

# BEAUTIFUL PATTERNS: EMPOWERING YOUNG WOMEN THROUGH EDUCATION IN COMPUTATIONAL THINKING

Abel Sanchez<sup>1</sup>, Leticia Almaguer<sup>2</sup>, Patricia Caratozzolo<sup>2</sup>

<sup>1</sup>*Massachusetts Institute of Technology (USA)*

<sup>2</sup>*Tecnologico de Monterrey (MEXICO)*

## Abstract

Our economy is rapidly shifting, and both educators and stakeholders increasingly recognize that computer science is a "new basic" skill necessary for economic opportunity and social mobility. In addition to problem solving skills developed in Computational Thinking (CT), which are transferable to other domains, CT reinforces other soft skills, such as critical thinking and creativity. Unfortunately, in Latin America, access to the education of computational thinking is scarce. For high school young women, access is virtually non-existent. Women in Mexico represent (i) only 17% of engineering students; (ii) 19% of the STEM workforce; and (iii) 10% of computer science students. Research shows that diversity leads to better decision-making, more innovation and improved outcomes. Gender is an important aspect of diversity, therefore, *Beautiful Patterns* seeks to empower adolescents through education, allowing them to reach their full potential and transform their communities and help Mexico compete globally. Developing algorithmic thinking skills of young women -taught by women students from high impact U.S. universities- *Beautiful Patterns* helps adolescents girls to learn and apply new skills in computational thinking and programming through grassroots leaders and Universities in Mexico. The present *work in Progress* project is innovative because it is women teaching other women. Learning doesn't happen in isolation; students learn best when constructing knowledge themselves within learning communities. Hands-on activities, help students internalize the computational thinking concepts, and then they are walked through carefully-scaffolded coding exercises with a mix of instruction and learning-by-doing. Over the weeklong program, all participants - high school students and college instructors from U.S and Mexico- build long-lasting bonds and friendships with each other.

Keywords: women in computing, gender equality, higher education, occupational inclusion.

## 1 INTRODUCTION

## 2 HIGHER EDUCATION FOR WOMEN IN MEXICO

The majority of Mexican students leave the education system at the upper secondary level. The main reasons for high drop-out rates are: on the one hand, that many educational institutions do not equip students with good quality skills that reduce the risk of unemployment; and on the other hand, that the students do not consider that it is worth investing more in education since they usually work prematurely in the informal economy. The informal economy of Mexico is very large. According to data from the International Labor Organization (ILO), in 2013 about 54% of workers had an informal employment relationship. The informal labor market does not provide stable income, comprehensive health care or training opportunities. The latter means that informal workers are trapped in low-skilled jobs without many possibilities of transition to higher quality employment. Regarding the gender issue, even considering that the investment in girls' education in Mexico has increased, many of them do not enter the labor market or do so only for short periods of time. In Mexico, the female participation rate in the workforce is 47% compared to an OECD average of 60%. Unfortunately, the proportion of female students who choose to pursue university studies in science, technology and computing is even lower than that of men. This problem requires actions at both school, work and cultural levels so that Mexico can take full advantage of the potential of its women. This will contribute to the commitment adopted at the G20 Summit to increase female participation in the labor market by 25% by 2025 [1].

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women take over and complete tertiary studies. Increasing educational coverage in tertiary education up to 40% in Mexico, requires improving the quality and relevance of tertiary education through better links with the labor market and ensuring that more women take over and complete tertiary studies. Documents such as the OECD Report [1] show a growing shortage of skills in workers in developing countries, so that their educational systems, including high school and VET (Vocational Education and Training), should guarantee the response to demand of the labor market and the promotion of employability. One good option for an excellent investment is to orient a greater number of students towards areas related to science, technology and computing. In the case of Mexico, it is also necessary to make better use of existing human capital by taking advantage of young women who do not participate in the labor market or who work in the informal economy.

The employment rate for Mexican women with tertiary degrees is more than 15 percentage points lower than that of men with similar education (72% for women and 88% for men). This is the fourth largest gap between OECD countries, after Korea, Japan and Turkey [1]. 47.3% of women remain outside the labor force in Mexico, while, on average in OECD countries, 62.7% of women are employed or seeking employment.

In Mexico, there was a gap of 14 PISA points in math performance among boys and girls in 2012, even when boys and girls are equally proficient in math and science. The problem is that their attitudes towards learning and the aspirations for their future are markedly different, and that has a significant impact on their decision to continue studying and choose their career. It is a fact that, in developing countries, women represent a small proportion in the fields of study and occupations of STEM, Science, Technology, Engineering and Mathematics, although graduates of these areas are in great demand in the labor market.

Reducing these gender gaps requires initiatives that strengthen, for example, the positive attitudes of girls and young women towards specialization in computer areas. Nor are boys and girls equally likely to choose a career that involves programming and software development: on average, 8% of Mexican girls (OECD average of 5%) versus 27% of Mexican boys (OECD average of 18%) plan to pursue a career in engineering or computing.

If initiatives were designed for more women to be involved in STEM professions, there would be more role models in these fields for young women to emulate, and a "virtuous circle" would be achieved. One way to start changing these mentalities is by making programming and algorithm design more interesting for girls. The first steps are: conducting studies to identify and eliminate gender stereotypes in the textbooks of primary and secondary education; the design of learning materials that are attractive to girls; the offer of workshops and short courses that engage girls and raise their self-esteem; and finally the promotion of disruptive female models to follow (women STEM students who act as mentors; women teachers who share their experiences in interviews and talks; recognition to women who obtain awards and professional achievements). Educational systems in developing countries have a responsibility to strengthen their professional advisory services to ensure that all female adolescent students are aware of the opportunities available in the labor market and which tertiary programs are most promising in terms of employability.

### **3 HOW TO PROMOTE COMPUTER AND SOFTWARE DEVELOPMENT CAREERS AMONG WOMEN?**

It is important to be aware that in developing countries many women continue to remain outside the workforce. The reduction of this gender gap can have a significant impact on growth and therefore policies to encourage more women to join the workforce and formal employment should be a priority [2].

On the one hand, governments must ensure reforms of labor laws to explicitly prohibit any type of discrimination against women in the labor market. In this way, the participation of more young women in the formal sector is encouraged and the incorporation of women into informal employment is reduced. On the other hand, the education sector, at all levels, must take concrete actions and take responsibility for incorporating more young women, promoting their STEM programs through campaigns and marketing that increase women's awareness of their great abilities in those fields, and the powerful labor and economic potential that this type of specialization can hold for them.

There are some effective strategies to attract more young women and teenagers to computing and algorithm design [3]:

**Make computing social.** A common stereotype is that programmers are lonely creatures, but programming today is a team sport. A particular agile practice, couple programming, has been adopted in many universities, it has even been shown that couple programming, in which two programmers work together to solve a problem together, increases women's retention.

**Bridge the confidence gap.** Another stereotype is that we imagine programmers as men, and this only amplifies the lack of trust. In a mixed group, young female students tend to have less self-confidence in the process of solving complex problems due to the predominance of their characteristic of "adaptor thinkers" that makes them appear disadvantaged to their male peers, who usually present strong characteristic of "innovator thinkers". To mitigate this, it is important to identify students who have similar levels of knowledge: the most experienced and self-confident programmers are incorporated into the intermediate level courses, while the real beginners and those who need more practice are incorporated into the initiation courses.

**Welcome girls and teens to the field.** The same stereotypes that undermine girls' confidence at an early age can take them away from computing in their teens. Robotics competitions and science clubs for girls and boys in elementary school are an excellent way to develop skills without gender distinction, however it is still very common for young women to start university without any previous programming experience. One solution is to offer introductory computing classes for sophomores and juniors when they are teenagers.

**Make computing relevant to the student.** Some women are more likely to obtain a degree in computer science if they see computing not only from the geek stereotype on the field (problem solving in gender domains such as investments in the stock market, football, war videogames), but as a tool to solve important problems from the feminine point of view (conservation of the planet, development of new foods, sustainable initiatives, health care, nutrition, fine arts). The solution is to involve all students beyond the traditional problems of male bias and add problems that include gender and inclusion perspectives, allowing female students to apply computer science in ways that seem personally meaningful.

**Provide diverse role models.** It is difficult for an adolescent woman to feel affinity or connection when all her science, math and computer teachers are men. Even when a high school or high school girl is not yet thinking about her own career plans, it is important to consider the symbolic value of having a woman as a computer science teacher to be reflected in the professional roles of women and their compatibility with all other aspects of the female universe: to have a career and also to be (or not to be) wife and mother.

#### **4 BEAUTIFUL PATTERNS INICIATIVE**

We must consider that the factors that inhibit the participation of women in the information technology industry that we have mentioned are not exclusive to Mexico or Latin America, but affect women worldwide. This shows that the way students are educated in schools and universities mainly drives male participation in the area of computer science.

A teacher committed to the meaningful learning of his students, noted the loss of interest that the female students had in his classes. The results of the evaluations showed that they had the ability to develop any algorithm or solve any problem as their male classmates would. By continuing with his inquiries, he discovers that the reasons for the indifferent participation of his female students had to do with the themes and examples he used in his teaching activities.

When experimenting with activities that address issues such as social welfare, the population, the couple and the family, he gained greater interest and attention from his female students and considered the opportunity to develop activities aimed at training girls in algorithmic thinking through the application of topics that will attract their interest in the study of computer science.

Beautiful patterns was born as a dream to encourage female participation in the study of science and technology, to show girls that they can become professionals who contribute to the economic development of their community and to show that society also benefits when there is a gender balance in the productive sector.

## 5 METHODOLOGY



*Beautiful Patterns 2019. Cuernavaca, México*

The program consists of a 5-day training camp, 6 hours of work per day plus one hour for lunch, where girls learn different methods and tools to develop logical thinking and computational algorithms with teaching methodology based on the problem solving in an atmosphere of play, fun and conviviality.

In the morning, the activities are oriented to algorithmic thinking without computers in the classroom. The female facilitators explain the topic and pose a problem to be solve in order to consolidate the learning. The participants are organized in work teams of 4 or 5 members.

The dynamics are physical demonstrations of the sequences for the solution of problems, as for example, in the exercise of the “Bubble Sort” where they are the ones that represent the objects and move to demonstrate the algorithm. The game stimulates the movement of the body and logical reasoning and, with it, understands the steps necessary to solve the problem, before attempting to build the algorithm on a computer.

Some activities generate competition among the teams, which causes an atmosphere of challenge, fun and conviviality.

In the afternoon, they go to the laboratory with the computers where the facilitators introduce the coding exercise and individually experience the programming with simple and structured practices.

The main challenge is a final team project that can cover a diverse set of topics, such as transportation, pollution, corruption and purchasing. It develops day by day through the following steps: (1) Present the idea, the story; (2) Demonstrate the idea; (3) Students demonstrate understanding, replicate what the instructor did; (4) Students apply the idea to real life, a problem of their choice; (5) Compare with other approaches. At the end of the week, the best team in the group will be reward with a prize for each of the team members.



*Beautiful Patterns 2019. Guadalajara, México*

The fundamental factor of the Beautiful Patterns model lies in the fact that it is female computer engineering students who train the girls participants of the program. With their example, the instructors motivate the participants by saying: "If I can, you can too"; in order to empowering them.

## 6 RESULTS AND FINDINGS

The camp has been held for the past three years in Mexico, impacting more than 2000 girls to date. The formalization of research is a work in progress that attempts to:

- 1) Measure attitudes towards computing, changes in interest and trust.
- 2) Collect demographic data, such as English level, schools of origin (public or private) and parental occupation.
- 3) Identify perspectives on gender and identity stereotypes.
- 4) Evaluate learning and difficulties in understanding activities, as well as, teaching practices and how to improve them.

The instruments are pre and post-event surveys that apply to students and their parents, the task of “draw an engineer” and the daily reflections that participants and instructors fill out.

Although, it is a task that has not yet been completed the preliminary results show a positive attitude of the participants towards the learning of computer science and a genuine interest in developing professionally in the area. However, they also reveal that approximately 10% of parents still believe that women are less intelligent than men and that the area of computer science is not appropriate for women.

The next steps in our research will include monitoring the vocational decisions of the first generation of participants; where there are some who have already enrolled in a professional career.



*Beautiful Patterns 2019. Santa Fé, Cd de México*

## 7 CONCLUSIONS

Beautiful patterns has become a program that helps female students learn new skills in algorithmic thinking and apply them in the development of computer programs. It also generates confidence in the use of technology and in their abilities to generate value proposals for the transformation of society.

It is a program that develops learning communities where students and their instructors, local and foreign, learn from each other and create lasting friendly bonds. In addition, it generates a favorable attitude towards computing and its gender stereotypes.

We hope to continue strengthening the program with the participation of committed sponsors to help us extend it to Latin America and other regions in the world to reach more girls who can bring their intellectual abilities and the application of technology to the development of a better place to live for everybody.

## REFERENCES

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