

Modern society still lacks the competence and knowledge of women, in fields like Computer Science. STEM education, whose acronym comes from science, technology, engineering and mathematics, represents that field of activity which evolved dramatically during the last twenty year.

In the United States of America, statistics say that in middle school, interest for STEM related subjects and classes is almost equal for boys and girls and diminishes by 15% percent as teenagers reach high school. The same statistics suggest the fact that at academic level the figures drop dramatically, resulting in a maximum 20% of all bachelor's degrees earned by women in Computer science.

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The sociological explanation for this issue is the fact that social barriers and gender stereotypes negatively affect girls' decisions related to applying for a bachelor's degree in computer science. There are a number of misconceptions still visible in today's modern society, where women are seen as too soft, more compromising than men, and less able to take decisions under a large amount of stress. Probably this is one of the reasons why the Dutch sociologist, Geert Hofstede, when he analyzed the IBM work environment all over the world, felt the sociological need to explain the difference between masculine and feminine societies, not in terms of the job responsibilities that should be assigned to men and women, but more related to the difference of approach of the two genders, particularly where top management positions are involved.

As Hofstede himself suggests: "A society is called masculine when emotional gender roles are clearly distinct: men are supposed to be assertive, tough, and focused on material success, whereas women are supposed to be more modest, tender, and concerned with the quality of life. A society is called feminine when emotional gender roles overlap - both men and women are supposed to be modest, tender, and concerned with the quality of life". [1]

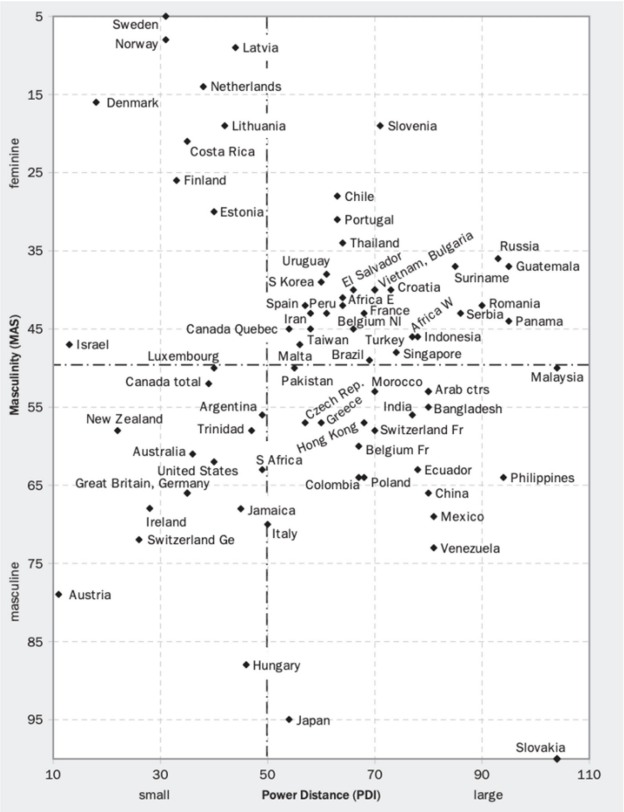

Fig. 1 Power Distance versus Masculinity Diagram

According to the results of Hofstede's study on masculinity and femininity levels at IBM, all over the world, the most masculine occupations are sales representatives, followed by engineers and scientists and technicians and skilled craftspeople on a third position, while among the most feminine occupations he observed the office workers and semiskilled and unskilled workers. Thus, we understand that the professional differentiation on a society is determined by socialization and the level of education is the key aspect, that creates the rules.

In a society which is dominated by the masculine pole, women usually accept male dominance tacitly. Family is the first environment where these rules are learnt, and where the core gender values are transferred from one generation to another.

In the power distance versus masculinity diagram (figure 1), developed by Geert Hofstede and published in his research entitled *Cultures and Organizations. Software of the Mind*, we can observe inequality between parents and children, which can become norm in different parts of the world, and which definitely imprints the pattern to be followed by the next generation. Romania is positioned in the top right-hand quadrant, which is characterized by Hofstede in terms of inequality and tenderness, which represent the type of society in which both parents dominate the relationship with their children, share equal values of life and care for the relationships, providing equal *authority and tenderness*.

Of course, when we talk about masculine and feminine societies, we are not discussing about marginalization of women in society and their inability to access male professional careers, but we realize that a more masculine or feminine society will display a preference for certain professions. It is still a fact, that for example more than 70% of all secondary and high school teachers in Romania are women, which shows the fact that teaching is perceived by the society as a job mostly dedicated to women. But as Hofstede suggests in his study: "Which behaviors are considered feminine or masculine differs not only among traditional societies but also among modern societies. This is most evident in the distribution of men and women over certain professions. Women dominate as doctors in Russia, as dentists in Belgium, and as shop- keepers in parts of West Africa. Men dominate as typists in Pakistan and form a sizable share of nurses in the Netherlands. Female managers are virtually nonexistent in Japan but frequent in the Philippines and Thailand. In spite of the variety found, there is a common trend among most societies, both traditional and modern, as to the distribution of social sex roles".

Men are competitive, sometimes stubborn and tough, while women are supposed to be more focused on family care, thus assuming a more tender role in society. In other words, a woman in science and technology would not be rejected as a professional or specialist, but this role would somehow exclude the possibility of both a career and family life. Of course, these are the challenges and stereotypes that modern societies are trying to overcome, and this is point where the present study wants to raise the question of how mentalities can be changed and how long will it take for societies to adopt a different perspective.

A society haunted by stereotypes is more prone to marginalizing women in a men's world, as is the particular case of female specialists in the field of computer science. If we can start from a clear definition of stereotypes, an understanding of all their negative implications and a preparation of the young generation against this form of aggression, then we are on the right path towards a more modern vision of the world where men and women could share the same ideals in life.

Tintori and Palomba, in their research on stereotypes about science and scientists, entitled *Turn on the Light on Science*, offer an extremely relevant definition of stereotyping as "a fundamental process of the human mind through which our brain can easily stock a large amount of information; it involves oversimplification and overgeneralization, because you apply to all the members of a group the characteristics that you have learned to associate to that group either by meeting one or a few of its members or from parents, peers, the internet or the media".[2]

A better understanding of how mentalities can be changed should start form an understanding of the field of STEM, the one that appeared quite recently in international curricula, all over the world, which will probably be the trigger to transform the young generation, where the gap between men and women in computer science will continue to shrink.

2. History of STEM Education

Science, Technology, Engineering and Mathematics are the pillars on which the modern world was built. Throughout history, humans have asked questions about the world around them and through these four subjects, they've also found answers which eventually led to technological wonders. One cannot say when STEM was created, because these four disciplines are so tightly intertwined that people have always studied them together without consciously knowing. However, the first moment that inspired STEM education as we know it today, has been the founding of NASA in 1958. Then in the early 90' the acronym SMET is used to describe the curriculum for these disciplines, which was later changed to STEM, in 2001, by Judith Ramaley, assistant director of education and human resources at the U.S. National Science Foundation. [3], [4]

Because of traditional gender roles and societal expectations of women in the past, there were far less women involved in STEM than men. However, those who took part in it, were indeed remarkable. For example, we have, Ada Lovelace, sometimes referred to as the world's first computer programmer, even though she didn't have one to work with. She was an inspiring mathematician who created the first algorithm and made extensive notes for the Analytical Engine, a project Ada worked on with her friend, Charles Babbage. [5] Then there was Marie Curie, the first woman to win the Nobel Prize, and the first person to win the award twice. She was a polish scientist who along with her husband discovered radium and

polonium and worked on the development of X-Rays. [6] Another incredible woman who worked in STEM is Edith Clarke, who worked as a "computer", someone who performed difficult mathematical calculations at that time, at the beginning of the 20th century. She became the first professionally employed electrical engineer in the United States in 1922 and was included in 2015 in the National Inventors Hall of Fame. [7]

Since technology is evolving at an increasingly rapid pace, STEM would represent the future, from the late 20th century till today, governments have tried to encourage and develop STEM education ever since early childhood so that every high school graduate would have basic STEM skills. Notably, in 2009, President Obama launched the campaign Educate to Innovate specifically to motivate young people to excel in STEM: "Reaffirming and strengthening America's role as the world's engine of scientific discovery and technological innovation is essential to meeting the challenges of this century. That's why I am committed to making the improvement of STEM education over the next decade a national priority."- President Obama
The priority areas of the project are the following:

1. Building a CEO-led coalition to leverage the unique capacities of the private sector
2. Preparing 100,000 new and effective STEM teachers over the next decade
3. Showcasing and bolstering federal investment in STEM
4. Broadening participation to inspire a more diverse STEM talent pool

The fourth area is specifically designed to include girls and women in STEM through partnerships and mentorships programs, for example „Department of Energy's Women in STEM mentoring program" and in 2013 issued a call to tech innovators to ensure representation and inclusion of minorities and unrepresented groups. [8]

One of the milestones for including end encouraging women in STEM is the 2017 INSPIRE Women Act. The bill was introduced by Representative Barbara Comstock of Virginia and compels the director of NASA to encourage young women to pursue careers in STEM fields.

The initiatives that will be supported by the director of NASA are the following

1. NASA GIRLS AND NASA BOYS- virtual mentoring that pairs NASA mentors with young students
2. Aspire to Inspire- a program that aims to spread information about women in STEM so that young girls may fallow into their footsteps
3. Summer Institute in STEM- a program designed to inform middle school students about nontraditional careers with Goddard Space Flight Center

The act also requires a report about how NASA plans to engage professionals (e.g. retired astronauts, scientists, engineers) to determine the next generation of young women to choose STEM careers. [9]

Even though the number of women is STEM is increasing, the gender gap is still present as shown by the graph below: [10]

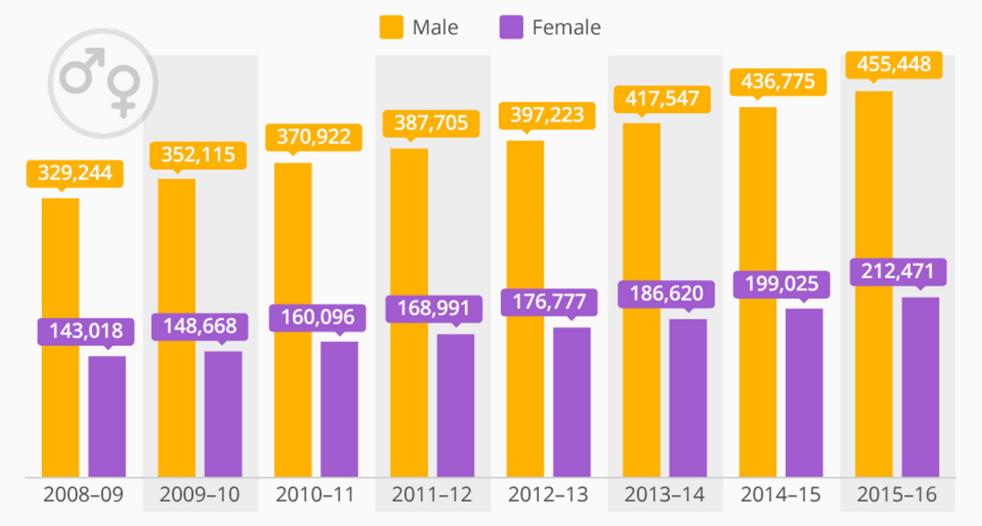

Fig. 2 Number of STEM degrees awarded in the United States, according to gender differentiation, showing a steady rise, Source NCES

However, there are more and more campaigns that promote STEM education among young girls and women such as Ada Lovelace Day, founded in 2009 and International Day of Women and Girls in Science, founded in 2015.

There is still a long way to go regarding the gender gap in STEM related study and work fields, but as we can learn from the past, women are perfectly capable and just as interested in STEM as men are. With the right role models and mindset, I strongly believe that, in the future, women will thrive in STEM just as they did before.

3. Gender stereotypes and their impact on STEM related fields – a solid link between education and women's career in computer science

The younger generation, which is extremely digitalized, due not only to technological developments, but also as a result of the shift to online learning, during the pandemic crisis, was affected by this whole trend. Thus, a new approach towards life appeared, where young people are surrounded by technology, which in

specific situations represents the only means of communication with the social group, other than the family.

As specialists suggest, the line between the information and communication technology is quite difficult to draw, and it is the role of STEM education to bridge the gap between this new technological world and the old normal.

STEM education can prepare students for this new trend, where their competences are challenged and makes them feel at ease in front of the computer or laptop and be able to fulfill the tasks required by teachers or tutors. In other words, more than never, there is now a stringent need for an immersion into virtual reality in education, lasting probably for the next couple of generations, and where men and women, boys and girls are required the same level of technical skills.

In 2017, Schwab predicted that the technological boom will be a 4th industrial revolution, developing at an exponential rate, compared to the previous ones. However, this megatrend that specialists predicted in the last couple of years was forced by a situation that the modern world had never experienced at these levels, which at the end of the day represents a mere advantage for the young generation, women included.

"Technology is not an exogenous force over which we have no control. We are not constrained by a binary choice between "accept and live with it" and "reject and live without it". Instead, take dramatic technological change as an invitation to reflect about who we are and how we see the world. The more we think about how to harness the technology revolution, the more we will examine ourselves and the underlying social models that these technologies embody and enable, and the more we will have an opportunity to shape the revolution in a manner that improves the state of the world". [11]

According to surveys on the importance of STEM education, starting from secondary school, among the values that young people appreciate in their education, we can mention achievement, relevance, practice, technology, communication and feedback. Gender differences showed some discrepancies of approach, only at the level of relevance, favoring boys at a higher rate. Thus, relevance is probably the only element of differentiation between boys and girls, men and women, and the explanation is again related to the gender stereotypes persistent in society, all over the world. They are related to the fact that mathematics is still considered a male field of activity. Nonetheless, PISA results showed no difference in mathematical literacy between boys and girls. Which represents a sign of gender equity in relation to mathematical performance. But it is also the result of the fact that boys and girls in most education systems are trained in multigender groups, as sex separated schools are a rarity in modern societies. [12]

In his study *Riding Waves of Culture*, Fons Trompenaars scrutinizes the existence of gender differences and the stereotypes that reinforce them, all over the world. It is true that women sometimes are labelled according to some misconceptions, that their role in the community is that of caregivers or caretakers, that their professional paths should not necessarily be related to technology or science, or in the rare cases when they are involved in STEM related fields they are just an exception from the rule. But it is a fact that women "need to work harder than men to show they are achieving individuals, measuring themselves by specific criteria and by universal yardsticks". [13]

6. How can mentalities be changed in a masculine society?

Monica Biernat and Diane Kobrynowitcz suggest that the gender construct is multifactorial or multidimensional in nature. That suggests the fact that gender involves a variety of elements, from stereotypes, to beliefs, identity, attitudes and perception. Along the years, there have been many different definitions of gender stereotypes, but they all have in common a different representation of men and women roles, which in very rare situations overlap. What is most disturbing for the modern society, is the fact that stereotypes can influence judgement.

Even though we are tributary to Ada Lovelace, the inventor of the first computer, and we owe Margaret Hamilton, the NASA engineer, the correct approximation of the lunar trajectory, when the Apollo 11 spaceship landed on the Moon, we have to admit that particularly the field of coding and development of computer tools in not necessarily a women's world.

Women are still underrepresented. Statistics suggest that in the United Kingdom, only 19% of the girls choose computer science as a major, versus 81% of the male high school graduates.

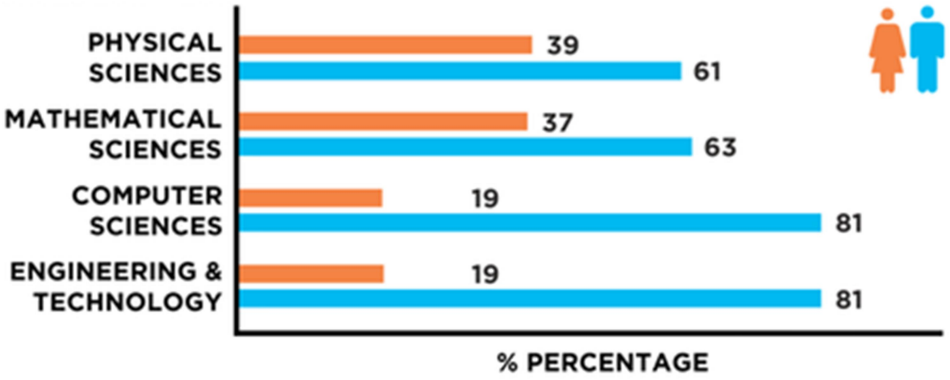

Fig. 3. Statistical data with regard to the percentage of women in STEM related fields [14]

At the same time, the development of a cultural awareness and promotion of female specialists as role models in STEM related fields, for the young generation, could develop the competitive skills much needed by modern girls who dream of pursuing a professional career in computer science. Furthermore, the creation of groups coordinated by female mentors, whose activity could be incorporated into the curriculum, could also correct the disproportions in figures between boys and girls in STEM education, at professional level. Last but not least, social media can be an efficient tool for creating awareness, for the spread of success stories and promoting successful women who could become role models for other women. "A cross-national data analysis has indicated that gender differences in math are closely related to cultural variations in opportunity structures for girls and women, in particular to gender equity in school enrollment, women's share of research jobs, and women's parliamentary representation (ibid., p. 103). Accordingly, the low proportion of women in STEM leads to the spread of a gender stereotypical image of math and science as a male domain and beliefs about male supremacy in technical and math-intensive fields. In turn, such beliefs affect young people's career choices, leading to a mutual reinforcement of gender stereotypes, and gender gaps in career related interests and choices." [15]

7. Conclusions

With a constant decrease of the number of female specialists in computer science, all over the world, with a special trend particularly during the last twenty years, governments have been forced to take some measures, as it has been realized that the trend negatively affects the societal progress.

Among the most important developments is the implementation of STEM programs in public and private schools, secondary schools and high schools, in many countries all over the world, aiming at training women so that they can enhance capabilities to get involved in science communication. Thus, school programs have raised awareness on the importance of engagement of women in STEM related fields.

Specialists consider that two other ways of potentially contributing to the development of technology skills among women is through experience and persuasion, which in turn could determine a female high school graduate to follow the computer science path at bachelor and master level. In other words, by helping women to challenge themselves and through persuasion, by offering positive feedback and promoting the important role models in the society, knowledge could be faster spread in the community. As Koenig and Eagly suggested in their 2014 study, stereotypes about women in STEM related fields, and particularly in computer science can be changed only by presenting different types of women whose professional behavior can alter the so-called *norm*, with the final aim of expanding normative social rules. [16]

On the other hand, from a financial perspective, once women achieve their bachelor's degree in computer science, the pay gap between them and men is extremely small, with women earning 94% of males' earnings. So, it becomes extremely important to encourage women to pursue a professional path in computer science, not only because it offers them an equal position with men in the society, but it also offers them the chance to compete with men, from a financial perspective.

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