TECHNOVATION Girls Chile

<Tecnología /con nombre de: mujer>

Motorola Solutions Foundation

TECHNOVATION PROGRAM REPORT FOR MOTOROLA 2021 - 2024

1. Introduction

The non-governmental organization (NGO) Tecnología con Nombre de Mujer (TecMujer) has been developing the 21st Century Digital Skills program based on the Technovation Girls curriculum since 2018. The organization has systematically carried out measurements at educational institutions and in interschool workshops where the program has been implemented. In 2020, the first version of the study on self-perception in relation to technology as well as computational thinking of the program's participants was made. In 2021, the application and methodology of the program's process were rethought, and, as a result, the Technovation Girls Chile team developed a unified measurement framework that would shed light on the effects of the program on STEM vocations, particularly considering the curriculum's influence.

This report presents the results of the impact measurement of the Technovation Girls Chile program, focusing on the educational institutions that have been supported by Motorola. It builds upon the 2021-2023 longitudinal report and the 2024 report, both available on the Technovation website1.

The main objective of TecMujer, through Technovation Girls Chile, is to foster STEM vocations among girls and young women. This program is held in more than 100 countries, each developing its implementation and evaluation processes independently while adjusting these guidelines to the local context, which allows a better alignment between the general objectives and the reality where the Technovation program is carried out.

In Chile, we use a "Project-Based Learning" model that is implemented at schools (high schools and colleges) that coordinate with the NGO on a voluntary basis. Teachers are trained in the program's curriculum that addresses various topics and methodologies of technology, problem definition, and project management. Students from these educational institutions participate in the program as part of a course (usually technology). This modality is given a name of the 21st Century Digital Skills Development Program.

Several educational institutions participated thanks to Motorola that supported a total of 6096 first- and second-year high school students (equivalent to U.S. 9th and 10th grades) (with at least 50% females) between 2020 and 2024.

Table 1.1 Educational institutions participating in the program

Year Execution[2]	Educational Institutions MOTOROLA	Total Students Educational Institutions MOTOROLA	Total Educational Institutions	Total Students
2020	3	441	7	2.401
2021	3	804	12	3.839
2022	5	1.290	19	5.758
2023	6	1.836	30	8.093
2024	6	1.725	18	5.124

*The 2024 figures were estimated for the educational institutions whose data had not been updated by MINEDUC (Ministry of Education of Chile

1 https://technovation.cl/impacto/#programas
2 The year of execution is one year after the year of application for funding.

2. Impact Measurement: Methodology

a) Approach and objectives

During the program, a survey is conducted at the beginning and at the end of the program. For analysis, only the subset of students who responded on both surveys is taken into account to ensure data comparability[3]. **A longitudinal comparison (measurement of the same group over time) can be considered more accurate** than assessing evolution (improvement or change) by measuring solely at the end of the process, which can lead to recall biases and reliability concerns.

The survey tracks the following variables: career interests, attitudes toward technology, perception of self-efficacy across multiple dimensions, and "technological thinking" defined as skills related to technology projects, including:

- understanding of basic technological concepts and technology project management methodologies, or "conceptual understanding";
- problem-solving of logical challenges through "systems thinking" (the use of sequence logic, hierarchical reasoning, and selection of relevant variables).

During the measurement process, the phrasing of some questions was adjusted and several improvements were introduced in the program's implementation to maximize survey participation in both measurements (pre- and post-program) and to enhance measurement accuracy.

In the context of the program, the main focus is to keep track of the development of **inductive learning**[4] of "**technological thinking**." Learning is considered inductive because participants engage deeply with content by executing real-world projects and because knowledge emerges as a by-product of project immersion rather than memorization. This approach aligns with deep learning[5] principles, emphasizing problem-solving skills applicable to real-world situations[6].

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[3] This methodological definition has a counterpart or "trade-off" since there is a participation bias (or unitary attrition) because the goal is to achieve census representation rather than sample representation.

[4] Prince, M. J., & Felder, R. M. (2007). The many faces of inductive teaching and learning. Journal of College Science Teaching, 36(5), 14–20.

[5] The concept of "deep learning" referring to algorithms used in artificial intelligence has been distinguished from the concept of "deep learning" that occurs in students.

[6] Chin, C., & Brown, D. E. (2000). Learning in science: A comparison of deep and surface approaches. Journal of Research in Science Teaching, 37(2), 109–138.

b) Study Population

For this study, we conducted a census of all individuals enrolled in the program for the entire period (even if they did not necessarily submit projects). It should be noted that the same measurement methodology has been maintained only since 2021.

For this report, all participants from Motorola-supported educational institutions were part of the population to be studied. All participants were contacted to respond to the survey, but not everyone did so, and some only responded to the workshop's baseline survey. Table 2.1 shows the number of respondents who completed both the initial and final workshop surveys.

Table 2.1: Participation of educational institutions and students in the program

Year	Educational Institutions MOTOROLA	Students MOTOROLA	PWeighted Average School Vulnerability Index (SVI)[7]	Respondents MOTOROLA
2021	3	804	95,0%	129
2022	5	1.290	86,8%	120
2023	6	1.836	71,3%	563
2024	6	1.725	78,7%	709

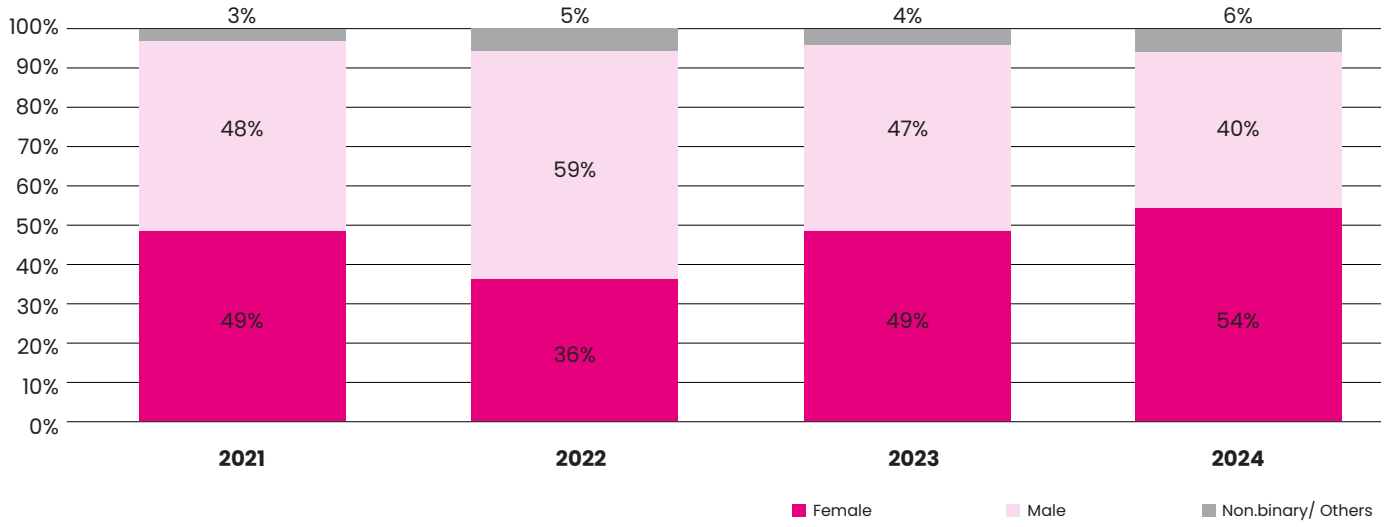
Table 2.2 shows the number of respondents by gender, and Graph 2.1 gives information about the percentage distribution by gender. In 2024, specifically, more female educational institutions were included in the program, which explains the higher number of female respondents.

Table 2.2 Respondents by Educational Institution and Year

Year	Female Educational Institutions	Male Educational Institutions	Non- binary* Others Educational Institutions
2021	63	62	4
2022	257	286	19
2023	280	404	28
2024	380	285	44

[7] The School Vulnerability Index (SVI) is an indicator used in the framework of JUNAEB's School Feeding Programs (PAE). It is calculated for elementary and middle school students and serves as a criterion for allocating PAE resources, generating values ranging from 0 to 1 (per hundred) that reflect the **percentage of the total number of students at an educational institution who have priority to receive the School Feeding Program**. It is a weighted average considering the number of students per educational institution. The figures for each educational institution for each year can be found at https://www.junaeb.cl/ive/.

Graph 2.1 Respondents (Motorola) - Distribution by Gender



3. Analysis of results of Motorola-supported Educational Institutions

In this section, we analyze results of Motorola- supported educational institutions. The analysis will focus on:

- identifying the evolution of technological thinking, both in conceptual understanding and systems thinking, using the same questions from the 2021-2023 study (and retained for 2024);
- identifying the evolution of the variable "impact of digital technology on my future occupation" as an approximation of interest in incorporating STEM studies into future careers[8].

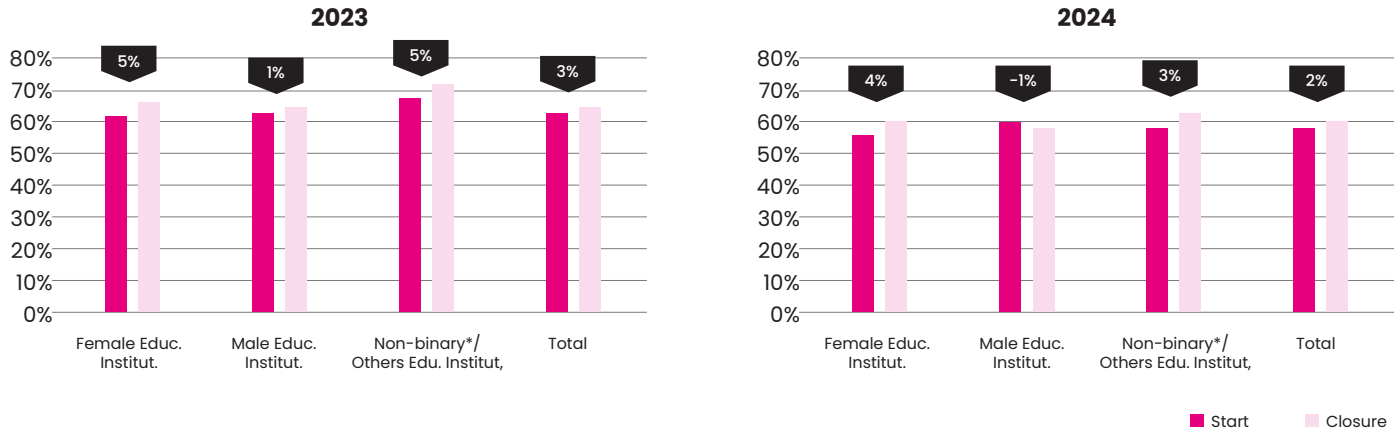
Due to participation rates, we decided to focus the analysis on 2023 and 2024 data, the years with the highest response rates among Motorola's educational institutions (31% and 41%, respectively).

In addition to response rate considerations, it should be noted that the study population of educational institutions changed significantly, so the direct comparison of results between the years is not recommendable. In particular, in 2024, educational institutions with higher vulnerability indices were included.

[8] Given the program's characteristics at schools, decisions about future occupations had largely been defined before the program began (based on the degrees available at the vocational schools that families have already chosen).

3.1 Evolution of Conceptual Understanding:

Graph 3.1 Technology Conceptual Understanding

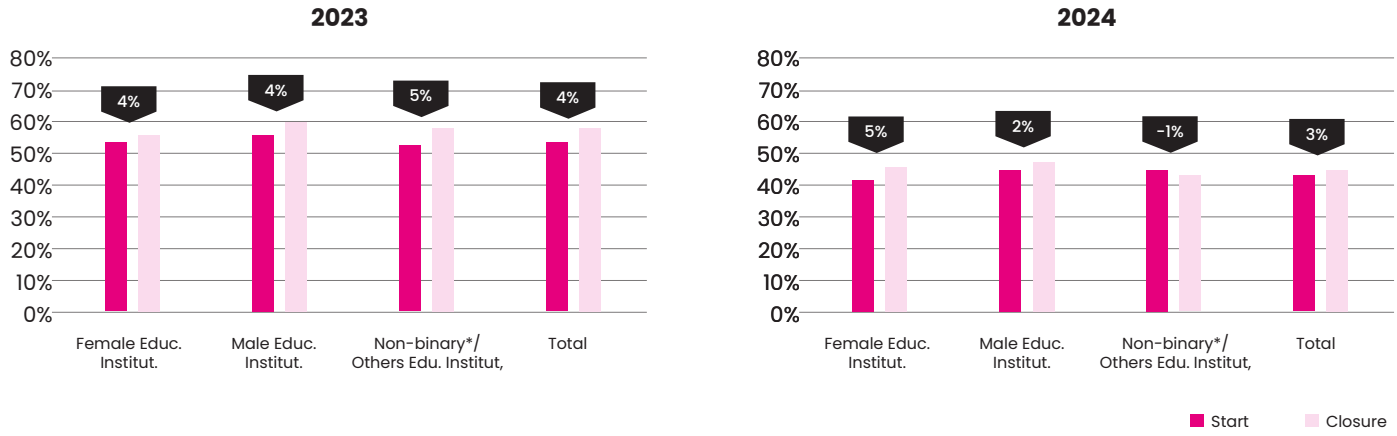


In 2023, there was a significant increase in female participants, from 61% to 66%, not only closing the initial measurement gap – when males accounted for 64% - but also surpassing them in the final measurement (66% for females vs. 65% for males).

A similar trend emerged in 2024 when the percentage of female students increased from 56% to 60%, closing the initial gender gap and exceeding male students in the final measurement.

3.2 Systems Thinking

Graph 3.2 Systems Thinking



In terms of systems thinking, it is worth noting that in 2023, we did not detect any large initial gender gap: the difference between female and male baseline measurements was 2% while in the endline measurement both genders showed an equal improvement of 4%.

In 2024, the overall performance in these variables began at a lower level than in the previous year (bearing in mind that we are referring to different schools). This year there was an initial 4% gender gap between male and female students; however, in the final measurement, this difference narrowed to only 1%, which means that female students improved by 5% whereas male students by 2%.

3.3 Impact of Technology on Future Career

One of the program's objectives is to encourage all participants to consider STEM fields in their future careers. However, choosing a future occupation is a long road, of which this program represents only one stage.

As shown in Table 3.1, in 2024, the preferences for future careers changed very little and remained concentrated in vocational specialties offered by the schools where the program was carried out.

Table 3.1

Future Career - 2024	Baseline	Endline
Science/Technology/Engineering and Mathematics	4,65%	6,00%
Basic Sciences	1,16%	1,20%
Information Technology	2,47%	3,20%
Mechanical (Industrial/Automotive)	6,83%	6,30%
Architecture and Construction	3,34%	3,80%
Health Sciences (Human or Animal)	19,48%	20,20%
Business Administration	9,74%	9,90%
Transportation and Logistics	1,89%	1,00%
Social Sciences	2,18%	2,00%
Human Resources Administration	2,91%	1,50%
Agriculture/Natural Resource Production/Agriculture/Food Industry	1,89%	1,20%
Education and Training	7,56%	7,30%
Law/Public and Private Security	5,38%	5,80%
Tourism and/or Gastronomy	20,93%	19,20%
Audiovisual Technology and Communication	2,18%	3,30%
Art/Design	6,83%	7,00%
Don't Know	0,58%	1,30%

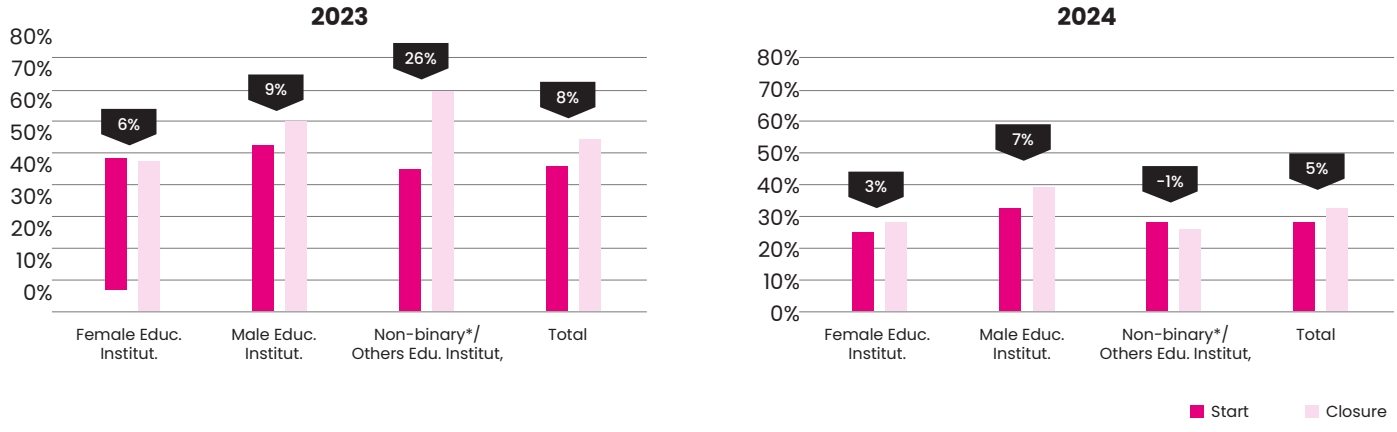
However, the program succeeded in orienting participants toward a future career that incorporates technology as part of the specialization they had already chosen. As seen in Table 3.2, there was a 5% increase in the number of students who believed that technology would impact the profession they had been considering.

In particular, it can be observed that the most significant increases in this attitude came from those contemplating professions related to social sciences and human resource management, followed by disciplines traditionally associated with STEM.

Table 3.2

Future Career - 2024	Impact of Digital Technology on my Future Career		
	Baseline	Endline	Difference
Science/Technology/Engineering and Mathematics	46,3%	59,4%	**13,1%**
Basic Sciences	0,0%	12,5%	**12,5%**
Information Technology	36,4%	47,1%	**10,7%**
Mechanical (Industrial/Automotive)	23,3%	29,8%	**6,5%**
Architecture and Construction	30,8%	43,5%	**12,7%**
Health Sciences (Human or Animal)	30,2%	33,6%	**3,4%**
Business Administration	39,7%	44,8%	**5,1%**
Transportation and Logistics	42,9%	38,5%	**-4,4%**
Social Sciences	7,1%	33,3%	**26,2%**
Human Resources Administration	40,0%	55,0%	**15,0%**
Agriculture/Natural Resource Production/Agriculture/Food Industry	12,5%	15,4%	**2,9%**
Education and Training	20,0%	25,0%	**5,0%**
Law/Public and Private Security	35,0%	32,4%	**-2,6%**
Tourism and/or Gastronomy	16,7%	15,3%	**-1,4%**
Audiovisual Technology and Communication	39,1%	46,7%	**7,6%**
Art/Design	31,3%	40,4%	**9,1%**
Don't Know	22,2%	50,0%	**27,8%**

Graph 3.3 Attitude: Digital Technology Impact on my Area of Interest



The bars reflect the % of values 4 and 5 (the highest) on the axis "agree" or "very much" with the proposed statement.

Regarding the perception of technology's impact on future career choice, we observed a notable 8% increase across all groups; however, the initial gender gap remained.

In 2024 (taking into account educational institutions with higher vulnerability), the perception of future impact of technology remained relatively low (28%), yet at the aggregate level there was a significant 5% improvement in the final measurement (although the initial gender gap was not fully closed either).

4. Teamwork

a) Importance of Teamwork

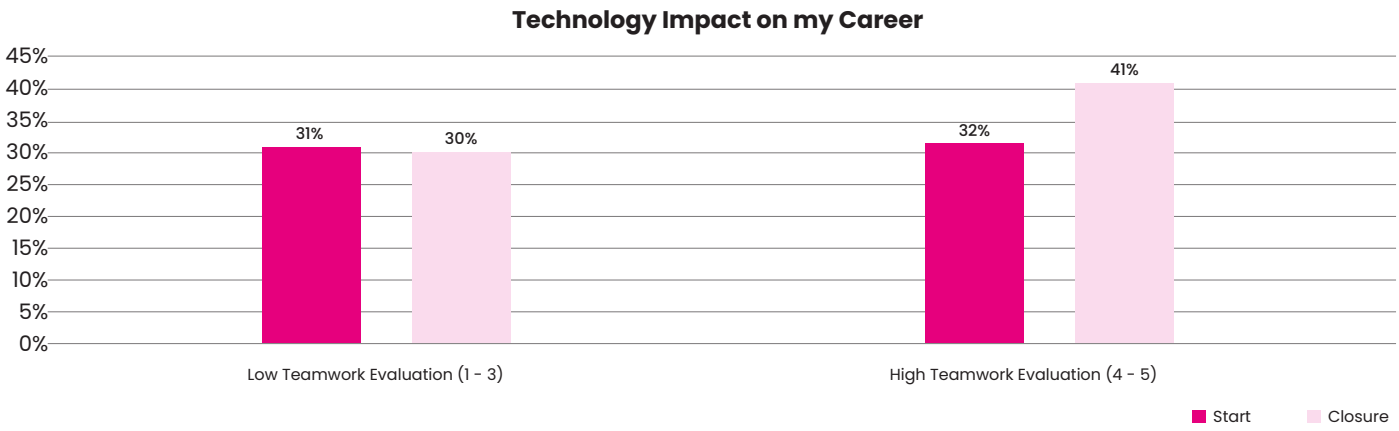
One of the main lessons from the 2023 Technovation study is that the teamwork experience is strongly associated with changes in key variables, such as the perceived importance of technology and the understanding of digital technology projects.

In Figure 4.1, participants who – upon the completion of the program - rated their teamwork experience between 1 and 3 showed no change in the perception of technology's importance for their future career (31% at the baseline vs 30% at the endline).

On the other hand, those who had a good experience with teamwork- rating it between 4 and 5- started from a similar initial level (32% believed that technology would have an impact on their future occupation) and increased their perception to 41% in the final measurement.

In other words, a positive teamwork experience during the project development improved participants' perception of technology's relevance to their future career choice.

Graph 4.1 Correlation between Teamwork Evaluation and Perception of Technology's Impact

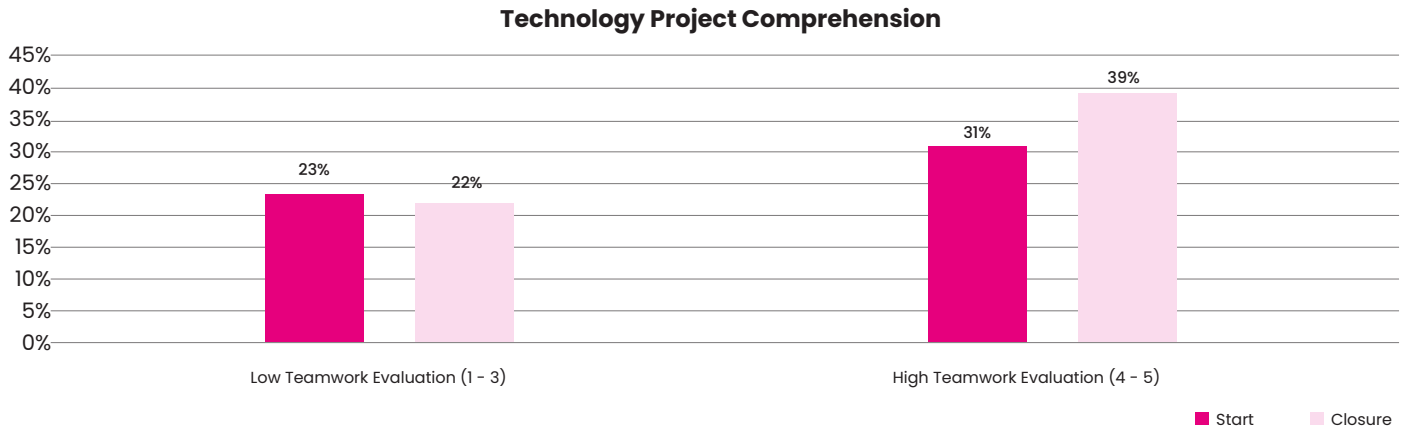


Bars reflect % of answers 4 and 5 in the question "How much do you think you will be affected by digital technology?" (where 1 is "not at all" and 5 is "a lot")

On the other hand, it was found out that teamwork experience also had a significant effect on participants' self-perception of their skills related to technology projects, as reflected in the statement "In general, I understand well what it means to do a digital technology project."

In Figure 4.2, it is observed that participants who had a poor teamwork experience started with a 27% self-perception of understanding and finished the workshop at 22%, whereas those who had a good experience started the workshop with a 32% self-perception of understanding (meaning that there appears to be an aspect of self-perception that may help explain a better teamwork experience), and finished the program with a 6% improvement in that parameter.

Graph 4.2 Correlation between teamwork evaluation and perceived understanding of digital technology projects.



Bars reflect % of answers 4 and 5 in the statement "In general I understand well what it means to do a digital technology project." (where 1 is "strongly disagree" and 5 is "strongly agree").

b) Teamwork Dimensions

As a result of these findings, in 2024, we incorporated some teamwork dimensions to the survey based on the tool "Teamwork Skill Assessment for "Cooperative Learning"[9] (Strom P. & Strom R., 2011) to identify which aspects should be improved or addressed in future versions of the program.

Table 4.1 summarizes teamwork experience assessment by gender and it can be observed that:

- There were no major gender differences in the overall evaluation of the teamwork experience, except for the non-conforming gender group, whose score was substantially lower.
- The highest-rated aspects are a.- positive treatment (consideration of criticism in a friendly and respectful way), b.- good communication (willingness to share opinions and listen to other points of view) and c.- the ability to evaluate evidence and logic in different opinions.
- There are no large gaps in these evaluations between male and female participants, with the largest difference being 4%.

Table 4.1 Evaluation of Teamwork Experience and Teamwork Dimensions

Teamwork Dimensions	Female Educational Institutions	Male Educational Institution	Other/Non-binary Educational Institutions	Total
Overall evaluation of teamwork experience	46%	48%	27%	45%
Evaluate your team: Fulfillment of assigned roles and responsibilities	45%	45%	35%	44%
Evaluate your team: Willingness to seek and share information	45%	43%	32%	43%
Rate your team: Willingness to share opinions and listen to other points of view	51%	49%	34%	49%
Evaluate your team: Keeping good treatment (courtesy and respect)	55%	52%	50%	53%
Evaluate your team: Ability to evaluate evidence and logic of different opinions	49%	50%	39%	49%

[9] Strom, P. S., & Strom, R. D. (2011). Teamwork skills assessment for cooperative learning." Educational Research and Evaluation, 17(4), 233–251.

c) Analysis of the Importance of Teamwork Dimensions

To identify which dimension is more important for teamwork, we performed two analyses:

i. In the initial survey, we asked participants to evaluate each of these dimensions in teamwork from 1 (the most important) to 5 (the least important), resulting in an intentional ranking or conscious or explicit importance ranking.

ii. In the final survey, we asked participants to evaluate their team first and then to evaluate each of the dimensions of teamwork. We then performed a linear correlation analysis[10], from which we could identify an implicit importance ranking based on the real experience of teamwork.

Table 4.2 Importance of Teamwork Dimensions

Dimension	Explicit Priority*	Implicit Priority / Correlation**	Difference
Seeking and sharing information	26,1%	28,0%	1,9%
Communicating and listening to opinions	24,9%	17,8%	-7,1%
Fulfilling assigned roles and tasks	22,9%	33,6%	10,7%
Respectful treatment (accepting criticism kindly)	17,3%	5,4%	-11,9%
Evaluating evidence and logical reasoning	8,8%	15,2%	6,4%

* Percentages represent the proportion of times that dimension was placed in the first place of importance.

** The percentages represent the proportion of the overall evaluation that is explained by that dimension, taking as total the sum of the standardized coefficients of each dimension.

From Table 4.2 we observe the following:

- The variable that has the largest difference between the explicit prioritization (what students value most before doing the project) and the correlation is “fulfillment of role and work assigned by the group,” which ends up being the most important variable in the implicit prioritization.
- This means that, from the beginning of the process, teams that develop the habit of giving feedback on the fulfillment of commitments and workload distribution in addition to monitoring these aspects by a facilitator tend to have a better experience.

[10] A general linear model was performed, considering each dimension as an independent variable. The model ends up resembling an equation in which the value of the overall evaluation is equal to the value of each dimension weighted by its correlation coefficient; the higher the coefficient, the greater the importance of the dimension. The quality of the model is measured by the standardized R2 value of 0.478, which is considered good, since it explains 47.8% of the overall evaluation. All dimensions were found to be statistically significant for the model with a p-value of 0.000 except “Treatment”, which had a p-value of 0.056.

- The variable of seeking and sharing information is the most valued at the beginning and ranks second in importance by correlation; therefore, it is recommended to provide self-study materials on strategies and tools for information search.

- The variable least mentioned as an explicit priority, yet showing a large difference in the significant importance / correlation with overall evaluation is "the ability to evaluate evidence and logic." Because of this difference, it is also recommended to dedicate time during program implementation to teaching how to evaluate the quality of information and arguments, within a framework of cordiality and objectivity.

5. Conclusions

- Overall, both in technological thinking and in the valuation of technology's role in the future career choice, significant improvements were observed in both years analyzed.

- In particular, in the technological thinking variables, there was a consistent narrowing of the gender:

    - In the conceptual understanding dimension, in 2023, a significant improvement was observed among female participants, from 61% to 66%, not only closing the initial gap (when men accounted for 64%) but also surpassing them in the final measurement (66% females vs. 65% males). A similar trend appeared in 2024, with female students rising from 56% to 60%, closing the initial gender gap and even exceeding males in the final measurement.

    - In terms of systems thinking, we did not detect a very large initial gender gap (the difference between the initial female and male gender was 2%) in 2023 while in the final measurement both genders showed equal gains of 4%. In 2024, we observed that overall performance in these variables began at a lower level than in the prior year (given higher vulnerability educational institutions). That year there was a 4% gender gap between male and female students in the initial measurement, but in the final measurement this difference decreased to only 1% (female students improved by 5% and male students by 2%).

- Regarding the valuation of technology's impact on the future career, we saw a substantial improvement in the final measurement in both years (8% in 2023 and 5% in 2024).

  This perception evolved very differently, depending on future occupation preference: the most significant increase came from those considering professions in social science and human resource management, followed by disciplines traditionally associated with STEM.

- The findings reaffirm the importance of improving the teamwork experience to maximize the program's benefit since it determines the evolution of the perceived impact/importance and of the understanding of what it means to do a digital technology project. Accordingly, the main adjustment with respect to the initial expectations should address the distribution of and fulfillment of roles and tasks within teams. As a result, it is paramount for teachers to monitor each student's compliance with commitments assigned by his or her team. This proves to be more valued than simply getting along well.

Annex

Motorola Study Population, the 2021-2024 Program at Educational Institutions

Year/ Institution	Students	Weighted Average SVI (%)
2021	**804**	**95,0%**
Instituto Superior de Comercio de Valparaíso (INSUCO) Francisco Araya Bennett	392	94,0%
Liceo Comercial Temuco Bicentenario de excelencia	240	95,3%
Liceo Comercial Vate Vicente Huidobro	172	96,8%
2022	**1.290**	**86,8%**
Instituto Superior de Comercio de Valparaíso (INSUCO) Francisco Araya Bennett	352	92,7%
Liceo Bicentenario Provincial Santa Teresa de los Andes (Corporación Colina)	403	70,9%
Liceo Bicentenario Técnico Puente Ñuble	93	93,6%
Liceo Comercial Temuco Bicentenario de excelencia	232	93,7%
Liceo Comercial Vate Vicente Huidobro	210	96,6%
2023	**1.836**	**71,3%**
Colegio San Agustin	181	40,6%
Colegio San Agustin Antofagasta	232	28,7%
Instituto Superior de Comercio de Valparaíso (INSUCO) Francisco Araya Bennett	410	91,3%
Liceo Bicentenario de Excelencia Polivalente San Nicolás	385	81,8%
Liceo Bicentenario Provincial Santa Teresa de los Andes (Corporación Colina)	399	68,9%
Liceo Comercial Temuco Bicentenario de excelencia	229	89,5%
2024	**1.725**	**78,7%**
Bicentenario Nuevo Mundo, Mulchén	276	96,2%
Colegio Bicentenario Miguel de Cervantes	280	90,1%
Colegio San Agustin Antofagasta	232	31,5%
Liceo Bicentenario Provincial Santa Teresa de los Andes (Corporación Colina)	400	73,4%
Liceo Jorge Sanchez Ugarte Coreduc Concepción	267	89,1%
Liceo José María Narbona Cortes	270	87,1%

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