2021 – 2023 Longitudinal Study

TECHNOVATION GIRLS CHILE PROGRAM'S IMPACT MEASUREMENT

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Foreword

Since 2018, NGO Tecnología con Nombre de Mujer has been implementing the 21st Century Digital Skills Program based on Technovation's curriculum. We have systematically conducted evaluations in both institutional settings (as part of the school's syllabus) and after-school workshops where the program is implemented. In 2021, we revised the methodology and approach to our evaluation processes, and as the Technovation Girls Chile team, we developed a unified assessment tool to assess the program's effect on STEM-related career choices, particularly focusing on key aspects of this curriculum.

This document compiles the insights of many who believe in the importance of encouraging girls and young women to explore STEM fields and consider careers in science, technology, engineering, and mathematics (STEM). This study is the result of extensive reflection and a continuous effort to integrate the challenges we have encountered, turning them into valuable opportunities for the improvement of our work and the evolution of the Digital Skills Program. This program is implemented in schools across more than eight regions in Chile and offered as after-school workshops (also called "interschool program") in six regions.

The document begins with a statistical description of the students who take part of the program, and an explanation of the data collection criteria, including the reasoning behind the adjustments that took place in each evaluation. The second part presents various comparisons, highlighting the development and progress of the students over time. Finally, the main conclusions from this research process are presented. We hope this report will be a contribution that highlights the significance of the Technology subject in the educational experience of high school students in their first and second years.

I would like to extend my gratitude to the MetLife Foundation, Scotia Inspira, and Medtronic for believing in our NGO's mission. I also want to thank the sponsors of each participating school, as well as the principals, curricular department managers (UTP), and teachers who day to day see the program's activities through. I'd like to add a special thanks to all the students who responded to our questionnaires, helping us improve our curriculum for the benefit of future generations. We know that without your help we can't improve.

To everyone who dedicated their time and efforts to this research, thank you. Your collaboration over these years has been invaluable, especially during moments when we doubted our readiness to measure impact or doubted the significance of our findings.

My heartfelt thanks also go to the entire NGO team; this accomplishment is collective, and it was this unified support that sustained us through the research journey. Finally, special recognition goes to Mathias Klingenberg for his unwavering support and to Francisca Lohaus for her guidance in the development of the bibliographic section.

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1. Introduction

NGO Tecnología con Nombre de Mujer (aka TecMujer), through its Technovation Girls Chile program, aims to promote interest in STEM fields among girls and young women, fostering the development of 21st-century skills through Project-Based Learning. Since 2021, the Technovation program in Chile has systematically measured its performance to assess the program's impact on students. Specifically, this involves evaluating knowledge, skills, and specific dimensions on personal growth of the participants, as well as tracking changes in conceptual understanding of technology terms, interest in STEM education and careers, STEM- related skills, attitudes towards digital technology, and self-perception of problem-solving skills in real-world contexts.

As part of this long-term strategic effort, the program's implementation is accompanied by ongoing research and development of the system of measurement needed to assess its broader impact on the community. Our hypothesis is that a community will be more resilient to external changes if:

- It experiences an increased sense of agency, influence, and self-efficacy.
- It builds a larger and more diverse network of social connections (e.g., industry mentors and leaders).
- It is more open to girls and women becoming technology innovators and entrepreneurs (as outlined in Rights and Resilience, Technovation 2020).

This approach allows us to refine and enhance the integration and effectiveness of STEM workshops for girls and adolescents in general across Chile, fostering a supportive ecosystem for future innovators.

[1] Science, Technology, Engineering, Mathematics

The Implementation of Technovation in Chile

The Technovation program aims to spark interest in science and technology, especially among girls and adolescents, in order to increase female representation in STEM fields and reduce gender gaps in this aspect. This is achieved through:

- Hands-on experience, where participants define and design a tech project that addresses a real-world problem.
- Team collaboration, with groups of 2 to 5 students who assume different roles and share ideas, interests, and responsibilities.
- Community engagement, involving various organizations and educational institutions in the program's implementation.

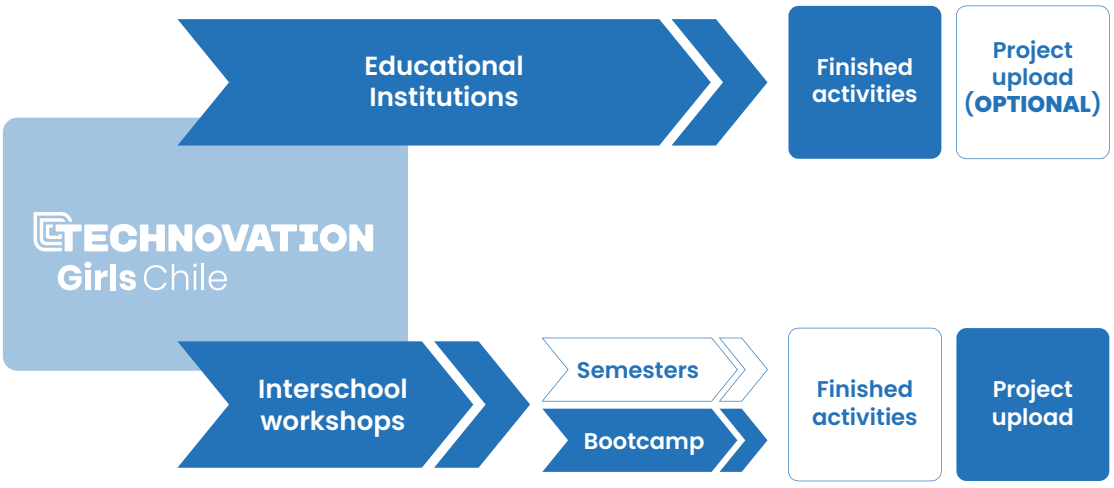
The program is active in over 100 countries. Each country develops its implementation and assessment process independently, adapting the program's guidelines to better align with local contexts and needs.
In Chile, we employ a "Project-Based Learning" model across two formats:

1. **Educational Institutions** (public and private schools, as well as charter schools) or School Program- These institutions sign agreements with TecMujer on a voluntary basis. Its teachers are trained in the program's curriculum, which covers technology, problem definition, and project methodologies. Students participate as part of the school's syllabus (usually as part of the "technology" course). This format is known as the "21st Century Digital Skills Development Program".

2. **Interschool Program** - Based on the Technovation curriculum, these workshops are carried out directly by TecMujer instructors, with the partnership of higher education institutions who provide infrastructure (classrooms and devices) across Chile. Students voluntarily enroll and the activities take place out of school hours, often on Saturdays (the semester workshop format) or during summer breaks (in a bootcamp format).

Each tech project is submitted to the Technovation platform, where teams are guided by a teacher or mentor who supports them throughout the process and ensures compliance with participation requirements. This enables them to enter the Technovation Challenge (or International Challenge[2]). Per Technovation's guidelines, only women may present projects at the international level (although most of the school's teams are all-gendered).

Infographic 1: Program Flow



Under this scenario, the measurement that accompanies the implementation consists of a questionnaire on attitudes, perceptions as well as technological competence questions, implemented at the beginning and at the end of the program.

[2] A competition that invites teams of girls ages 8 to 18 from around the world to learn and develop skills to solve world problems through technology.

Context of the Program's Implementation

Since the first versions of the program were implemented in 2019, a consistent study has been carried out at schools and interschool organizations where the program is being implemented, arriving at a unified measurement instrument from 2021 to 2023. In this process, it has become evident that the reality of the country has been affecting both the way in which the program has been carried out and the issues included in the measurement.

Implementation 2021

This period was heavily influenced by the government's measures in response to the COVID-19 pandemic. Classes and workshops at educational institutions were conducted in hybrid formats (both in-person and online) or entirely remote (online). In this context, the evaluation included factors that may have affected the delivery of classes, such as:

- Access to technology and internet connectivity at home.
- The way they use and relate to technology.
- The ability to access online learning content remotely.
- This year was deeply challenging in terms of class attendance.

Implementation 2022

In 2022, Chilean students returned to in-person classes after almost two years of online or hybrid learning due to the pandemic. This transition back to physical classrooms highlighted several issues:

- A deterioration of mental well-being, related to an increase in school coexistence challenges (inter-personal relationship conflicts), and greater difficulties in learning among students in the "after pandemic reopening"[3]. This prompted the incorporation of questions in terms of the emotional state of students participating in the program.
- In the context of the reopening, teamwork was challenged by experiencing problems in face-to-face settings: communication difficulties with peers and teachers and a sense of discomfort in social interactions[4]. This prompted the implementation of qualitative inquiries between the initial and closing measurements
- The pandemic's cumulative disruptions on learning were particularly evident in mathematics, where the impact was almost double that observed in reading skills. This is partly because households are generally better equipped to support reading at home, whereas mathematics learning relies more heavily on teachers, formal classes, and school environments[5].

[3] "Efectos de la pandemia en el bienestar socioemocional de los niños y adolescentes en Chile y el mundo"; Granese et. Al; CEP Chile 2023. https://static.cepchile.cl/uploads/cepchile/2023/03/pder647_granese_etal.pdf

[4] "Post-Pandemic Blues: Collaborative Learning (CL) and Communicative Competence in The English As A Second Language (ESL)", Ibrahim, n. et. Al; Classroom International Journal of Academic Research in Business and Social Sciences Vol. 1 3 , No. 4, 2023.

[5] "Inequalities in Learning Losses during the COVID-19 Pandemic: The Importance of School Effectiveness," Working Paper prepared by Centro de Investigación Avanzada en Educación (CIAE) U. de Chile and Escuela de Gobierno de la PUC (2023); available at https://ciae.uchile.cl/index.php?page=view_biblioteca_digital&id=1058&langSite=es.

- The scope of the program expanded significantly during this period. The "Development of 21st Century Digital Skills" program (schools- based format) increased from 11 to 18 schools, implementing the curriculum throughout the academic year. Additionally, the number of interschool workshops grew from 6 sites with a single cohort in 2021 to 8 sites in 2022, with a threefold increase in cohorts (first and second semesters of 2022, plus a summer bootcamp in 2023, each with 12 classes of 4 hours each). This expansion resulted in a doubling of participation in the interschool format.

- School absenteeism continued to be high, while intermittent attendance was also very high, which made it difficult to develop learning. There is no data showing the predominance of any gender regarding this phenomenon.

Implementation 2023

The main events of 2023 in the context of implementation were:

- After significant declines in 2022, SIMCE (National Learning Outcomes Assessment System, which measures 4th and 10th grades performance) results have largely returned to pre-pandemic levels (2018 measurement). However, students in 10th grade (or 2nd year of highschool- the a level close to the age at which the program is implemented) scored 257 points in mathematics, still below the pre-pandemic score of 264 points. Additionally, the gender gap in mathematics increased between the 2022 and 2023 measurements.

- In terms of absenteeism, improvements were also recorded- in comparison to 2022: the number of students who are absent 3 days or more per month, which is known as "serious non-attendance", decreased by 140 000. Thus, cumulative serious non- attendance was 34.2%, which was better than the rate of 38.2% in 2022, but still 15 percentage points above pre-pandemic levels.

- As for the implementation of the 2023 program, as seen in 2022, we see a significant increase in its scope:

    - From 18 schools in 2022, the program jumped to 29 schools[6], increasing the number of registered participants in this format from 5 758 to 8 093 (a 40% increase).

    - In the half-year interschool workshops, the number of participants who successfully completed the program more than doubled, from 367 girls in 2022 to 877 in 2023 (139% increase).

[6] In addition, one school abandoned its participation in the middle of the year due to a prolonged work pause.

2. Measurement Methodology

Approach and objectives

As outlined in the introduction, a survey was conducted at both the beginning and end of the program. For the analysis, we considered only the subset of students who responded on both occasions to ensure comparability[7]. This longitudinal approach—measuring the same group over time—provides a more accurate view of change and development than relying solely on end-of-program assessments, which can introduce issues on recall and reliability of the answers.

The survey aimed to capture the following variables: work interests, technology-related attitudes, and perceived self-efficacy across various dimensions, including "technological thinking," defined as skills associated with technological projects and technology, which considers two dimensions:

- Understanding of basic technology concepts and technology projects, or "conceptual understanding".
- The problem-solving of logical challenges through "systems thinking" (the use of sequence logic, hierarchies, and selection of relevant variables).

[7] This methodological definition has trade-off, since it is more likely to have participation bias (or unitary attrition) for each measurement, here we are not using a sample but we aim to obtain a census.

In the context of the program, the main objectives of this measurement are:

- Record of trajectories of work interest in STEM areas.
- Observe the evolution of inductive learning of "technological thinking." We call it inductive because the contents and subjects are taught only as relevant for the project development. Learning occurs as a result of an executed project (the lived experience) and not as a result of memorization, based on the assumption that learning through this activity is associated with "deeper learning" (which emphasizes knowledge and skills applied to real world circumstances and to solve new problems)[10].

Survey Approach as a Standardized Tool for Measuring Technological Capability

This survey, as a measurement tool, uses multiple-choice questions on "technological thinking" as a way to estimate basic levels of competence in this area, and thus account for the learning process that may have occurred during the program. In this sense, it is worth noting that this assessment is similar to standardized tests using multiple-choice questions with a limited number of responses. This implies some disadvantages and limitations which are offset by some adjustments in the implementation as well as broader considerations:

a. It is a limited way of measuring a complex mental process such as the mastery of types of knowledge and their learning. In that sense, this measurement is a supplementary way of measuring learning, since other important aspects (of learning) are the workshop outcomes themselves, in terms of the number of participants who manage to finish and present their projects, and among them those who manage to qualify for the international challenge.

[8] "The Many Faces of Inductive Teaching and Learning"; Prince, MJ; Felder, R.M; Journal of College Science Teaching, November 2006.
[9] Recently "deep learning" has been associated with the algorithms used in artificial intelligence, therefore to address the process in students has emerged the use of the term "deeper learning".
[10] "Learning in Science: A Comparison of Deep and Surface Approaches", Chin Ch, Brown, D; Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 37(2), 109-138

b. We know that training or workshop orientations are complex processes, in which many factors have an influence throughout students' learning career, and this is an effort to measure contributions in trend changes, and by measuring such contributions, we hope to present bifurcations on this path. In addition, there are other initiatives that the NGO is working on, aiming to identify impacts on former participants of the program some months or years after its completion.

c. The main objections to standardized tests lie in their use as ranking tools and high-stake decisions (such as university selection or resources for an institution). In this sense, these questions should be seen as a reference and not as an absolute parameter, whereby participants are tested on what they know or how they reason at that moment, in a way that is as brief as possible; we put an emphasis on making clear to students that their answers should be as natural as possible, without performance or ranking/comparison anxieties; in this aspect, no performance pressure is imposed on either students or institutions. Likewise, the questions avoid equivocal phrases that include options such as "all of the above" (which is a way of punishing more risk-averse people) and seek to incorporate a certain degree of reading comprehension for their resolution.

d. The implementation of the same instrument (designed according to the specific learning process in accordance with the program) allowed us to have a significant number of comparable cases, so that we can make inferences about statistically significant patterns.

[11] Some examples of the unintended consequences of using a standardized assessment for "high-stake" decisions: it incentivizes adjusting processes (classes) for testing (and not for learning); it can diverge focus and time on test taking, and less on the transmission of knowledge and learning experiences; very frequent modes of standardized test implementation can have implicit gender biases, e.g., discounting wrong questions from the score causes the most risk-averse (usually women) not to answer all questions. Carly Berwick, "What Does the Research Say About Testing?" edutopia.org, Oct. 25, 2019.

[12] "The Relationship Between Test Item Format and Gender Achievement Gaps on Math and ELA Tests in Fourth and Eighth Grades"; Reardon, S. et.al; Educational Researcher 47(5), 2018.

Summary of adjustments to the questionnaire 2021 – 2023

In terms of data collection, the following should be noted:

- In the 2021 program implementation, the survey was conducted mainly through digital surveys sent to e-mail addresses that the participants voluntarily submitted at the beginning of the program.
- In 2022, information was obtained on the total number of participants in the programs, who had to register their emails in the enrollment process, sending invitations via email (which was used as a key to link the initial and closing responses), which made it possible to identify those who did not respond as well as to make targeted efforts to increase the participation of the groups that tend to have lower response rate.
- In 2023, the process of having information on all participants was maintained, and a mixed approach to the digital survey was implemented, since while in 2022 and 2021 it was mainly done by sending surveys via e-mails, the new platform allowed respondents to identify themselves by mailbox or by their national identification number in 2023.

This way, the percentage of participants in the initial measurement was 39% in 2021, 55% in 2022, and 81% in 2023.

In terms of adjustments to the questionnaire:

- In 2021 and 2022, the questionnaire placed a strong emphasis on capturing students' confidence in their own abilities, focusing on 11 skills identified as key for the Fourth Industrial Revolution according to the World Economic Forum (WEF)[13]. This module was eliminated in 2023 because of: its length, the fact that no major variations of this item were recorded, and that it didn't correlate with technological thinking[14] and the impact variables (systems thinking).

[13] https://www.weforum.org/agenda/2020/10/top-10-work-skills-of-tomorrow-how-long-it-takes-to-learn-them/

[14] It does present a correlation with the option for STEM occupations but not as strong as other attitudinal questions that remain in the questionnaire.

Regarding the questionnaire's adjustment:

- In 2022 and 2023, a question on emotional state was incorporated, given the relevance of this dimension in the context of returning to school, as well as factors related to school coexistence.

- In 2022, some questions were rephrased to clarify the concept of "technology," which had been broad (several interpretations), while the program focuses on "digital technology" and "projects with digital technology," which were the terms added in the questions.

- In 2023, a module called "Attitudes Towards Problem Solving Scale" (ATPSS) was introduced, which we labeled as "Disposition towards Problem Solving" in our questionnaire. The "problem solving" referenced here are also known as "word problem solving" or "mathematical problem solving" (sometimes referred to as "verbal problem solving"). This type of problem solving is not purely mathematical; it also requires reading comprehension, situational analysis, after which takes place a mathematical formulation. The attitude or disposition toward these challenges correlates with the performance of what we coined as "systems thinking," as the problems share similar characteristics.

- In 2023, during the qualitative work, the importance of the teamwork experience for the program´s participants was identified when evaluating processes and learning; as a result, a general evaluation question on the teamwork experience was included[15].

[15] Since this adjustment was made in the second semester closure measurement, participants who completed the program in the first semester did not have this question in their questionnaire.

Impact and Population of the study

As mentioned above, the program is implemented in two modalities: school program and interschool workshops; within the interschool workshops, participants are divided into those who participate in semester modalities (12 sessions, 4 to 5 hours each class, mainly Saturdays) and those who take part in intensive summer programs ("bootcamps") in which the 12 sessions are concentrated in 2 weeks. During the year we have the following cases:

- People who enroll and drop out of the program, mainly in the interschool workshops (at educational institutions there are only dropouts when there is extended absenteeism, which is less frequent).
- People who participate during the entire period, but do not manage to finish developing a project.
- People who complete a project, yet do not manage to upload it onto the international challenge platform (they do not meet all the requirements).

In this sense, the definition of "achievement" for each modality is also differentiated:

- For participants of interschool program, the first definition of achievement (and the main impact indicator) is to get as many participants as possible to the stage of uploading their projects onto the international platform.
- For participants of the school program, the definition of achievement is defined as completing all the contents and activities (which are graded by the teacher, as part of a course) during the entire period.

So, the definition of the research population consist of:

a. Participants from the school program, all those who participated in the program for the entire period (even if they didn´t upload projects) and passed the course, with all the workshop's activities finished.

b. Participants of the interschool workshops, who participated in semester workshops and managed to upload their projects onto the platform (which is the achievement criterion for this modality). Participants of the bootcamps were not included, because the deadlines and dates of its development were not compatible with the logistics of the data collection.

Infographic 02: blue boxes indicate the cases that were included in the survey

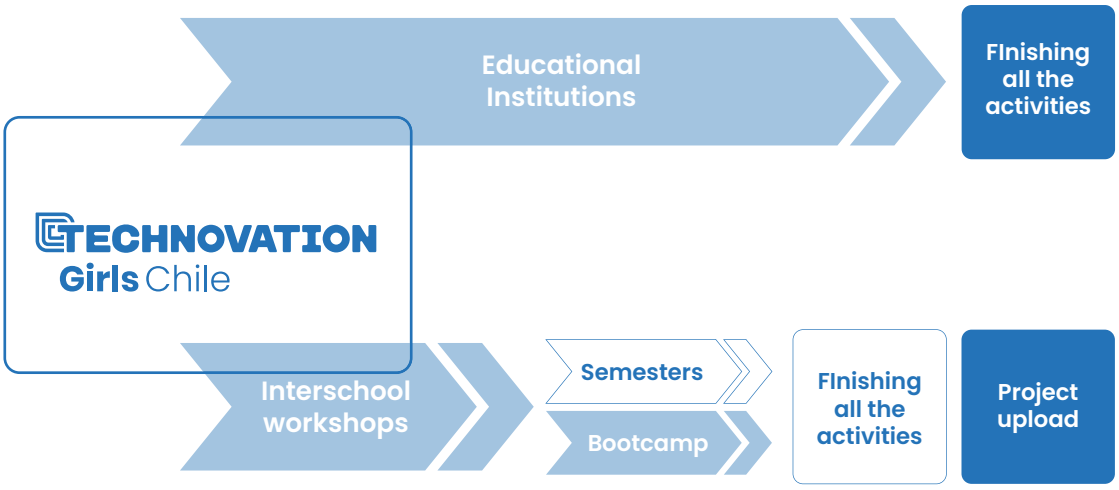


Table 1.1: Number of program participants and identification of the samples considered for measurement.

		2021	2022	2023
Educational Institutions	Finishing Activities (a)	3839	5758	8093
Intereschool	1.- Bootcamp	120	536	498
	2.1- Semester- finishing activities	440	694	1547
	2.2- Semester-project upload onto the international platform[16] (b)	357	367	877
	Total Number of interschool participants (Bootcamp + Semester)	560	1230	2045

[16] They are a subset of the participants in the half-year (semestral) workshops.

3. Participation in the Program

a. Characterization

Table 3.1 shows an increase in the number of schools, while Table 3.2 demonstrates a rise in the number of participants according to the type of educational institution, with a concentration in those with delegated administration (mostly technical/professional high schools) and in charter schools were 63% and 67% of the total number of people participated in the program in 2022 and 2023 accordingly[17].

Table 3.1 Schools of the Program[18]

Type of Administration	Measurement Year		
	2021	2022	2023
Delegated Administration (C. P. 3166)	2	7	14
Charter School	3	5	9
Local Educational Service[19]	1	1	2
Municipal Corporation	1	1	2
Municipal Department of Education	3	2	1
Private Paid	1	1	0[20]

[17] In 2023, 2 facilities that started measurement that year but did not complete the program were not counted.
[18] It does not consider interschool workshops.
[19] There is one institution that participated in the 3 measurements and was dependent on a Municipal Corporation in 2021, but since 2022 it became dependent on a LES. For the purposes of this report, it will be considered as dependent on a LES in all measurements.
[20] The school did not participate in the 2023 measurement because it was restructuring its curriculum and teaching staff, and it was not able to comply with operational aspects of the data collection.

Table 3.2 Quantity of the program´s participants

Type of Administration	Measurement Year		
	2021	2022	2023
Delegated Administration (C. P. 3166)	572	2628	4294
Charter School	1455	1220	1754
Local Educational Service	71	376	1195
Municipal Corporation	1260	457	753
Municipal Department of Education	315	950	97
Private Paid	165	127	0
Interschool Program	357	367	877
TOTAL	4196	6125	8970

Table 3.3 shows the number of respondents who participated in both measurements (at the beginning and the end of the program, "initial" and "closing" measurements). It can be seen that by the end of 2023 a better response rate was achieved: the number of respondents more than doubled compared to that in 2022 (140% growth).

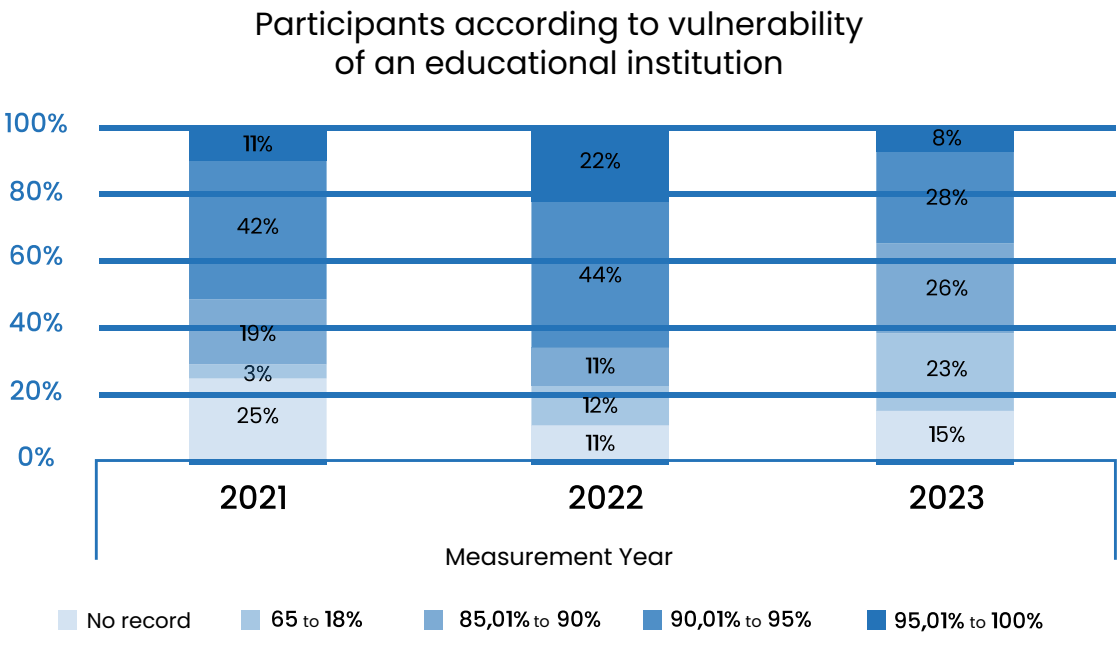
Table 3.3 Number of matched respondents (participating in initial and closing measurement)

Type of Administration	Measurement Year		
	2021	2022	2023
Delegated Administration (C. P. 3166)	136	392	1541
Charter School	234	305	798
Local Educational Service	52	25	469
Municipal Corporation	48	215	181
Municipal Department of Education	273	339	55
Private Paid	9	86	0
Interschool Program	83	30	314
TOTAL	835	1392	3358

From the information recorded by the Ministry of Education (MINEDUC), the school vulnerability index was obtained from the National Allocation System with Equity for Scholarships (IVE- SINAE) that the National Board of School Aid and Scholarships (JUNAEB) must prepare, which measures the percentage of students who are classified according to the Board's first 3 priorities (according to poverty conditions and risk of school failure).

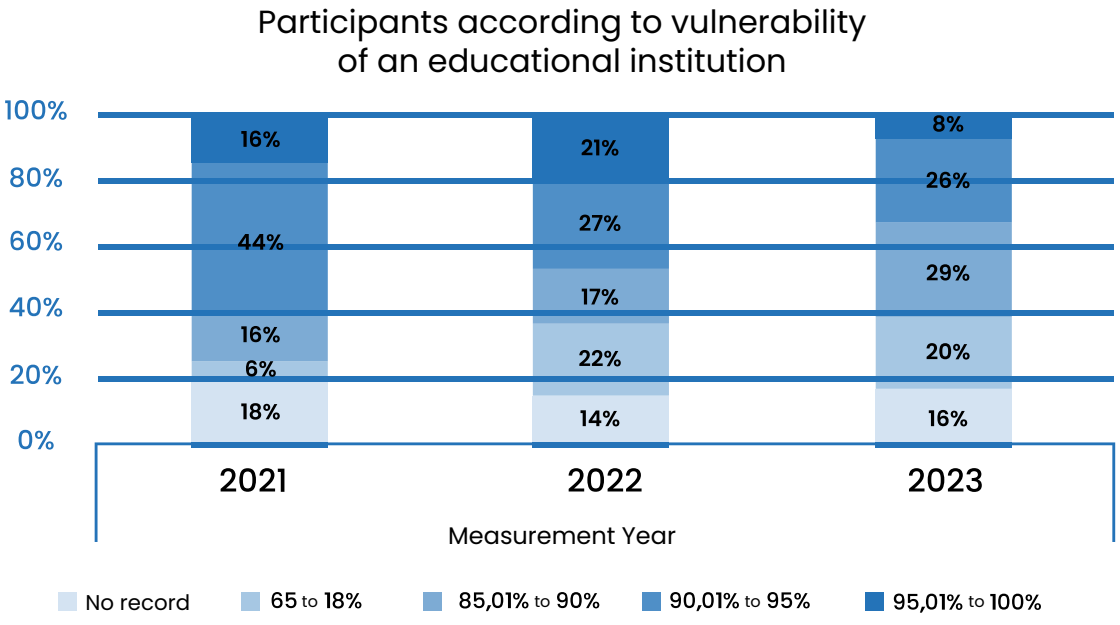
There are educational institutions that do not register vulnerability level (1 charter school and 1 private paid), which were added to the interschool program for this category. Figure 1 shows that the year 2022 was different in terms of a higher percentage of participants (22% of all participants) coming from schools in the most vulnerable bracket (schools with over 95% of enrollment in vulnerable conditions), compared to other years, , and Figure 2 for the same year shows that the 90.01% - to - 95% vulnerability bracket is underrepresented in terms of the percentage of respondents (44% of participants to 27% of respondents).

Graph 3.1 Vulnerability index of all program participants



[21] For more details, the calculation documentation can be found at https://obtienearchivo.bcn.cl/obtienearchivo?id=repositorio/10221/28517/2/BCN_IVE_Cerro_Navia.pdf.

Graph 3.2 Vulnerability index of respondents



Given program goals, the gender dimension is central to the analysis and review of the trends in all the parameters and variables measured in these studies. However, it should also be considered that the two formats in which the program is implemented (school and interschool programs) present significant differences in the composition of participants and the dynamics they show during the workshops: in the case of the interschool program, they are volunteers, who dedicate their weekends and free time to the development of activities; as opposed to the people from educational institutions, who do not usually have the same degree of voluntariness and for whom the workshop implies a grade that affects their school grades.

For all above reasons, the variable "segment" is created, which in the case of institutions differentiates self-identification by gender, while in the interschool program all identities are grouped together, considering that by definition of this program only people with a female sex (assigned at birth) can enroll.

In Table 3.4, we see that the gender distribution of educational institutions is more or less balanced, while in Table 3.5 (which shows data on respondents) we see that in 2022 male respondents decreased their proportion (lower response rate).

Table 3.4 Total distribution of program participants by gender

Segment	Measurement Year		
	2021	2022	2023
School No info	0	335	0
School Female	692	2638	4029
School Male	734	2633	3841
School Non-binary* Other	36	152	223
Interschool Program	357	367	877
TOTAL	1819	6125	8970

Table 3.5 Gender Distribution of Respondents

Segment	Measurement Year		
	2021	2022	2023
School Female	390	726	1487
School Male	348	581	1442
School Non-binary* Other	14	55	115
Interschool Program	83	30	314
TOTAL	835	1392	3358

As for the school levels of the respondents (Table 3.6), we see that at schools, there is a majority in the 10th grade in 2021; there is an equal distribution between the 9th and 10th grades in 2022, and there is a majority in the 9th grade in 2023 (54% of the total of school program respondents).

Table 3.6 Distribution of students respondents by level / school year

Educational Level	Measurement Year		
	2021	2022	2023
9th grade	298	660	1634
10th grade	406	689	1410
11th grade	48	13	0
Junior (Technovation Interschool)	0	0	150
Senior (Technovation Interschool)	0	0	164
Technovation intereschool / no id	83	30	0

As part of the characterization, table 3.7 shows the distribution of respondents by program and age. Overall, we observed an increase in the average age of participants in the interschool program in 2023.

Table 3.7 Distribution of respondents by program and age

Category		Measurement Year		
		2021	2022	2023
School program	No record	0%	0%	8%
	11 a 13	3%	0%	0%
	14	37%	15%	14%
	15	45%	44%	46%
	16	12%	32%	27%
	17 to 20	2%	8%	6%
Intereschool	No record	0%	0%	4%
	11 a 13	51%	43%	19%
	14	17%	27%	16%
	15	8%	13%	22%
	16	12%	10%	20%
	17 to 20	12%	7%	20%

b. Attitudes

Using the questions that allow comparability (considering the phrasing adjustment), we see that in Table 3.8 the general belief in the equal ability of men and women in technology is remarkably high in all segments, although it is observed that participants from schools show a lower initial level of this belief in 2023 (it is worth to point out the significant increase in schools who took part of the program that year, so we are talking about a more heterogeneous population and respondents).

Table 3.8 What Respondents Believe about STEM Abilities of Men and Women

Segment	Men and women can be equally good at developing digital technology projects (initial)	
	Measurement Year	
	2021	2022	2023
School Female	98%	95%	87%
School Male	98%	91%	82%
School Non-binary* Other	100%	93%	85%
Interschool Program	100%	97%	97%

The % reflects values 4 and 5 (the highest) on the scale of "agreement" with the proposed sentence.

However, when referring to their own capabilities in relation to technology (Table 3.9), we observe that favorable attitudes are not so high, and there is a significant gender gap at schools, with women having between 19% and 11% less favorable attitude/ belief on their skills.

It is worth noting that between 2022 and 2023, there was a significant change in phrasing, but both refer to belief in one's own technology-related capabilities. This change in phrasing also suggests that - as the question refers to a more concrete aspect of the skill (in this case, "digital technology project" vs "technology") - there is less of a sense of "statement of intent" that respondents can understand in the initial measurement, and more of a sense of self-assessment of a specific capability, which would be reflected in the gap of school responses being smaller relative to interschool program responses[22].

Table 3.9 Self-perception of Technology-Related Skills

Segment	*I consider that I have technology skills (initial)*		*In general, I understand well what it means to do a digital technology project (initial)*
	Measurement Year		
	2021	2022	2023
School Female	33%	46%	30%
School Male	52%	57%	42%
School Non-binary* Other	57%	36%	21%
Interschool Program	67%	60%	48%

The % reflects values 4 and 5 (the highest) on the scale of "agreement" with the proposed sentence

[22] In this sense, a survey on attitudes at the beginning of a course or workshop can be understood as an evaluation antecedent, or it can be due to exaggerated initial expectations. These survey effects would be particularly present in adolescents. See "The performativity of surveys: Teenagers' meaning-making of the 'Health Behavior in School-aged Children Survey' in Sweden;" Anette Wickström, Kristin Zeiler; Children & Society. 2021; 35: 428-444.

When asked about the impact of technology on the job to be performed (Table 3.10), we can observe the "questionnaire effect" (i.e., the impact of the question's phrasing) both in the general level of response and in the emergence of a gender gap: as long as we do not specify the impact of technology in a specific area of work, all segments show a very high degree of agreement, and women at schools show more favorable indicators than their male counterparts. However, when we look at the specific occupational area -that participants previously mentioned in the questionnaire-, the belief on this impact drops substantially at all levels (even among those in the interschool program where the belief still remains significantly higher compared to the rest), and the gender gap appears at the school program.

Table 3.10 Impact of technology on job performance

	Knowing about technology is important for any area of work I develop myself in (initial)		*As for area of interest mentioned previously, how much of it will be impacted by digital technology? (initial)*	
Segment	**Measurement Year**			
	2021	**2022**	**2023**	
School Female	98%	95%	87%	
School Male	98%	91%	82%	
School Non-binary* Other	100%	93%	85%	
Interschool Program	100%	97%	97%	

The % reflects values 4 and 5 (the highest) on the axis "agree" or "strongly" with the proposed sentence.

c. Variables related to participation in the survey

The recording of variables from the initial survey allows us to explore the profiles associated with the higher or lower participation rate in the closing measurement / survey in greater depth, thus identifying possible biases in the analysis of the results of the respondents who participated in both measurements (compared to those who participated only in the first measurement).

We conducted an analysis of the variables related to participation in the closing survey for 2022 and 2023, given that in these years there were more variables in the sample of participants (a more complete database).

As can be seen in Table 3.11, this data analysis shows that there was a significant difference in participation based on (in order of importance):

- The previous year's grade point average (note that in Chile, grades go from 1 to 7, being grades lower than 4 a failing grade, grades between 4 and 4.9 are "barely passable", grades between 5 and 5.9 are "good", and grades above 6 are "very good").
- Performance conceptual understanding, as the average percentage of questions answered correctly.
- Performance in systems thinking, as the average percentage of questions answered correctly

For both years, there was a very similar correlation between the closing measurement participation rate and the average grades of the previous year, in which grades lower than 5 had a 40% participation rate and grades higher than 6 had a 58% participation rate in the closing survey. In other words, there was a consistent profile of students who were discouraged from continuing to participate in the measurements.

However, the fact that the level of technological thinking (both in conceptual understanding and systems thinking dimensions) is related to participation may imply that the impacts detected (an increase between initial and closing values) in these variables are being underestimated, since those who respond both times have less cases with greater potential for improvement and, on the other hand, increases the average of these variables in the initial measurement.

Table 3.11 Factors associated with closing participation rate[23]

Variables		Participation Closing	
		2022	2023
Average grades previous year	Less than 5	40%	41%
	5 to 5,9	50%	48%
	6 or more	58%	59%
Level of conceptual understanding (initial)	Low (less than 34% correct)	47%	48%
	Medium (between 34% and 66% correct)	54%	53%
	High (67% to 100% correct)	54%	58%
Systems Thinking Level (initial)	Low (less than 34% correct)	50%	50%
	Medium (between 34% and 66% correct)	52%	55%
	High (67% to 100% correct)	57%	57%

[23] The closing participation rate considers the number of respondents in the closure measurement divided by the number of respondents in the initial measurement. In 2022, this rate was 53%, and in 2023, it was 51%.

4. Impact of the Program

The following is the evolution of the 3 key variables (conceptual understanding, systems thinking and choice of STEM occupations) in the initial and closing measurements for 2021, 2022 and 2023. Only the "technological thinking" questions that remained unchanged in the 3 measurements are considered.

For an adequate comparison of the evolution of the indicators[24] only the educational institutions that participated in all years were considered in this comparison. Thus, we have two comparison series:

- The 6 institutions that participated in 2021, 2022 and 2023 (in addition to the semester-long interschool program).
- The 12 schools that participated in 2022 and 2023 (in addition to the semester-long interschool program).

[24] It should be noted that for visual purposes, given the few recorded cases of gender nonconformity, they are not included in the graphs in this section. Data tables including all variables will be available in the digital annexes of this report.

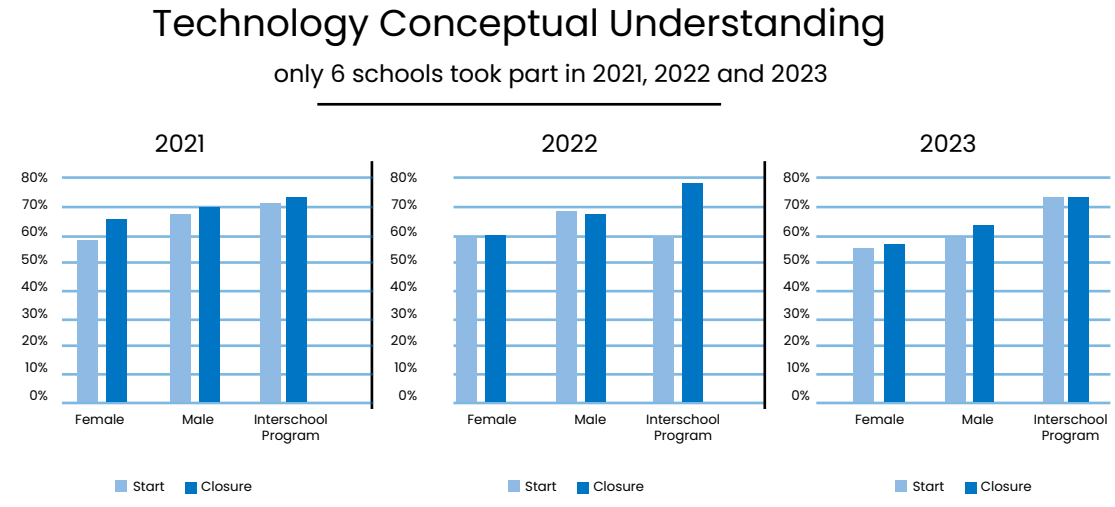
a. 2021 – 2023 Evolution

These graphs include only 6 institutions that historically participated in all measurements in 2021, 2022, and 2023. We also included interschool program comparisons in those years.

Graph 4.a.1 shows the evolution of conceptual understanding values:

- In general, this parameter was initially at less than 60%; in the closure measurement there was a significant increase: 7% for females in 2021, 4% for males in 2023, 18% for non-binary in 2022 and 20% for the interschool program in 2022.
- In 2021, there was a decrease in the gap between males and females at educational institutions by 5%, while in 2023 (in line with what happened with that year's Education Quality Measurement System-SIMCE) there was an increase in the gap by 3%.
- As has been consistently observed, the initial levels of the interschool program were substantially higher than other segments (in particular, in the closure measurement), so it was more challenging to obtain significant increases in the closure measurement (except when the initial measurement was exceptionally low for the interschool program).

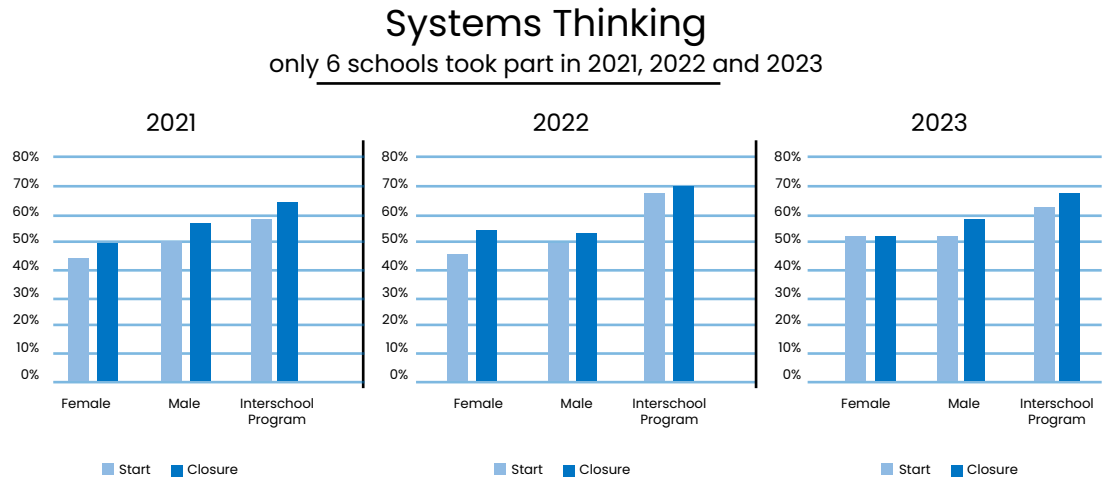
Graph 4.a.1: Comparison of Conceptual Understanding Indicator, 2021-2023



As for the evolution of systems thinking (graph 4.a.2), we can observe that there were consistent advances in the 3 most numerous segments, in general for all measurements, with increases hovering around 5%.

- In 2021, an increase of 6% was observed in the 3 main segments.
- In 2022, this parameter showed a closing of the gap between the female and male segments at educational institutions: females showed an improvement by 8% (from 43% to 51%) while males showed an improvement by 3% (from 47% to 50%).
- In this case, the interschool program consistently started at higher levels and reflected similar levels of progress between the initial and closing measurements.

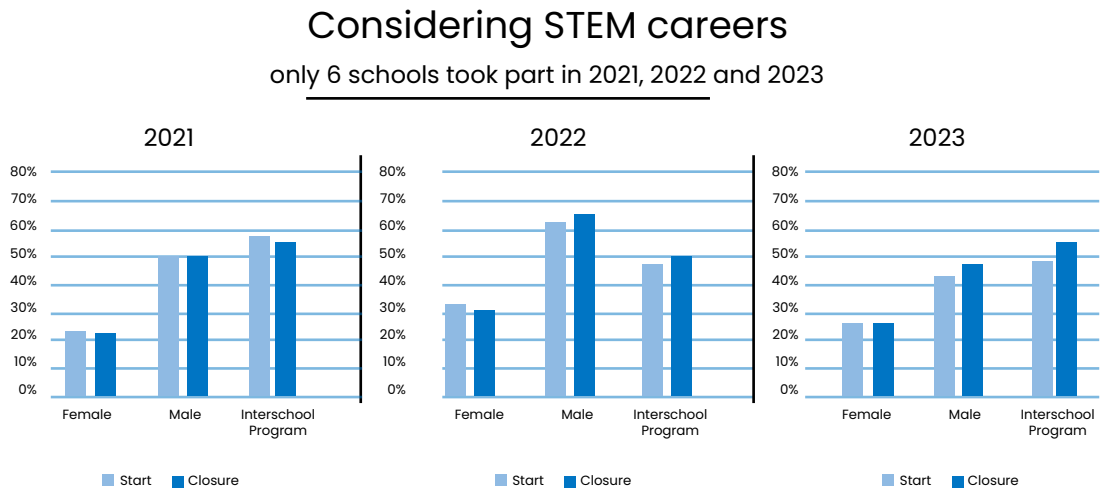
Graph 4.a.1: Comparison of Conceptual Understanding Indicator, 2021-2023



Regarding the option for careers related to STEM areas (graph 4.a.3), we observed the following:

- There was a significant gender gap in schools in all years, which was not closed.
- The interschool program was the segment that consistently registered the most progress (3% in 2022, 7% in 2023).
- There was one striking phenomenon related to high levels of STEM interest registered in 2022 for the male segment (even surpassing the interschool program on this single occasion).

Graph 4.a.3: Comparison of STEM Occupation Interest Indicator 2021 -2023



b.- 2022 – 2023 Evolution

To compare these two periods, we focused on 12 schools that participated in both the 2022 and 2023 measurements, along with the interschool programs from those years. We found no substantive differences, on average, between these institutions and those that participated only in 2022 or only in 2023.

Additionally, an imputation process was conducted for the parameters of conceptual understanding and systems thinking for students who only responded to the initial survey. It's important to note that these two variables were linked to the closing participation rate, meaning those who did not participate in the second measurement generally had lower scores in these variables, thus having more potential for improvement in the closing measurement.

This imputation process was implemented by assigning the respective average to each subgroup identified through a decision tree analysis. This approach sought to identify associations in the closure measurement of conceptual understanding and systems thinking parameters based on data from the initial measurement.

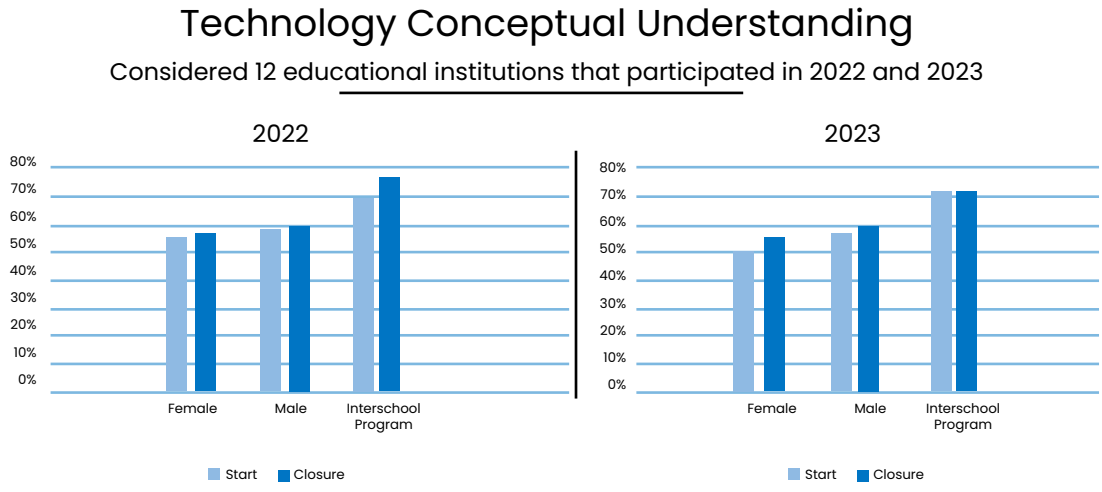
In graph 4.b.1, we see evolution in the initial and closing measurements of conceptual understanding from 2022 to 2023:

- In general, the average of the initial measurement was lower (with respect to the non-imputed statistics), which implies that it was more likely to record progress in the closure measurement.

- Graph 4.a.1 (which does not have imputed data) shows a significant jump by 20% in 2022, while in this graph (with imputed data) we see that the interschool program had a 6% increase (which was still relevant, although of a smaller magnitude).

- In 2023, the gender gap was reduced by 3% (it was initially 6% for that year).

Graph 4.b.1: Comparison of Conceptual Understanding Indicator, 2022-2023



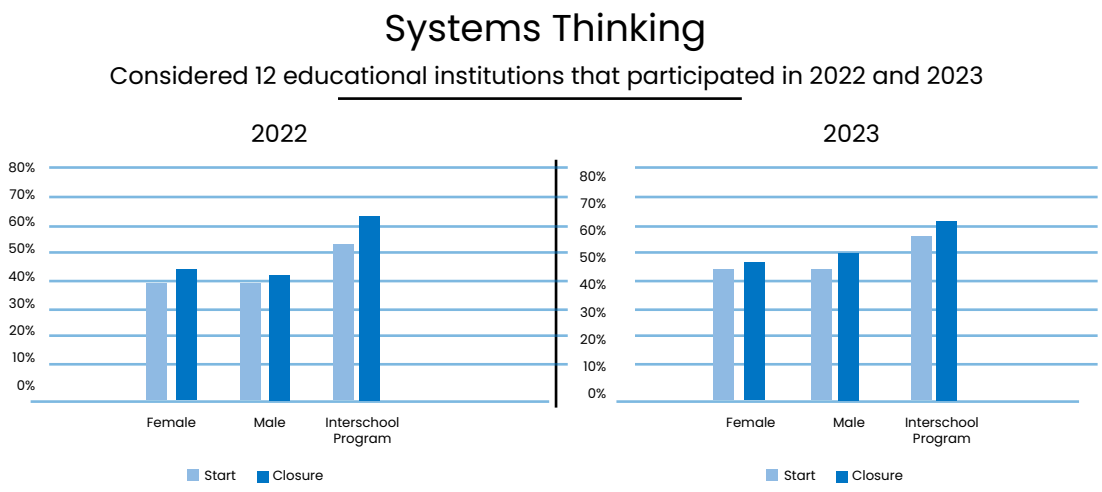
In the systems thinking parameter (graphs 4.b.2), we can observe the following:

- In the 2022 measurement there was a relevant progress in the 3 main segments, and there was an increase by 7% in the female segment (compared to 4% in the male segment) while the interschool program improved by 10% in this measurement by the end of the year.

- The 2023 measurement showed a homogeneous improvement in all segments by around 5%.

- It is confirmed that in this parameter the interschool program started at the highest levels and at the same time showed the most relevant increases.

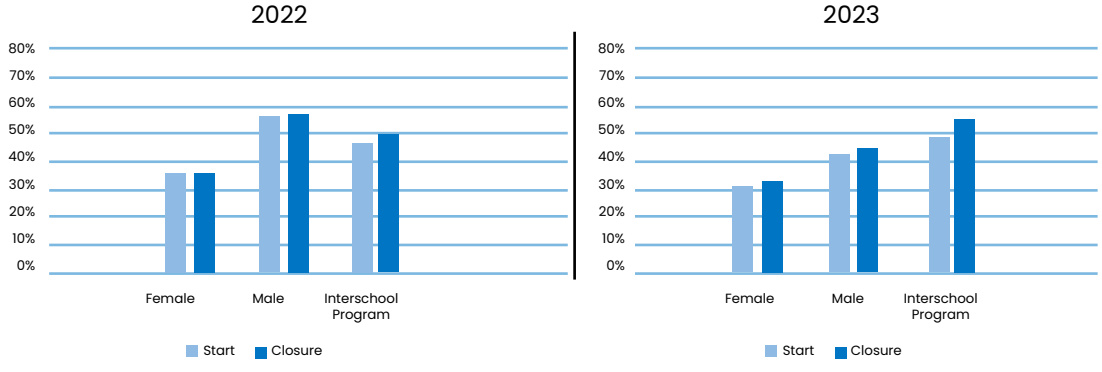
Graph 4.b.2: Comparison of Systems Thinking Indicator, 2022-2023



As for STEM occupation (Graph 4.b.3), we saw that no imputations were made since it was not possible to identify participation biases associated with this parameter. What we observed was the following:

- There were persistent gender gaps (20% in 2022 and 11% in 2023), but they were not as pronounced as those identified in the 2021-2023 comparison (of up to 30%).
- The same pattern of a very high level of STEM occupations was observed in the male segment in 2022, so it can be assumed that there was a cross-cutting impact that occurred that year for this group.
- For the male and female segments, almost no increases were detected in the closure measurement of both years, while in the interschool program, consistent and relevant increases were identified (especially in 2023) in the closure measurement.

Graph 4.b.3: Comparison of STEM Occupation Interest Indicator, 2022 -2023



5. Analysis of variables correlated with the impact indicators.

We conducted an exploratory analysis from the 2023 data that allowed us to make some hypotheses on how to achieve greater impact on the variables of interest. The exploration sought to identify:

- The variables most correlated with the indicators of interest (particularly in the initial measurements).
- The variables most correlated with the variation of these indicators between the initial and closure measurements.

Two variables were not explored because some of their categories had few cases:

- The variable “region” was not shown, given the uneven distribution of the program at the national level, taking into account that in some regions there was only one place where the program was carried out, which contrasts with other regions with a large number of schools and interschool programs.
- The exploration of correlations by the school’s type of administration (dependency- ownership, ration and funding) was not included in all crosstab analysis since, analogously to what happens with regions, some categories (such as municipal departments of education or municipal corporations) contain one or two schools, so the correlations could refer more to the behavior of a particular school than to the relevance of the variable itself.

a. Variables correlated with occupational preferences in the STEM area.

To review this phenomenon, we analyzed both program formats separately since - as we have shown - they presented different dynamics due to their composition, the implementation process, and the initial levels of motivation and technological thinking (conceptual understanding and systems thinking).

School Program

Whe should keep in mind that gender was a main factor correlated with a career choice in the STEM area, but beyond this variable, Table 5.1 shows other significant correlations.

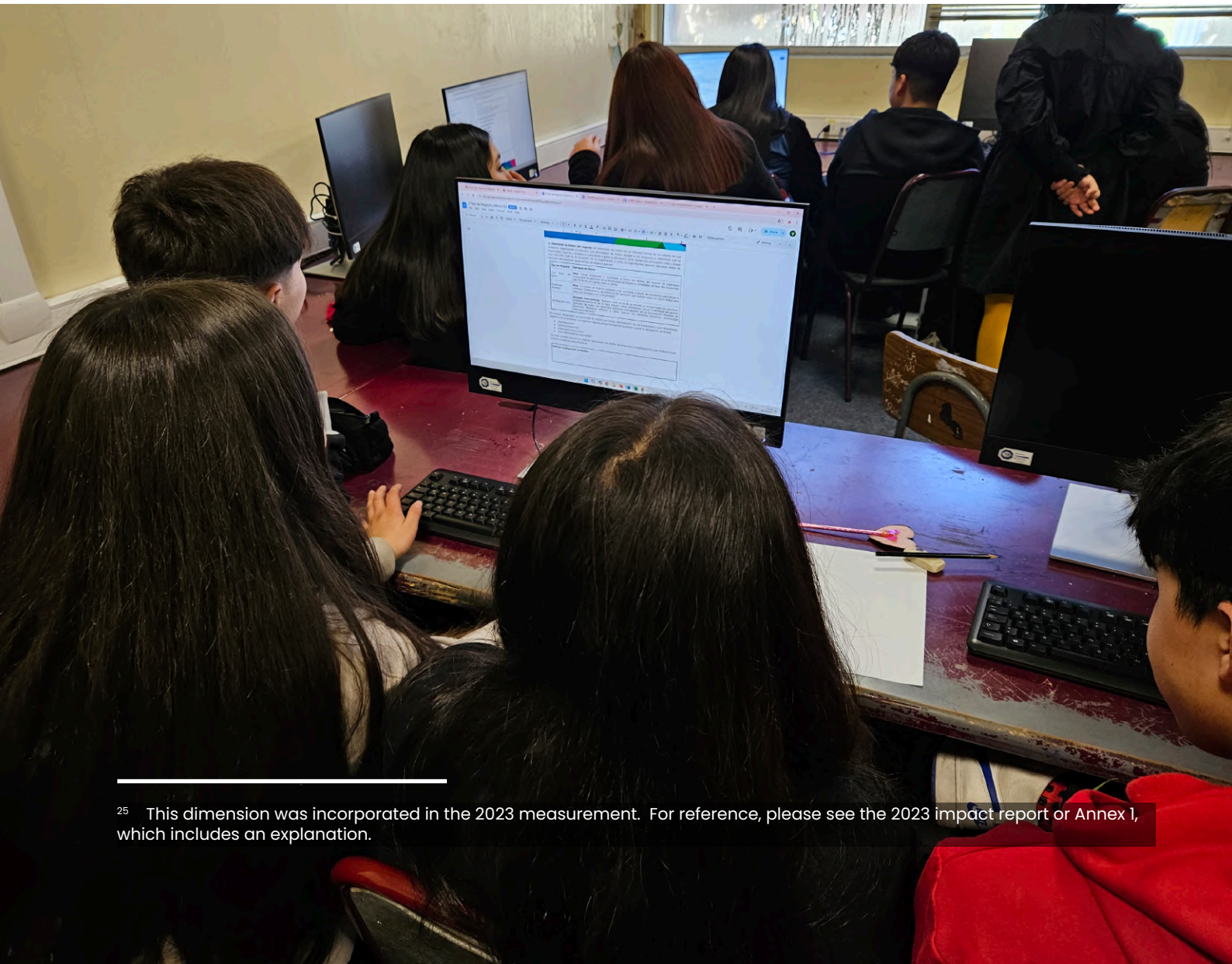
- The correlation observed in 2022 between the previous year's grade point average and the preference for STEM areas (a higher grade would imply a greater disposition towards that area) was ratified; however, while in 2022, people with lower averages lost motivation for the STEM area, their number increased slightly in the closure measurement in 2023.

- The type of administration also had an impact on the initial level of motivation, highlighting delegated administration institutions, which showed the lowest preference for the STEM area (31%) and at the same time represented 50% of the respondents of this segment (14 educational institutions), being mostly technical / vocational schools. It is worth contrasting this with private charter schools, since the latter category includes 9 schools (3 of which have a technical/ professional orientation) and represent 26% of the respondents, with a 39% preference for STEM careers. The other categories that showed higher percentages in this parameter included only 1 or 2 schools for each category, so the contrast might have corresponded more to the particularities of these schools than to some common structural factors.

- Disposition towards problem-solving[25] (or "to solve problem) is one of the variables that is most correlated with initial inclination toward STEM (13% difference in STEM orientation between low and high disposition) and at the same time is associated with increased preferences in the closure measurement.

- The level of conceptual understanding had a significant impact on the initial disposition to the STEM area (12% difference), but did not seem to have much impact on the evolution of this item.

- The level of systems thinking also affects the initial disposition towards STEM areas (6% difference between the low and high level), and the high level of systems thinking also was associated with an increase in this preference (by 4% in the closure measurement).



[25] This dimension was incorporated in the 2023 measurement. For reference, please see the 2023 impact report or Annex 1, which includes an explanation.

Table 5.1 Variables correlated with STEM preferences in School Program

Variables	Values	STEM initial	STEM Closure
Type of Administration	Municipal Corporation (1)	49%	49%
	Local Educational Service (2)	43%	43%
	Municipal Department of Education (1)	40%	36%
	Charter Schools (9)	39%	41%
	Delegated Administration (C. P. 3166) (14)	31%	32%
Average grades previous year	4,9 or less	30%	31%
	5 to 5,9	32%	33%
	6 or more	39%	40%
Ed. Level	9th grade	35%	35%
	10th grade	38%	40%
Conceptual Understanding Level	Low	29%	33%
	Average	35%	37%
	High	41%	40%
Systems Thinking Level	Low	33%	33%
	Average	36%	36%
	High	39%	43%
Disp. to problem-solving	Low	32%	31%
	Average	35%	38%
	High	45%	49%

Interschool Program

In the interschool program, which overall had a 7% increase in inclination toward STEM areas with respect to schools, we can observe the following patterns in Table 5.2:

- The variable with the strongest association with preference for STEM careers was the disposition to solve problems, with a 31% difference between those with low and high disposition. However, this variable did not make much difference in the evolution with the closure measurement (all levels of disposition increased similarly by between 6% and 8%).

- The variable "average grade from the previous year", on the other hand, had a 26% difference in preferences for STEM occupations between those who had averages below 5 and those who had an average of 6 or higher. At the same time, those with an average grade of 6 increased their preference for STEM from 51% to 60% in the closure measurement, while those with lower average grades did not increase (or even decreased) their preference for STEM in the closure measurement.

- The level of the interschool program (Junior or Senior) also showed an initial difference in this dimension, with seniors having 15% more inclination towards STEM areas. However, junior participants showed a more significant increase in the closure measurement (12%), closing the gap with the senior level by 10 points.

- The table 5.2 also shows that those who had a lower level of technology conceptual understanding showed a greater initial tendency towards STEM areas, which is curious, since, in the case of the school program this correlation goes in the opposite direction (keep in mind that in that case a higher level of conceptual understanding is associated with a greater willingness to pursue a STEM occupation, as shown in Table 5.1).

- The correlation between the level of systems thinking and inclination towards STEM careers is linear, showing a 20% difference in this preference between those with low and high levels of this variable.

Table 5.2 Variables correlated with STEM preferences in Intreschool Program

Variables	Values	STEM Initial	STEM Closure
Average grades previous year	4,9 or less	25%	25%
	5 to 5,9	35%	31%
	6 or more	51%	60%
Ed. Level	Junior	40%	52%
	Senior	55%	57%
Conceptual Understanding Level	Low	58%	58%
	Average	50%	59%
	High	45%	51%
Systems Thinking Level	Low	32%	40%
	Average	50%	55%
	High	52%	61%
Disp. to problem-solving	Low	31%	39%
	Average	42%	48%
	High	61%	68%

b. Variables correlated with Conceptual Understanding

In an exploratory analysis, we identified the variables that correlated most strongly with the level of conceptual understanding in technology issues and their evolution, broken down by type of program.

School Program

In the program implemented at schools, we identified some variables related to the performance and evolution of conceptual understanding:

- The average grade from the previous year was associated with a 15% variation in the performance of conceptual understanding (47% for those with an average of less than 5 and 62% for those with an average of 6 or higher). This variable was also associated with a greater increase in this index, with those with lower averages improving more in the closure measurement (4%) than those with higher averages (1% increase), i.e., an initial gap based on previous academic performance was narrowed.

- Disposition to solve problems also experienced a 15% difference between those with a low disposition (53% in conceptual understanding score) and those with a high disposition (68% in conceptual understanding score).

- Conceptual understanding was also closely related to the other aspect of technological thinking, "systems thinking", i.e., they are aspects that complement each other, with a 13% difference between those who had a low level of systems thinking (51% in conceptual understanding score) and a high level (64%).

- Finally, it can be observed that one of the emotions (sadness) had a negative correlation with conceptual understanding, varying by 8% between those who reported a feeling of sadness (51%) and those who did not have this emotion (59%) in the initial measurement. This gap continued to exist in the closure measurement. In another section, we will check whether any other emotion had a significant impact on any of the key indicators.

Table 5.3 Variables correlated with Conceptual Understanding Score-School Program

Variables	Values	Conceptual Initial	Conceptual Closure
Systems Thinking Level. (initial)	Low	51%	54%
	Average	58%	59%
	High	64%	68%
Average grades previous year	4,9 or less	47%	51%
	5 to 5,9	53%	56%
	6 or more	62%	63%
Disp. to problem-solving (initial)	Low	53%	55%
	Average	58%	60%
	High	68%	68%
Emotion: sadness (initial)	No	59%	61%
	Yes	51%	54%

Interschool Programs

The same variables identified in the program of educational institutions also had a significant degree of correlation with the understanding of technology concepts in the interschool program. However, we cannot lose sight of the fact that in this format there was no relevant increase in the closure measurement in 2023, taking into account that in the initial measurement the level of conceptual understanding was already significantly high (73%), so there was not so much room for improvement and a risk of worsening over time. It is for this reason that the analysis of the evolution of parameters is focused on factors associated with "performance decline."

- The variable most related to the conceptual understanding was the average grade from the previous year, with a 10% variation between those with an average grade below 5 (63%) and those with an average grade above 6 (73%). Likewise, those with a lower average grade had a worse performance in this variable in the closure measurement, dropping 13% in that measurement, while those with an average of 5 to 5.9 decreased by 5% in this parameter. In other words, those with lower academic performance would not have as consolidated "systems thinking," which implies that their performance would be less consistent.

- Systems thinking also had a relevant relationship with conceptual understanding, with a variation of 9% between those with a low level (68% of conceptual understanding score) and a high level (77%). Those with a low level showed a 4% drop in the closure measurement.

- The disposition to solve problems in the initial measurement showed an unexpected correlation: those with low disposition had 5% more in conceptual understanding score (78%) than those with high disposition (73%). However, the most important difference occurred in the evolution since the number of those with low disposition decreased by 14% in the conceptual understanding, while the number of those with high disposition increased by 2%.

- Finally, the correlation of the emotion "sadness" was reiterated: those who did not have it showed a 9% better understanding of concepts than those who had it (in the initial measurement).

Table 5.4 Variables correlated with conceptual understanding-Interschool Program

Variables	Values	Conceptual Initial	Conceptual Closure
Systems Thinking Level. (initial)	Low	68%	64%
	Average	71%	73%
	High	77%	77%
Average grades previous year	4,9 or less	63%	50%
	5 to 5,9	76%	71%
	6 or more	73%	74%
Disp. to problem-solving (initial)	Low	78%	64%
	Average	71%	75%
	High	73%	75%
Emotion: sadness (initial)	No	74%	73%
	Yes	65%	65%

c. Variables correlated with Systems Thinking

Unlike the exploratory analysis carried out on factors associated with STEM career preferences and level of conceptual understanding, both program modalities (educational institutions and interschool programs) shared several correlation factors. However, in this case, we observed that the variables associated with the greatest differences were distinct.

School Program

- The variable that correlated the most with the level of systems thinking was the level of concepts, showing a 12% variation between low and high level of conceptual understanding.
- Disposition to solve problems is also relevant, with a 10% difference between those with low disposition and those with high disposition.
- Academic performance was associated with an 8% variance in the average number of correct systems thinking responses.
- The presence of optimism (in the initial measurement) was also associated with an 8% average higher performance

Table 5.5 Variables correlated with systems thinking - School Program

Variables	Values	Systems Thinking Initial	Systems Thinking Closure
Disp. to problem-solving (initial)	Low	48%	52%
	Average	49%	53%
	High	57%	58%
Emotion: optimism (initial)	No	49%	53%
	Yes	57%	59%
Average grades previous year	4,9 or less	44%	48%
	5 to 5,9	47%	50%
	6 or more	52%	56%
Conceptual understanding Level (initial)	Low	42%	46%
	Average	50%	53%
	High	54%	58%

Interschool Programs

- In the interschool program, the variable most associated with systems thinking performance was the level of conceptual understanding, with a difference of 11% between those with low and high level of conceptual understanding.

- Preference for STEM careers was also associated with a higher level of systems thinking, with an average of 64% of correct responses from those who considered STEM careers, in contrast to 56% of those who did not. On the other hand, the number of those who did not consider a STEM career increased their performance in the closure measurement by 7% (in contrast to those who did choose a STEM career and who increased their performance in the closure measurement).

- The previous year's average grade was associated with only a 5% difference between the lowest and highest averages. However, it was one of the variables most associated with the increase in systems thinking performance, observing that those with an average of 6 or higher increased by an average of 6%, while those with an average below 5 did not improve in the closure measurement.

- Finally, there were almost no differences in the level of systems thinking according to the level of the interschool workshop (Junior or Senior), but it was observed that junior participants improved by 7% in the closure measurement in contrast to the senior participant's improvement, which increased by 4%.

Table 5.6 Variables correlated with systems thinking - Interschool Program

Variables	Values	Systems Thinking Initial	Systems Thinking Closure
Workshop Level	Junior	61%	68%
	Senior	59%	63%
Average grades previous year	4,9 or less	56%	56%
	5 to 5,9	54%	56%
	6 or more	61%	67%
Considering STEM career (initial)	No	56%	63%
	Yes	64%	68%
Conceptual understanding level (initial)	Low	52%	58%
	Average	57%	64%
	High	63%	67%

6. Conclusions

The following are the main conclusions on impacts and factors associated with them:

- In terms of the gender gap, considering the evolution in schools (of the School Program), there is evidence that the technological thinking gap is narrowing, with greater consistency in systems thinking. In terms of the gap in STEM occupation, a more modest progress is achieved.

- Also, each program showed different emphasis of the impact indicators:

  - The interschool program in general registered higher initial levels of performance in the technological thinking dimensions as well as greater motivation towards STEM careers (in addition to a significant advance in this aspect towards the closure measurement, with 7%).

  - Regarding the disposition towards future STEM careers in the School Program, we see that female and male segments of schools registered an average of 1% increase in 2022 and 2023, maintaining a gender gap of 20% in 2022 and 10% in 2023. Also we identified that 2022 witnessed especially high initial levels in this dimension for the male segment.

  - The conceptual understanding level reached in the interschool program (72% in 2023) makes it difficult to observe improvements in the closure measurement. On the other hand, the schools showed progress, with greater progress being observed in 2023 in the female segment (narrowing the initial gender gap in this aspect).

- In systems thinking, significant progress was observed in both programs. The gender gap in the closing measurement of this parameter was only 2%.

- It is also noteworthy that some values of the "emotional state" of the initial measurement (in particular, optimism and sadness) would be associated with the level and evolution of systems thinking and conceptual understanding, respectively.

- Regarding technological thinking, the data indicated that there would be a complementarity between conceptual understanding and systems thinking since a good foundation in one dimension favored the performance and improvement of the other.

- The incorporation of the variable "disposition towards problem-solving" seems to be relevant, because it appeared as a relevant factor associated both with the initial difference of the indicators and in the more favorable evolution of the inclination towards STEM areas of conceptual understanding and systems thinking. Likewise, this indicator was also associated with the previous year's academic performance, which was also relevant when analyzing orientation to the STEM area and systems thinking.

- In this sense, this correlation makes us notice that motivating inclination towards STEM areas is a particular challenge, as it seeks to attract adolescents towards an activity that requires patience and a certain degree of frustration tolerance, since addressing motivation towards occupations in the STEM area does not seem to have an immediate solution, especially when it comes to such aspects as self-image, self-confidence, attitude toward risks, academic performance, stereotypes / social imaginary, feedback from teachers and family members shaped by cultural factors, etc. that have shaped preferences for years before starting the workshop.[26].

[26] "Early Influences and the choice of college major: Can policies reduce the gender gap in scientific curricula (STEM)?"; Granato, .S, Journal of Policy Modeling, Volume 45, Issue 3, May-June 2023, Pages 494-521.

Regarding the learning process, a keynote should be taken of what was revealed in the qualitative stage and the figures of this study on the importance of teamwork experience. There are quantitative indicators which show that this experience can have an impact on key dimensions such as the conceptual understanding or the disposition towards problem-solving (which, as we have already indicated, is relevant to explain several aspects of the difference in initial level and the evolution of key indicators).

As a complement to the analyses carried out and to illustrate this point, Table 6.1 shows an association between teamwork experience and the evolution of technology concepts, where a good experience is associated with more people increasing their performance in this parameter.

Table 6.1 Association between the experience of teamwork and the evolution of technological concepts

Evolution of Teamwork Experience	Change in indicator responses Technology concepts			Net change (increase– decrease)
	Decrease	Stay the same	Increase	
1 to 4	27,6%	45,8%	26,6%	-1,0%
5	25,9%	46,8%	27,4%	1,5%
6 to 7	21,8%	47,4%	30,7%	8,9%
Total	25,0%	46,7%	28,3%	3,3%

In the case of table 6.2, an association was observed between the teamwork experience and the evolution of the disposition to solve problems, which showed that a bad experience would be associated with a significant decrease in the score of this dimension (it would be a hygienic or "discouraging" factor of these attitudes). In this sense, this correlation should be explored since the management of a better teamwork experience (of which some interviews provide guidance) can favor the achievement of impacts, both in STEM and in technological thinking.

Table 6.2 Association between teamwork experience and the evolution of problem-solving readiness

Evolution of Teamwork Experience	Change in indicator responses Technology concepts			Net change (increase– decrease)
	Decrease	Stay the same	Increase	
1 to 4	43,6%	28,7%	27,6%	-16,0%
5	39,2%	25,5%	35,3%	-4,0%
6 to 7	34,8%	27,0%	38,2%	3,3%
Total	39,2%	27,2%	33,6%	-5,7%

- To schematize the observations about the pathway to move program participants toward STEM areas, the data seems to indicate that:
  - Obtaining technological thinking tools - in both dimensions - would make the inclination toward STEM areas more likely. In that sense, there are indications that these aspects can be to some extent "leveled" by the program if it starts below a certain threshold. This is in line with studies on motivations to study STEM specializations[27], in which performance in the associated fields is one of the determinants of the choice to pursue a career or major in STEM.
  - Motivation towards STEM areas - at the time workshops are implemented- already carries a backpack of previous factors, among which is the decision the type of school where the students are enrolled - which has implications on a future occupational orientation - and previous academic performance, which is associated with possibilities of academic and occupational orientations as well as a certain level of confidence in one's own abilities.
  - The teamwork experience is a relevant factor to consider at the planning stage, since aspects of coexistence, emotional management and perceptions about

[27] Wang, X, "Why Students Choose STEM Majors: Motivation, High School Learning, and Postsecondary Context of Support, American Educational Research Journal,Volume 50, Issue 5 (2013).

the distribution of workloads often affect motivation in relevant points such as disposition to solve problems. In contrast to what is usually the experience of group work in schools, whereby several specific projects are delivered with different groups during the year, the Digital Skills and Technovation Program considers the development of the same project with the same team throughout the year. The qualitative survey provides some clues in this regard: that the establishment of teams is voluntary but guided, that the evaluation (at educational institutions where a grade is given to the course) incorporates a group grade and a personal grade (based on whether a participant can respond to own and teammates' components), the generation of instances and tools for the resolution of conflicts or disagreements.

- Although the correlations are not entirely consistent in this aspect, it is worth noting the emotional aspects that may be involved in the development of the program, particularly at the stage in which the workshop takes place (in adolescence, self-image aspects undergo a period of intense redefinition and the so-called "math anxiety"). These emotions can favor[28] or hinder the performance or acquisition of these skills[29].

- From a program perspective, an implementation design that successively delivers skills (technological thinking) and tests them while providing teamwork experience that supports and fosters a willingness to face certain types of challenges (requiring patience, trying various paths) can lead participants to consider STEM career options.

[28] Usan, A. et al., "Self-Efficacy, Optimism, and Academic Performance as Psychoeducational Variables: Mediation Approach in Students", Children 9 (3)- 420, 2022 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8947550/

[29] Abí, A., et al. "Predicting Mathematics Achievement in Secondary Education: The Role of Cognitive, Motivational, and Emotional Variables," Frontiers in Psychology, VOL 11, 2020.

Anex 1: STEM Attitudes y Competencies

Some methodological challenges in 2023 were about identifying which attitudinal factors relate most strongly to competencies in STEM areas. This part addresses the rationale for the "Problem Solving" question section of the 2023 questionnaire and how it was implemented.

During the review of academic literature, it was identified that many of the skills necessary for good project planning and implementation (being it on technology or in other field) it is required the ability to "problem solving," and at schools the first approach to this type of challenge is the resolution of mathematical problems ("word problem"), which involves identification of elements, variables, substitution and combination of elements, etc.

Thus, in this area, there are several studies[30] that have established the importance of certain attitudes for the improvement in the performance of this competence.

[30] Zakaria et Al, "The Reliability and Construct Validity of Scores on the Attitudes Toward Problem Solving Scale", Journal of Science and Mathematics Education in S.E. Asia, vol27 No. 2, 2004; Mohd, et al, "The Effects of Attitude Towards Problem Solving in Mathematics Achievements", Australian Journal of Basic and Applied Sciences, 5(12), 2011; Brockhoff & Weber, "Towards Empirically Measuring Patience", Universal Journal of Management, 2015; Erdemir N, "Determining students' attitude towards physics through problem-solving strategy", Asia-Pacific Forum on Science Learning and Teaching, Volume 10, Issue 2, 2009; Demirel et al, "A study on the relationship between reflective thinking skills towards problem solving and attitudes towards mathematics",7 th World Conference on Educational Sciences, (WCES-2015), 05-07 February 2015.

For this questionnaire we adapted one of the best- known tools in the field, called the ATPSS, that stands for "Attitudes Towards Problem Solving Scale." For this case, 6 questions indicating levels of agreement and disagreement on "Problem Solving" (PS) were implemented, and 3 questions of attitudes were implemented both in positive phrases - in which greater agreement implies better attitude - and 3 questions of "negative phrases" (in which greater disagreement implies better attitude), on a 5-value Likert scale (disagree / agree axis).

a) I don't like to do exercises or problems that are difficult to understand (np- negative phrasing).

b) I can spend a lot of time exercising/solving a problem.

c) My ideas of how to solve a problem/exercise are not as good as those of other students' (np)

d) I write down any answer in order to finish an exercise/problem soon (np).

e) I like to try to solve a difficult problem/exercise.

f) I am confident that I can solve most of the exercises/problems.

The variables of the scale are grouped as follows:

- Taste for challenges, questions a) and e)
- Patience / dedication, questions b) and d)
- Trust, questions c) and f)

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