Analysis of the professional development level of participants of the TecnoGirls project at the Gerardo Barrios University of El Salvador

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Abstract

This study aimed to analyze the level of professional development achieved by the participants of the TecnoGirls project at Gerardo Barrios University in El Salvador through their self-perception of the project's influence on the technological, educational, and socio-professional dimensions. Using a retrospective quantitative approach, a questionnaire was administered to a sample of 36 former TecnoGirls participants. The results reveal that 73% of the participants fully agree that the program has improved their digital skills, learning strategies, and competencies relevant to their academic performance and future career. The findings indicate a predominantly positive view of the impact of TecnoGirls among the graduates, which is confirmed by the qualitative analysis of interviews.

Keywords

Women, STEM, ICT, Higher education

1. Introduction

Professional development is a complex process that involves the integration of various components for the improvement of knowledge, skills, and attitudes essential in a given career. In higher education, the effectiveness of training depends on multidimensional approaches that articulate personal, collective, and institutional aspects. The effectiveness of training depends on multidimensional approaches that promote desirable personal qualities in students (proactivity, resilience, self-efficacy), collaborative work processes, and collective construction of knowledge, as well as institutional alignment around the integral development of the student body [1], [2]. Excellence in professional training aims to foster a comprehensive range of skills in students, not just transmit knowledge [3]. It is a complex and continuous process that requires multidimensional approaches, articulating personal, collective, and institutional elements [4]. It involves acquiring skills, knowledge, attitudes, and competencies specific to a given career. Higher education takes place in an interactive environment, where motivation, communication, and learning influence the results [5]. Professional training requires the integration of knowledge, skills, and values to solve problems by linking academia with practice. To guide this process, we have taken up three key dimensions proposed by Aníbal Alonso-Betancourt [6]: professional training technology, which describes the knowledge and technical skills acquired; professional training didactics, which defines the learning strategies developed; and professional socio-training, which measures the impact and applicability of what has been learned in the work context.

This study focuses on analyzing the level of professional development achieved by female students who participated in the TecnoGirls project at Universidad Gerardo Barrios, considering three dimensions: technological, educational, and socio-professional. The technological dimension encompasses the acquisition of specialized knowledge and practical proficiency, including mastery of Information and Communication Technologies (ICT) [7], [8], [9], with key

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digital competencies outlined by the National Autonomous University of Mexico (UNAM) [10] and the International Society for Technology in Education (ISTE) Standards 2016 [11]. The educational dimension involves learning strategies, which are conscious and intentional activities guiding actions to achieve learning goals [12], promoting autonomy and reflective access to knowledge [13], with metacognitive, information processing, and contextual strategies being the most commonly used by university students [14]. The socio-professional dimension evaluates the applicability of learning in new academic and professional contexts [15], analyzing personality, professional identity, personal and professional ethics, and specific competencies [16].

By assessing the professional development of female students in Science, Technology, Engineering, and Mathematics (STEM) careers from a multidimensional perspective, this study aims to analyze the professional development level of TecnoGirls project participants at Gerardo Barrios University of El Salvador, identifying challenges and barriers they face, to inform effective strategies for promoting their successful integration into technology fields. In addition, this research can serve as a tool for other universities seeking to improve the education and training of young women in STEM, helping to close the gender gap and fostering a more diverse and inclusive workforce in these critical areas for societal progress.

2. Women in STEM

Science, Technology, Engineering, and Mathematics (STEM) are fundamental to technological development and future employment [17]. According to the United Nations Educational, Scientific, and Cultural Organization (UNESCO), only 35% of enrollment in STEM majors is female [18]. The gender gap not only means a loss of opportunities for women but also impacts the attraction of talent in these fields.

Women in STEM and ICT (Information and Communications Technology) have been historically underrepresented in these fields [19]. However, initiatives such as "Building the Future of Latin America: Engaging Women into STEM (W-STEM)" seek to close this gap in the region [20]. In addition, programs such as Science, Technology, Engineering, Arts, and Mathematics (STEAM) for Girls offer training opportunities in technological fields for teenage girls and women [21]. These efforts seek to promote gender equality and diversity in STEM and ICT.

2.1 TecnoGirls

According to Universidad Gerardo Barrios (UGB) authorities, the low enrollment of women in technology majors at UGB highlighted the need to address the gender gap in computer science and informatics. In 2016, the TecnoGirls project was underway. The project aims to comprehensively empower its high school participants from the eastern region with solid technical knowledge in areas such as programming, robotics, and electronics. At the same time, it promotes a cultural change in technological spaces traditionally dominated by men.

Based on the project profile [22], it has three modules:

- "Get Connected": Introduces basic concepts of digital technology, web browsing, email, and social networking. Includes practice on internet security, operating system installation, and computer assembly.
- "Programming with NAO Humanoid Robot": For two months, participants interact with the NAO robot, learning about sensors, actuators, reactive programming, and image processing in the electronics lab.
- "Programming with Arduino": Explores Arduino concepts, such as serial monitor management, over two months. Includes the development of an applied project presented at an achievement fair at the end of the course.

Through tutoring, mentoring, inspirational talks, and teamwork on specific technology projects, TecnoGirls gives these future professionals confidence in their abilities. In this way, the project aims to reduce entrenched gender biases in the industry and to expand educational and employment opportunities for women in the fields of technology and innovation. The above was taken from the institutional descriptor of the program.

Table 1
Participants in the TecnoGirls Project over the past five years. Source: Own elaboration based on institutional project reports

TecnoGirls cohort	Former participants
2019	35
2020	21
2021	17
2022	22
2023	33

Figure 1: Participants of the 2020-2021 TecnoGirls cohort

3. Methodology / Design of study

The study has an explanatory sequential mixed method quantitative and qualitative (QUANT-qual) design, where the quantitative part is the main part, and the qualitative part supports the quantitative data. This is based on the approaches of Creswell [23], who points out that in this mixed design, quantitative and qualitative data are collected sequentially, but the qualitative part has a complementary or secondary role to the main quantitative part.

It is based on a quantitative approach with a descriptive scope and a non-experimental retrospective cross-sectional design [24]. The quantitative approach, which is characterized by the collection and analysis of numerical data, was used to evaluate the level of professional development of the students of the TecnoGirls project. This approach made it possible to objectively measure and describe progress in the technological, educational, and socio-professional dimensions. The former participants were asked to recall their evolution during their participation in TecnoGirls. In this way, without intervening again in their education, the aim was to retrospectively analyze the past impact that the project had in promoting these key competencies in their training.

The quantitative component is complemented by nested qualitative elements, using phenomenological semi-structured interviews to enrich understanding of participants' experiences and perceptions regarding the TecnoGirls project's impact on their professional development. The qualitative data were analyzed using thematic analysis, a method for

identifying, analyzing, and interpreting patterns of meaning ('themes') within qualitative data [25].

3.1 Population and sample

The target population of this study consists of 38 young women (see Table 1) between 17 and 24 years old who completed their participation in the TecnoGirls project implemented by Gerardo Barrios University in El Salvador in 2020 and 2021.

Inclusion criteria are established as follows:

- Have participated in and passed the TecnoGirls program at Gerardo Barrios University, with a minimum of three years and a maximum of four years after the end of the project. The lower limit allows the young women to have had time to put into practice the knowledge and skills developed in the TecnoGirls project; while the upper limit is intended to avoid recall bias and minimize other external factors that could influence them over time.
- To express availability and consent to participate in the study.

No exclusion criteria were established, so any young person who met the inclusion criteria could participate in the study.

The sample was selected according to the size of the target population with a confidence level of 95%, resulting in 36 participants. For the selection of participants, non-probabilistic convenience sampling was used.

Concerning the qualitative component, a smaller homogeneous sample of 3 participants was selected to obtain more detailed information on their experiences and opinions about the impact of the TecnoGirls project on their professional development.

3.2 Ethical considerations

Ethical considerations in research focus on the participants, defined as those from whom the researcher obtains data through intervention or interaction, including personally identifiable information [26]. Key ethical considerations in the research included informed consent, in which participants voluntarily agreed to participate; confidentiality, to safeguard data privacy; beneficence, which seeks to maximize benefits and minimize risks; equity, which guarantees equal treatment without discrimination; and the right to withdraw at any time [27]. The study was carried out respecting the ethical considerations mentioned above. The participant declared that she was informed of the characteristics and aims of the research and that she confirmed her voluntary participation in it. To protect privacy, confidentiality was maintained by encrypting personal data and participants' anonymity will be maintained in all reports or deliverables. Participants were treated equitably at all times, without favoritism or discrimination. The strictly voluntary nature of their participation was emphasized, and the participants could leave the study when they deemed it appropriate, without having to face any adverse consequence or reprisal for such a decision.

3.3 Techniques

The survey technique was used to collect quantitative data. The survey instrument was designed following a structure based on closed questions, whose answers were expressed numerically. The study design employed a deductive analysis of theoretical concepts through a variable operationalization matrix, establishing specific indicators to measure key dimensions of TecnoGirls participants' professional development. *This design was based on a deductive analysis of the theoretical concepts addressed in the study through a matrix of operationalization of*

variables, in which specific indicators were established to measure each dimension of interest related to the professional development of the participants of the TecnoGirls project.

In addition to the survey, semi-structured interviews were conducted with a selected sample of participants. The purpose of these interviews was to obtain qualitative information that would complement and enrich the quantitative data collected through the survey. Unlike the closed questions of the survey, the semi-structured interviews allow for a more open and flexible dialogue, where participants can express their experiences, opinions, and perceptions in a more detailed manner.

3.4 Instruments

An online questionnaire was developed using the Google Forms tool. For the application of the questionnaire, the direct link generated by Google Forms was shared with the participants through the communication channels established with the TecnoGirls graduates, mainly through closed groups and e-mail. The responses were compiled in an automated way in a Google spreadsheet linked to a form, which allowed direct downloading.

A semi-structured interview script was designed to complement the quantitative data obtained through the questionnaire. The interview script included open-ended questions that allowed the selected participants to delve deeper into their experiences, opinions, and perceptions about the impact of TecnoGirls on their professional development. The interviews were conducted individually with an average duration of 30 minutes, through videoconferencing platforms, according to the availability of each participant.

3.5 Data analysis

The data analysis was carried out for each indicator using a 5-level Likert scale and assigning values from 0 to 10 points according to the following ranges:

Table 2
Categories and rank levels

Category	Rank Level	Color
Strongly disagree	[0,2]	
Disagree	(2,4]	
Neutral	(4,6]	
Agree	(6,8]	
Strongly agree	(8,10]	

An analysis of the qualitative responses was conducted, identifying patterns and repetitive themes that helped to contextualize and deepen the quantitative results. Similarly, the qualitative responses helped to generate more informed conclusions about the impact of TecnoGirls on the professional development of the participants.

The analysis of the qualitative data was carried out using Atlas.ti software version 24, where 3 documents were processed with the transcripts of each volunteer and coded using the emergent thematic analysis [25]. A total of 67 themes related to their experiences in the TecnoGirls program were obtained.

4. Discussion of results

The analysis and interpretation of these results by dimension evaluated are presented below:

4.1 Technological dimension

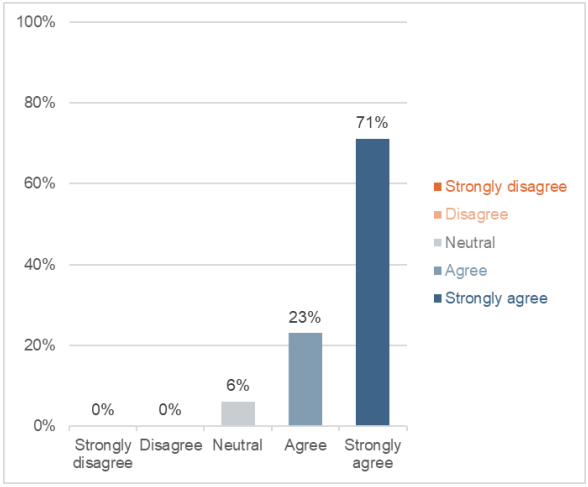

Figure 2: Results of TecnoGirls self-perception of the technology dimension

The percentages in Figure 2 show conclusively that none of the participants perceived the TecnoGirls program as having negative effects on the technological dimension. It is interesting to note that a minimal percentage, 6%, remained neutral on the impact of the project on the indicators analyzed. On the other hand, about a quarter (23%) recognized moderate contributions of TecnoGirls on the indicators examined. Meanwhile, most of the findings reinforce the idea that the project has been perceived beneficially, attributing to it 71% of positive and strong influence on the development of their digital skills and capabilities linked to their professional training. There is a very significant concentration of individual perceptions with maximum agreement on the favorable impact of the TecnoGirls project in multiple competencies considered key for a good academic performance and labor projection of the participants.

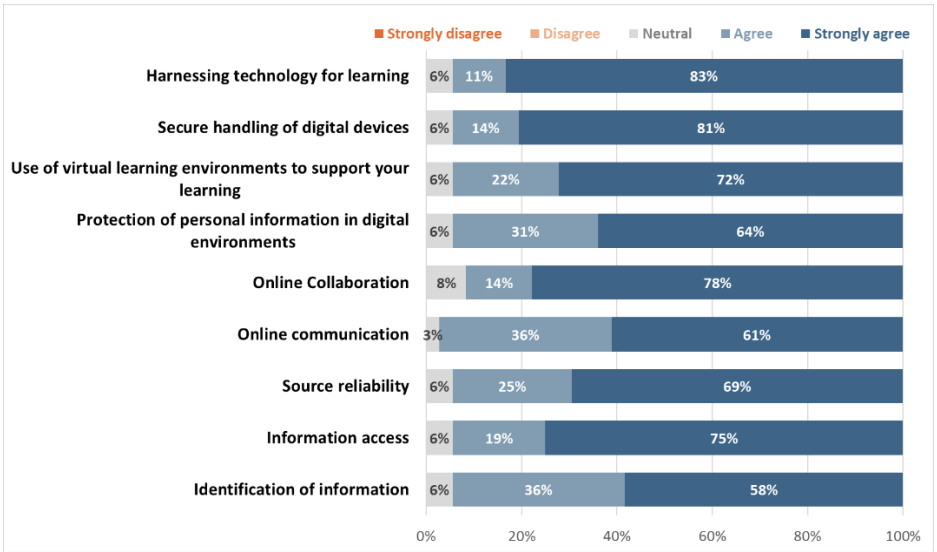

Figure 3: Results of self-perception of indicators for the technological dimension of the TecnoGirls project

Figure 3 shows that the TecnoGirls project contributed to improving and optimizing: the identification (58%), access (75%), and verification (69%) of online information; communication (61%) and virtual collaboration (78%); data privacy protection (64%); the use of technological environments (72%), devices (81%) and resources (83%) for informed and lifelong learning. For each indicator, the remaining proportion is distributed between those who simply agree between 11% and 36%, and a neutral minority of 3% to 8%.

The indicators evaluated in the technological dimension show that at least three-quarters of the participants fully agree that their participation in TecnoGirls has made a significant and positive contribution to the development of the company.

Based on their perception, these contributions are manifested in the development of various digital skills that they consider useful for their academic performance and subsequent professional careers. The fact that the participants unanimously recognize the usefulness and relevance of the skills acquired during their participation in TecnoGirls suggests that the program has effectively fulfilled its objective of strengthening the digital competencies of young women. The high levels of concordance between their perceptions allow for inferring and dimensioning the vast positive impact that they assign to their previous participation in TecnoGirls in multiple computer skills applied later in the program.

4.2 Educational dimension

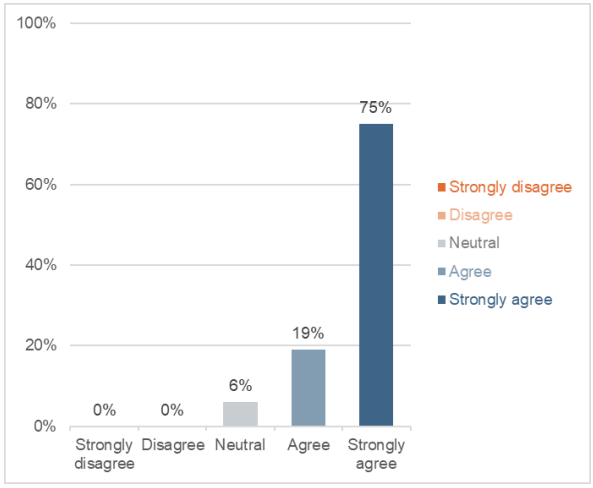

Figure 4: Self-perceived contribution on TecnoGirls of the educational dimension

The results in Figure 4 clearly show that none of the participants perceived negative impacts of the TecnoGirls project on the educational dimension. Only a small percentage of 6% remained neutral in this regard, while 19% recognized moderate contributions in information management and learning motivation. Most notably, however, an overwhelming 75% of the participants attributed to the program a highly positive influence on developing and strengthening effective learning strategies and reinforcing their commitment to continuing professional development for academic success. This last finding suggests that TecnoGirls has had a profound impact on the participants.

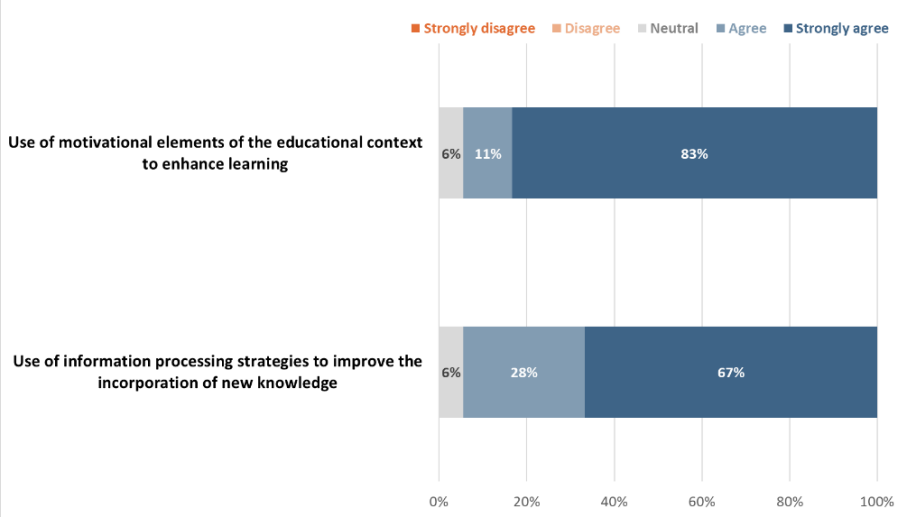

Figure 5: Self-perceived contribution of TecnoGirls by educational dimension indicators

The information presented in Figure 5 highlights the participants' self-perception regarding information processing strategies to facilitate the incorporation of new knowledge. It is encouraging to note that 67% of the participants strongly agree and 28% agree that TecnoGirls provided useful tools that effectively optimized this dimension. In terms of taking advantage of incentives and other motivational elements integrated into the program to enhance their dedication to learning, 83% strongly agreed and 11% agreed that this positively boosted their interest in continuing their training in technological skills after the program. Similarly, 6% of the respondents remained neutral on this aspect.

The analysis of the indicators of the educational dimension reaffirms a majority view within the collective self-perception of the participants, who positively value multiple factors and effects of TecnoGirls, which they consider strengthened personal skills to manage and motivate their training permanently.

4.3 Socio-professional dimension

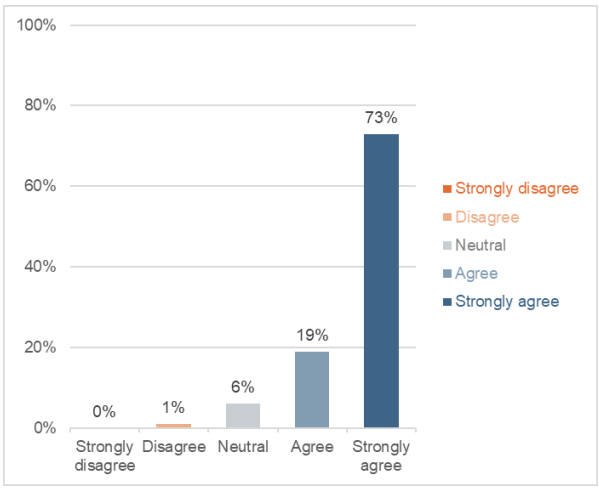

Figure 6: Evaluation of TecnoGirls in social and professional dimension

The data represented in Figure 6 shows that a minimum percentage of 1% stated that they "Disagree" with having obtained improvements in the social and professional dimension thanks to the project. In addition, a small 6% were neutral in this respect. On the other hand, a significant 19% stated that TecnoGirls had a moderate but positive contribution in terms of the growth of theoretical and soft skills necessary for good academic performance. But what is most notable is

that almost three-quarters of the sample, equivalent to 73%, attributed a solid influence on the program.

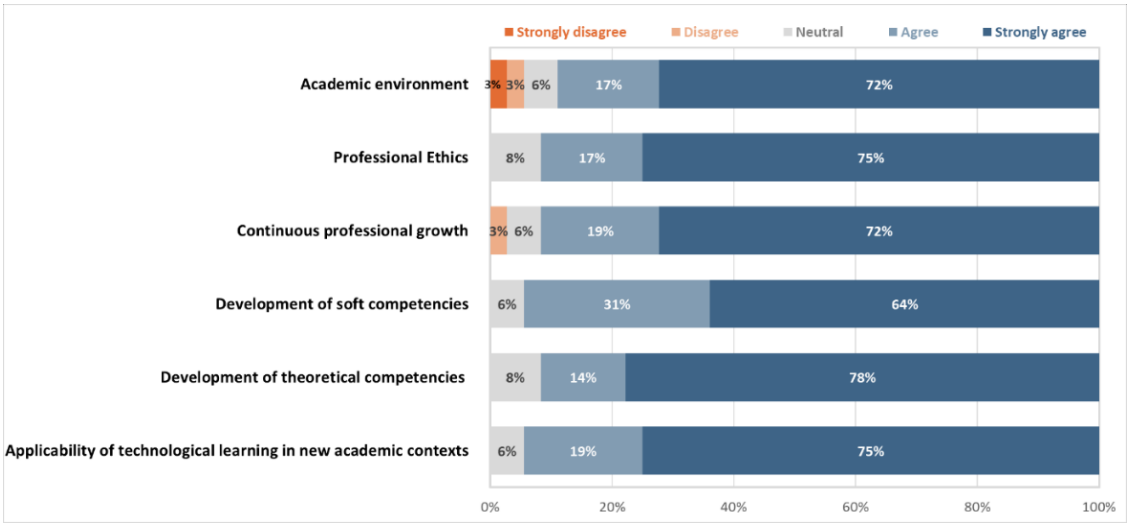

Figure 7: Evaluation of TecnoGirls by social and professional indicators

Figure 7 shows that, regarding the applicability of technological learning in new academic contexts, 75% strongly agree, 19% agree, and 6% are neutral that TecnoGirls made it easier to take advantage of new platforms and tools for their studies. Regarding the development of theoretical competencies, 78% have maximum agreement, 14% agree, and 8% are neutral on the impact of TecnoGirls on technological conceptual knowledge. Regarding the growth of soft skills, 64% strongly agree, 31% agree, and 6% neutral on strengthening communication skills, leadership, and teamwork. On continuous professional growth, 72% strongly agree, 19% agree, and 6% neutral that TecnoGirls motivated them to continue technology training. In terms of professional ethics, 75% strongly agree, 17% agree, and 8% neutral that TecnoGirls improved their confidence in performing with integrity. In the educational environment, 72% strongly agree, 17% agree, 6% are neutral and 3% disagree and strongly disagree.

The consistency of high scores among the participants denotes a positive and shared collective perception of improvement in multiple competencies. These competencies, applicable to their academic performance and professional trajectory, are primarily attributed to their training experience in the TecnoGirls project.

4.4 Emergent thematic analysis Semi-structured interviews

Qualitative information was obtained containing the narrative of the participants' experiences and reflections about their trajectory in the TecnoGirls program.

Using Atlas.ti, information was attained about how these experiences are connected to their participation in the TecnoGirls program in 2020 and how this experience impacted their lives and education in technology. Each of the participants highlights aspects of the program, such as learning in specific areas like electronics, robotics, ethics, cybersecurity, and Microsoft Office, among others. Participant 2: *So, it was quite exciting, for example, in the robotics or electronics subject, normally it had to be done physically so that we could learn, but they provided us with tools that were quite interactive and were equal or even better than doing it in person, so it was basically the same level of learning, but it was more fun, so to speak.*

They also share how the program allowed them to discover and develop latent skills, as well as to improve themselves personally. Participant 1: *...maybe we didn't know about skills that we had hidden, so the part of exploiting, sorry, all that, maybe we didn't know that we were good in one area or another, so in that part I feel that personally, it helped me a lot, to see skills that I thought maybe I didn't have.*

In addition, they all suggest improvements for future editions of the program, such as adding artificial intelligence topics and updated technology, as well as a greater focus on hands-on practice. Although they faced individual challenges, such as balancing studies with the program, they expressed gratitude for the support received and encouraged other young women to join similar programs for their development in technology. Participant 3: *First I would motivate them, because it is one of fear of learning new content, new opportunities we could opportunities in high school are only once in a lifetime and when you are offered a project or take it, because you don't know what will be waiting for you at the end of that project, it opens up new opportunities, it opens up new knowledge, new knowledge and it is never too late to start, this, to study something else*.

The thematic analysis of semi-structured interviews complements the quantitative results, revealing contributions such as development in technological, educational, and socio-professional dimensions to participants of the project.

On the technological dimension, they highlight learning in areas such as electronics, robotics, ethics, cybersecurity, and digital tools, which aligns with the quantitative results on the contribution of TecnoGirls in the development of key digital skills. Participant 2 highlights the interactive tools that facilitated effective and motivating learning. In the educational dimension, they emphasize how TecnoGirls allowed them to discover and develop latent skills, as well as to excel personally, which relates to the positive impact of the program in strengthening effective learning strategies and commitment to lifelong learning. Participant 1 highlights how the program helped her to identify and enhance unknown skills. In the socio-professional dimension, they suggest improvements such as the inclusion of updated topics and a greater practical focus, expressing gratitude for the support received, and motivating other young women to participate in similar initiatives. This reinforces the perception of the applicability of learning in new contexts and the growth of theoretical and soft skills. Participant 3 highlights how TecnoGirls opened up new professional and personal opportunities.

The experiences shared by the participants reaffirm the effectiveness of TecnoGirls in promoting a development that articulates personal, collective, and institutional aspects. Their testimonies highlight how the program has been transformative, providing them with technical skills and motivation to grow in the technological field. This is in line with the literature that emphasizes the importance of multidimensional approaches in professional training of excellence [21], [3], [4]. Participants highlight the importance of promoting innovation and youth technology programs, as Participant 1 notes the need to adapt to impending technological innovations and capitalize on opportunities to develop skills - aligning with the increasing STEM talent demand and efforts to close gender gaps in these fields [1], [2], [17], [18], [19].

In summary, these stories show how TecnoGirls has been a transformative experience for these participants, providing them with technical skills and motivation to grow in the field of technology, while highlighting the importance of continuing to promote programs that encourage innovation and the development of young people in this field.

Participant 2: *Yes, yes, it contributed a lot because thanks to the project I can understand the basics of the major since in the project we saw several topics of technology and all those and basically it is something that we saw in the first year of the career*. She currently is in the fourth year of the Computer and Network Systems Engineering major.

Participant 3: *To have participated in this project was to have opened new opportunities, both professional and personal*. This participant is studying her third year of Engineering in Database Systems and Management

Participant 1: ... *we are facing an imminent innovation in technology, we know today how artificial intelligence is also getting involved (Sound background sound) so motivating all these young ladies to participate is not something that some may think, it is a waste of time, I do not*

have this time maybe or something like that, but it helps to exploit our skills, also the part of knowing a little more about certain areas... At the time of the interview, she was in her fourth year of a Bachelor's in Marketing and worked part-time in a credit union.

5. Conclusions

The study provides interesting preliminary results by revealing a shared positive view among the participants regarding the favorable effects of the TecnoGirls project on the development of digital competencies, effective learning strategies, and skills applicable to their academic and professional performance. The high levels of agreement between the individual perceptions of the participants allow inferring that TecnoGirls had a significant favorable effect on the technological, educational, and socio-professional progress of most of the young graduates, from their subjective point of view.

Qualitative results highlight learning in various areas, such as electronics, robotics, ethics, and cybersecurity, as well as the opportunity to discover and develop skills that had not previously been evident. In addition, participants express support for future improvements to the program, such as the inclusion of artificial intelligence topics and a more hands-on approach. Although they faced individual challenges, they showed gratitude for the support they received and encouraged other young women to join similar programs.

The self-reported, retrospective data limits definitive conclusions about the program's quantitative effectiveness. However, the prevalence of positive beliefs provides preliminary evidence of TecnoGirls' perceived utility in promoting competencies for higher education and technology-based careers. Future studies using control groups, objective measures of skills, and evaluations are needed to examine with greater precision and less bias the multidimensional impact that participants subjectively assign to their training experience in TecnoGirls. Likewise, employability studies conducted in cooperation with companies and organizations benefiting from these STEM programs are needed to measure the real impact on the labor market insertion of its participants.

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