

CONNECTIONS IN NETWORKS: STRATEGIES FOR INCLUSION OF WOMEN ON STEM AREAS

Abstract– Data from INEP show that women are the majority in higher education, but in engineering women are underrepresented. There is a significant numerical disparity in vocational training and, consequently, a direct reflection of the inequality of opportunities for inclusion of women in the areas of STEM (Science, Technology, Engineering and Mathematics). It is essential to promote actions so that girls can have contact with Science, Technology, and Innovation from the most basic cycles of education. So, the purpose of this article is to share the actions, strategies and connections made by the project Girls 4.0 - Connection to change the world. The project includes the development of activities and gamified dynamics, technical visits and partnerships with other educational institutions aiming to approximate, inspire and provide opportunities for girls to be motivated and included in STEM areas.

Keywords: *STEM, Education, inclusion, gender, SDG*

I. INTRODUCTION

According to data from the National Institute of Educational Studies and Research Anísio Teixeira [1] related to Education in Higher Education in Brazil demonstrate that women are the majority in higher education, representing 58.4% of the total enrollment in undergraduate courses. Regarding the percentage distribution of graduates of higher education, segmented by gender, the study shows that in engineering [production and construction] women represent 36% of graduates, while men, 64%. However, the data that stands out most is correlated to graduates in computing and Information and Communication Technologies (ICT) since men are configured as the vast majority of graduates, with the percentage of 85.2% of graduates and women represent only 14.8%. That is, there is a significant numerical disparity in vocational training and, consequently, a direct reflection of the inequality of opportunities for women to enter the areas of STEM (Science, Technology, Engineering and Mathematics). If less than 20% of women are trained in STEM areas, low female participation in the labor market and entry into STEM careers remains.

Data from the World Economic Forum [2] show that women remain underrepresented in STEM areas. In engineering and manufacturing, women represent no more than 6.6% and men 24.6% of graduates in these areas. Data from UN Women Brazil [3] highlight that women are out of the main jobs generated by the digital revolution, and only 18% of them have a degree in Computer Science. They currently account for 25% of the digital industry's workforce.

For [4] there is a low participation of women in the different professional and productive fields of knowledge and

are underrepresented in STEM. Even with increasing professional demand, this has been the subject of debates, technical productions, and scientific studies in several areas. In this regard, it is essential to demystify stereotypes, make visible and encourage the inclusion and permanence of girls in technological and scientific education.

According to [5] the participation of women in STEM areas is essential to avoid the reproduction of inequalities in scientific production and the creation of algorithms of technologies that significantly impact on life today, individual right, and social need.

The [6] study highlights that underrepresentation of girls in STEM education has deep roots and establishes a harmful barrier to progress towards sustainable development. Thus, more and more actions and programs are needed that stimulate and enable the inclusion of women in STEM.

The 2030 Agenda of the United Nations National Program [7] is an example of the joint work of governments and citizens around the world to create a global model that seeks to promote gender equality, education regarding access to the world of work and economic development. Thus, gender equality is the Sustainable Development Goal 5 (SDG 5) of the UN Agenda 2030.

Thus, understanding the importance and need to promote actions and initiatives that can contribute to stimulate, motivate, and promote the insertion and maintenance of girls in the careers of STEM fields, this article aims to present the strategic and participatory actions developed by the project Garotas 4.0 - conexão para mudar o mundo! Garotas 4.0 is a university extension project that aims to bring together, inspire, and guide high school or elementary school girls to enter careers focused on STEM.

Through practical workshops, gamified activities and creative learning, participants develop customizable educational kits, combining the knowledge and training contents of project management, product development, automation, electronics, programming, robotics, and emerging technologies such as: augmented reality, virtual reality, additive manufacturing [3D printing]. The project methodology includes problem situations and learning strategies with the use of active methodologies, such as: Project-Based Learning - PBL (Project Based Learning); Design Thinking and maker learning, skills, and autonomy of the members in carrying out the activities and challenges.

II. EMPOWERING GIRLS IN STEM

The Garotas 4.0 project is an interdisciplinary project designed by three STEM educators. The main motivation to conceive the project comes from the observation of the tiny and unequal participation of girls in engineering courses, as well as the desire to share the professional experience of teachers, not only in technological education, but also in industry, considering encouraging greater participation and inclusion of women in the exact sciences.

In the structuring of the project, the Sustainable Development Goals (SDGs), advocated by the United Nations 2030 Agenda (2015) are used as reference, specifically, the SDGs 4 - Quality Education; SDG 5 - Gender Equality; SDG 8 - Decent Work and Economic Growth; SDG 9 - Industry, Innovation and SDG 17 that emphasizes the need to encourage and promote public, public-private partnerships and with civil society, from the experience of resource mobilization strategies. Figure 1 illustrates the SDGs that guide the project initiatives.



Fig.1- Guiding SDGs of the Garotas 4.0 Project

It is worth mentioning that the development and implementation of the actions of the Garotas 4.0 project began with the participation in a call for proposals to promote teaching initiatives in a university center, in March 2021. The activities of programming, robotics and project challenges are designed to promote creativity, with practices of the digital universe, contemplating the technical, critical, creative dimensions, producing senses of learning to learn. The workshops contextualize the application of languages and their technologies, as an example, the realization of the activity "What is even programming", in which maker learning is used and the training content is approached as a "cake recipe". That is, the traditional approach to programming is replaced in a playful, fun, and simplified way to motivate the assimilation of learning from project members.

It is worth mentioning that the activities of the workshops of the Garotas 4.0 project are structured by level of competence, integrated with the skills and training itineraries and the skills contemplated in the BNCC (2017) and the workshops are classified into 03 levels of complexity: basic, and intermediate and advanced. Figure 2 illustrates some of the dynamics carried out in the workshops.

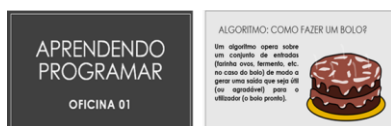


Fig. 2 - Learning to program

It is worth noting that the beginning and closing events of each stage of the workshops involve the participation of those responsible for the project members. Figure 3 below shows some of the events.



Fig. 3 – Garotas 4.0 Events

The participation of parents or guardians in the events is very important as the objective, proposal and methodology of the project are presented at this point. It is essential that those responsible understand how the activities are developed, what results are expected, as well as the actions and partnerships developed by the project, as they can effectively influence and motivate girls' participation in the project.

Another result achieved by the project was the production of a report highlighting the actions of Garotas 4.0, broadcast on the Conexão Bahia program on TV Bahia "Project in Bairro da Paz aims at female inclusion in the area of technology and science available at" <https://globoplay.globo.com/v/10804054/?s=0s>. The report was very positive because the project members participated in the interviews and brought great visibility to the project's actions at the school and in the Community.

In order to expand the actions and partnerships, the Garotas 4.0 project was selected in the call for proposals - 2nd Call for the STEM Girls Program: Forming Future Scientists of the British Council. With the selection in the Program STEM GIRLS: Forming Future Scientists" it was possible to acquire items to provide the necessary structure for the operational activities and workshops, such as kits with Arduino board, sumo robot and interactive and educational applications, considering maker culture, computational thinking, and robotics.

The resource of the public notice was fundamental for the realization and maintenance of the workshops already with the participation of a scholarship holder. Figure 4 illustrates the call for tender

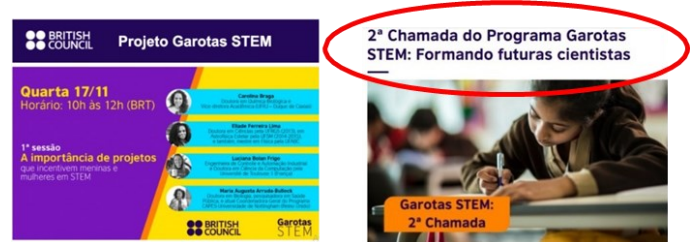


Fig. 4- Programa Garotas STEM: Forming Future Scientists.

In August 2022, the project was submitted to the notice "Women in the Creative Industry 2022" of the Institute Goethe, Germany. The call for proposals included 10 projects,

05 projects from Brazil and 05 projects from Chile. With the selection in the announcement, it was possible to acquire items to provide the necessary structure for expansion of activities and gamified workshops, such as 3D printer, glasses for augmented reality, educational lego, notebook, projector, software licenses and interactive and educational applications (didactic kits).

The selection in the call for proposals "Women in the Creative Industry 2022" (MIC) of the Goethe Institute provided an opportunity for the selected projects, Brazil and Chile, a meeting in São Paulo for three days. The proposal of the meeting was extremely positive since it provided the opportunity for the exchange of experience regarding the strategies, methodologies and inspiring practices carried out in each of the selected projects. Figure 5 below illustrates the call for tender and image of the meeting held in São Paulo.



Fig. 5 - MIC and meeting of projects in São Paulo.

In addition to the workshops held at the partner school, project members participate in extracurricular activities, which include visits to the university center, visits to industrial plants, as well as participation in scientific congresses and ongoing research projects.

III. NETWORK CONNECTIONS: BEYOND THE CLASSROOM

In addition to the workshops and gamified dynamics in the classroom, the project seeks partnerships to expand the actions beyond the school space. The objective of these actions is to provide project members with visibility of the various opportunities and possibilities for action in the STEM field. Visits to multi-segment companies provide project members with direct contact with the scientific field, as well as various careers and professional activities related to the STEM area. It is worth mentioning that the members of the Garotas 4.0 project, in this edition, are high school students, aged between 15 and 17 years old.

IV. VISIT TO AN EDUCATIONAL INSTITUTION TO SUPPORT INDUSTRY

Among the actions carried out, the members of Garotas 4.0 participated in visits, initially to the higher education institution, aimed at the development of the Bahian industry

and which involves three macro-processes: technological center, university center and technical school. Visits to the educational institution seek to highlight opportunities for use regarding laboratory infrastructure, the academic and research environment, and above all, the participation of women scientists in the STEM area.

For the visits to take place, prior planning is carried out so that the members of the Garotas 4.0 project are received, accompanied and have contact throughout the visit with monitors and researchers (female collaborators), including during laboratory presentations. It is worth highlighting that the institution has a large infrastructure of laboratories with advanced technologies, integrated skills that incorporate an academic environment into a technological center. Figure 6 below illustrates the visit to one of the laboratories.



Fig. 6 – Visit to the partner institution's laboratories

Figure 6 above illustrates the visit to the Experiences laboratory (VP&X) and in LabMaker. During the visit is made the presentation of the infrastructure of laboratories, courses offered and some research for the development of products, services and innovation being carried out by the university center. During the visits, the project members also could use some of the tools, resources, and technologies of Industry 4.0 available in the laboratories. The visit was publicized on the social network available at the link: <https://www.instagram.com/reel/CiQLbPoANoK/?igshid=MDJmNzVzMjY=>. Figure 7 illustrates the visit to event to University Center.

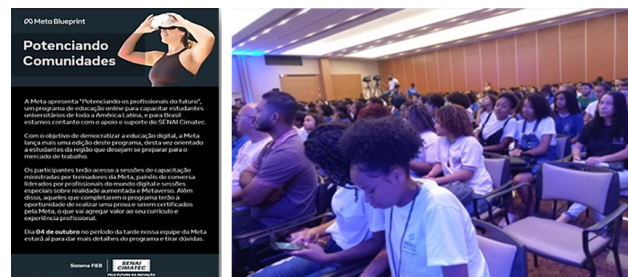


Fig. 7 – Visit to event University Center

V. VISIT TO THE INDUSTRIAL PLANTS

In the visits to industrial plants of companies in the productive sector, the proposal is to make visible the participation of women working in the various activities of the

productive sector. Figure 8 shows one of the visits of the members to an industrial plant of a chemical industry.



Fig. 8 - Technical visit a chemical industry company

It is noteworthy that the visits to the companies' impact and mark in a very positive way the members of the project, since they are made the presentation of female professionals acting in various productive segments. During the visit, holding conversation circles with female professionals working in the productive sector enables the project members to have direct contact with female leaders, supervisors, process operators and women industrial maintenance techniques.

The proposal is to demystify "man's profession" and "woman's profession" in the world of work and show to the project members that women work and are inserted in various professions related to STEM areas. It is worth noting that the actions and visits carried out are opportunities for access to potential spaces for transformation of contexts and professional motivation, since most of the project members are unable to access places beyond the community in which they live. It is ratified that some of the girls expressed that they only leave home to go to school, and that the visits to the university center, along with the technical visit to the industry were their first experience outside the home-school path.

Another inspiring initiative is the participation of project members in scientific initiation programs. That is, the members of the Garotas 4.0 project, students at public school, become scholarship students of scientific initiation, linked to calls for funding for Science, Technology, and Innovation, and start to act as scholarship holders in projects in STEM, together with the research group of the university center. Now, three members of Garotas 4.0 were selected to work on the research project selected in the FAPESB Public Notice to be developed by the university center in partnership with three other higher education institutions, started in April 2023.

It can be observed that before starting the activities of the project, in the first contact made with these young people, it was mapped that they did not know and could not mention the name of any female scientist. Today, with the actions of the project, it is possible to perceive the motivation, commitment, and engagement of the participants, including when they express themselves and leave recorded that the actions of the project enabled them to aim to follow the professional trajectory in STEM. The following statements are from some of the members of the Garotas 4.0 project:

"The project proposed experiences that we have never seen before and they are amazing to learn new things, connections that can change the way we see the world. "

"This project was enlightening, it brought knowledge, we learned to question, to want to know how the process is until we reach the final result. "

"Summary in an incredible experience, in a new world to discover, only those who are in the project GIRLS 4.0 know what I'm talking about. "

"It changed my way of seeing what engineering really was, and coming out of a bubble where I lived can make me see that I am able to do what I always wanted regardless of my color, gender, social class, sexuality "

"It's an incredible experience, in this project I discovered that my mind could go beyond, that my ideas can be future projects, and improvements in a certain way. Impactful! "

VI. PARTICIPATION IN SCIENTIFIC CONFERENCES

Participation in events and scientific congresses highlighting the actions of the Garotas 4.0 project also consolidated the results achieved. Figure 9 shows some articles presented at scientific conferences



Fig. 9 – Publication in Scientific Conferences

VII. NATIONAL AND INTERNATIONAL COOPERATION

As for cooperation, partnerships with educational institutions are already underway, both nationally and internationally. The actions aim to form a partnership with Higher Education Institutions, which have initiatives to increase the participation of women in STEM. One of the initiatives was to carry out action with the WIEP (Women in Engineering Program) of Purdue University in Indiana in the United States. The action enabled the exchange, for 15 days, of the teachers of the SENAI CIMATEC University Center in

the activities in the summer camps in the USA, developing playful activities with a STEM approach. Figure 10 illustrates the visit to Purdue University.

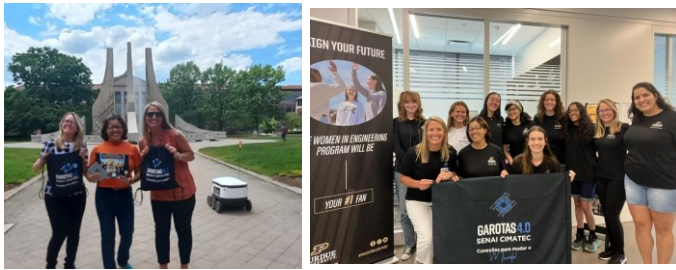


Fig. 10 - Mission to Purdue University [WIEP and Girls 4.0]

It was also carried out in partnership, the organization of the event Connecting Engineers Online of WIEP, held in June 2023, with the participation of the project Garotas 4.0. Figures 11, 12 and 13 shows the CEO event of Purdue University.



Fig.11 - Girls 4.0 at the CEO event.



Fig.12 - Girls 4.0 at the CEO event.

It is worth noting that the CEO event was attended by 23 members of Garotas 4.0 in Brazil and students from 4 schools

located in West Lafayette in Chicago. It was a very significant exchange of experience because, in addition to carrying out the workshop with a STEM approach, the students here in Brazil and those in the United States had contact with another language and were able to exchange experiences with each other. Figure 13 shows the CEO event of Purdue University.



Fig.13 - Girls 4.0 at the CEO event.

VIII. LESSONS LEARNED

The results achieved are quite positive. The holding of the workshops and the proposal for visits and partnerships with companies had very promising results for the members of Garotas 4.0. Carrying out activities beyond the classroom is motivating and allows for a very rich exchange of experience regarding the strategies, methodologies and practices carried out.

Regarding the lessons learned, the need for mapping and expanding partnerships with other educational institutions that have initiatives similar to those of Garotas 4.0 can be highlighted. Another point of improvement that can be highlighted is the dissemination of project actions on social networks in general. Due to the demands of holding workshops and visits, there were gaps in publicity and posts on social media about the project. To make the actions and activities carried out in the project visible and share, as well as publicize the notice of courses and opportunities for project members, a project profile account was created on Instagram @garotas4.0.

IX. FINAL CONSIDERATIONS

The results achieved by the Garotas 4.0 project are relevant and of positive valence. The workshops, visits to a higher education institution, visits to various companies had promising repercussions for the members of Garotas 4.0. The realization of activities beyond the classroom is a motivating educational agent and enables an intense and significant exchange of experience regarding the strategies, methodologies and practices performed.

It is possible to verify that the realization of the activities beyond the classroom, allows the members of Garotas 4.0 to explore new spaces, arouse interest and connect with the labor market. It is also possible to highlight the connection with the learning carried out in the activities of the workshops with the

practice in the productive sector and, above all, the diversity of opportunities to act in the areas of STEM.

To ensure the sustainability of the project, the proposal is to increasingly expand the actions of Garotas 4.0 in partner schools, consolidate partnerships with companies in the productive sector, partnerships with educational institutions and other sectors that seek to intensify strategies to include actions related to the SDGs (Sustainable Development Goals) and the Global Compact (UN) to bring together, inspire, and motivate girls to join STEM careers.

ACKNOWLEDGMENT

Thank all the support received from the university center and the partner school for support and realization of the actions of the project Garotas 4.0 - conexão para mudar o mundo!

REFERENCES

- [1] Ministério da Educação Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (INEP). https://download.inep.gov.br/educacao_superior/censo_superior/documentos/2021/apresentacao_censo_da_educacao_superior_2021.pdf. Acesso em: 04 abr. de 2023.
 - [2] WORLD ECONOMIC FORUM. WEF Global Gender Gap Report, 2022. Disponível em: https://www3.weforum.org/docs/WEF_GGGR_2022.pdf <https://www.weforum.org/reports/global-gender-gap-report-2021> Acesso em 04 maio de 2023.
 - [3] ONU Mulheres Brasil. ONU Mulheres defende investimentos públicos e privados em igualdade de gênero para aumentar participação de meninas e mulheres em ciência e tecnologia. Brasília, 15 fev. 2018. Disponível em: <http://www.onumulheres.org.br/noticias/onu-mulheres-defende-investimentos-publicos-e-privados-em-igualdade-de-genero-para-aumentar-participacao-de-meninas-e-mulheres-em-ciencia-e-tecnologia/> Acesso em: 02 fev. de 2023.
 - [4] WIESELMANN, J. R.; ROEHRIG, G. H.; KIM, J. N. Who succeeds in STEM? Elementary girls' attitudes and beliefs about self and STEM. **School Science and Mathematics**, v.120, p. 297-308, 2020. Disponível em: https://www.researchgate.net/publication/341333386_Who_succeeds_in_STEM_Elementary_girls'_attitudes_and_beliefs_about_self_and_STEM . Acesso em: 28 abr. 2023.
 - [5] UNESCO,2022 - Mapeamento de iniciativas de estímulo de meninas e jovens à área de STEM no Brasil em 2022 pela Organização das Nações Unidas para a Educação, a Ciência e a Cultura. Disponível em: <https://unesdoc.unesco.org/ark:/48223/pf0000380903> . Acesso em: 10 abri. de 2023.
 - [6] UNESCO. Decifrar o código: educação de meninas e mulheres em ciências, tecnologia, engenharia e matemática (STEM). Brasília, 2018. Disponível em: <https://unesdoc.unesco.org/ark:/48223/pf0000264691>. Acesso em: 10 mar. 2023.
 - [7] PROGRAMA DAS NAÇÕES UNIDAS PARA O DESENVOLVIMENTO – PNUD. Articulando os Programas de Governo com a Agenda 2030 para o Desenvolvimento Sustentável e os Objetivos de Desenvolvimento Sustentável. Disponível em: <file:///C:/Users/marinilda.lima/Downloads/Articulando-os-Programas-de-Governo-com-a-Agenda-2030-compressed.pdf>. Acesso em: 03 maio de 2023.
- Ministério da Educação. Base Nacional Comum Curricular. Disponível em: <http://basenacionalcomum.mec.gov.br/> . Acesso em junho 23.