
# Lessons and challenges teaching Computer Science in schools

## The Argentinian Program.AR Initiative

CAF DEVELOPMENT BANK OF LATIN AMERICA AND THE CARIBBEAN
Fundación Sadosky
<Program.AR/> DIEZ AÑOS
Ministerio de Ciencia, Tecnología e Innovación Argentina

**Title**

Lessons and challenges teaching Computer Science in schools. The Argentinian Program.AR Initiative

**Legal deposit:** DC2023000316

**ISBN:** 978-980-422-300-6

**Editors:** Development Bank of Latin America and the Caribbean (CAF, publicaciones@caf.com) and Sadosky Foundation (info@fundacionsadosky.org.ar)

**Coordination:** Cecilia Llambí (CAF), Mara Borchardt and Vanina Klinkovich (Sadosky Foundation)

**Authors:**

Chapters 1, 2, 3 and Appendix: Borchardt, Mara (Sadosky Foundation); Klinkovich, Vanina (Sadosky Foundation), and Iocca, Natalia (Sadosky Foundation). With the collaboration of Llambí, Cecilia (CAF); Martinez, Cecilia (Universidad Nacional de Córdoba), and Scasso, Martín (Quántitas Foundation)

Chapter 4: Llambí, Cecilia (CAF); Borchardt, Mara (Sadosky Foundation); Klinkovich, Vanina (Sadosky Foundation), and Iocca, Natalia (Sadosky Foundation)

**Correction and edition:** Natalia Florencia Acher Lanzillotta, and Alejandra Stafetta (Sadosky Foundation)

**Layout:** Fabio Viale (Sadosky Foundation).

**Pictures:** Facundo Manini (Sadosky Foundation).

**Graphic design:** Estudio Demaro-Buenos Aires, and Jaqueline Schaab (Sadosky Foundation).

# Foreword

## Sadosky Foundation

Program.AR is an initiative from the Sadosky Foundation, a public-private institution from Argentina[1]. Since 2013, Program.AR has encouraged Computer Science as mandatory content in Argentine schools. This objective has been sustained over time through plans to address two problems related to the absence of this knowledge in the classroom. Firstly, it hinders the vocation for computing-related careers. Secondly, the general public does not understand how digital and computational technology works and how it affects their individual and collective rights.

Since its beginning, the Initiative has identified different challenges to solve these problems. Some of these challenges are few professionals trained in Informatics, the lack of teachers trained in the field, the shortage of teaching resources in Spanish and adapted to the local context, and educational authorities and unions that do not understand how this knowledge impacts on citizen engagement and the country's technological development.

Program.AR actions were supported by the Development Bank of Latin America and the Caribbean (CAF), the Argentine Ministry of Science, Technology and Innovation, a network of public universities, teacher training institutes and the Ministries of the 24 Argentine provinces. We provide workshops in secondary schools to encourage Computer Science careers, and we offer teacher training in Computer Science Teaching. We also support curriculum updates for preschool, primary, secondary[2] and higher educational levels. Moreover, we distribute textbooks to teach Computer Science and develop platforms for assisted and autonomous programming learning. Finally, we disseminate information regarding computing-related careers across the country.

Thanks to the team's vision and technical capacity that has designed and led the actions, other countries ask the Sadosky Foundation to provide strategic advice to teach these contents in their countries (for example, Ceibal's Computational Thinking Program in Uruguay). Moreover, international organizations engaged in educational research (such as UNESCO) request Program.AR to develop studies on the progress of Computer Science programs in Latin America.

The first activities were aimed at raising awareness of the differences between the use of computer tools and Computer Science learning among the educational community. In the recent years, the advances led by computer technology and its increasing incorporation into contemporary life have generalized the concern about what the school teaches when we refer to technology or computing. The recent massive spread of artificial intelligence in teaching and learning makes us think how we can integrate technology in the teaching-learning process. Doubts about its use are still in the core. The most frequent question posed by teachers is: how can we propose the activity to ensure it will have human authorship? However, the emergence of this technology should lead to policies aimed at sharing knowledge for people to understand, create and transform. Something that was important ten years ago is now urgent.

The path ahead is still complex. Although every student in Argentine public schools has not had the opportunity to develop computational practices yet, at least a third of Argentine provinces have started the path to achieve such goal. Thus, we hope this will reduce the gap in computational knowledge.

[1] The Sadosky Foundation is dependent on the Argentine Ministry of Science, Technology and Innovation, and the Argentine Chambers of Software.

[2] Preschool is for children from 4 to 5 years-old, primary school refers to children from 7 to 12 years-old, and secondary school refers to students from 12/13 to 18 years-old.

We are proud of our achievement and we want to share them. Hopefully, our colleagues will use our experience as a guiding instrument. We have contextualized our work to the processes of the last twenty years and the history of Computer Science teaching in Argentine schools. We try to account for the most significant plans of action and their results. Finally, we share some lessons that may be valuable for potential readers.

I want to commend my colleagues in the Program.AR Initiative for their dedication.
I would like to highlight the outstanding work of those who are currently part of the Initiative and those who were once part of the team to achieve this essential goal. Finally, our task would have been impossible without the contribution of the other areas of the Sadosky Foundation.

I would like to especially thank Cecilia Llambí from CAF for her invitation to elaborate this material, Vanina Klinkovich for the idea and the development of content, Natalia Iocca for her research on additional technical information and her detailed reviews, Cecilia Martinez and Martin Scasso for their contributions in different Chapters. I also want to thank the communication team of the Sadosky Foundation for their attentive reading.

It would be unfair to finish my words without mentioning the following. Although this Initiative has been and will always be a collective effort of specialized professionals who are absolutely committed to public and free-of-charge education of quality, this project would have been impossible if Belén Bonello and Fernando Schapachnik were not staunch optimists, believing that something impossible only requires more ingenuity, patience, human quality and, perhaps a little money.

Mara Borchardt
Director of the Program.AR Initiative
Sadosky Foundation

## Development Bank of Latin America and the Caribbean

The need to include Computer Science in schools is relatively new for most Latin American and Caribbean countries. This inclusion that is so important to acquire the necessary skills to understand today's world. In fact, there is no consensus on what Computer Science includes and, thus, what and how it should be taught.

However, technology has changed the skills required to work and participate integrally in society. Now, everyone should learn about algorithms and programming, as well as understand how the Internet or computers work. And this should start from school.

Latin America and the Caribbean face this significant challenge. This publication is a contribution to learning from each other, learning about promising experiences and identifying key elements and challenges to move forward.

How can we introduce Computer Science into school curriculum? How can we address professional training to teach this discipline? How can we provide tools for this task? How can we address heterogeneous contexts and capabilities within each territory? How can we motivate teenagers and young people to choose ICT careers in a context with no vocation, but which faces expansion and accelerated changes? This publication addresses these and more questions, and describes the experience and lessons of the Program.AR Initiative regarding policy development in Argentina. Based on a comprehensive analysis of different plans of action, it is possible to identify key elements to inform and sensitize the educational community and society, implement a strategy for professional teacher development, develop tools and materials and create knowledge. This contributes to achieve progress in how education systems can address challenges and barriers to successfully teach Computer Science and ensure that every student has equal opportunities to acquire these crucial skills.

This publication is part of the actions promoted by CAF to contribute to its educational agenda pillars: to increase access and strengthen education at all levels so that students of all ages acquire the necessary skills to live and work in the 21$^{st}$ century.

We hope that this publication serves as a guide for policymakers, researchers, educators and those who work to achieve better educational opportunities for children, teenagers and young adults in the region. Although the analysis mainly focuses on the Argentine case, we also hope the lessons and critical factors to decisively move forward in teaching Computer Science in schools can be helpful for all countries in Latin America and the Caribbean.

Pablo Bartol
Social and Human Development Manager
CAF- Development Bank of Latin America and the Caribbean

# TABLE OF CONTENT

CHAPTER 1

# Computer Science in the classroom: a global perspective

In the last few years, two simultaneous processes have been taking place in modern societies. On the one hand, the emergence of computational technology in the organization of more aspects of everyday life. On the other hand, the appearance of words such as “artificial intelligence,” “algorithms,” “programming,” “robotics,” and “computational thinking” in education.

In this regard, this chapter addresses both processes. Teaching the necessary knowledge to understand computational technology and its impact on daily life is a debt of the mandatory curriculum of educational systems. And we are confident that that this knowledge is essential to exercise citizenship in the 21st century.

## Why is it relevant to understand Computer Science?

**Computer Science[1] is the leading technology of the 21st century** since its development deeply affects current societies in their social, political and economic spheres. The impact of the changes is such that some authors refer to a fourth industrial revolution, signaled by the convergence of computational technology: automation, robotics applied to cyber-physical systems or genetic engineering, etc. (Schwab, 2016). In addition, social ties have crucially changed human relationships, professional and emotional development, and entertainment since technology supports all these spheres.

**Computer Science** (CS) is the basis to develop and create most of technological products. Some examples include considerable advances in image diagnosis, microsurgery, genetic tests that analyze DNA to determine family relationships or predisposition to genetic disorders, satellite information systems to analyze environmental problems, or assistive devices for people with low vision or disability. One of the most relevant advances in education has possibly been the emergence of Informational and Communicational Technology.

These computational developments involve automation, programming, modeling, storage and processing of large volumes of data.

[1] In this document, computing, Computer Science, computational technology and digital technology will be used as synonyms.

**Even so, a considerable part of citizens does not know how these technological innovations are developed and operated, or what their purposes and implications are.** Democratizing access to computing devices[2] and the Internet has reduced the digital gaps of access and use without demanding thorough training. However, the ongoing inequality regarding how CS works continues to limit appropriation, modification, adaptation, intervention and development to address local problems from a sovereignty perspective.

As computers are generally considered a "black box," which is impossible to access, the selection and massive use of technological devices depend on recommendations from experts or simple guidance by the market. This is highly risky if we think that most people cannot distinguish an expert from someone who is not, especially in a matter that has significant consequences for exercising individual and collective rights.

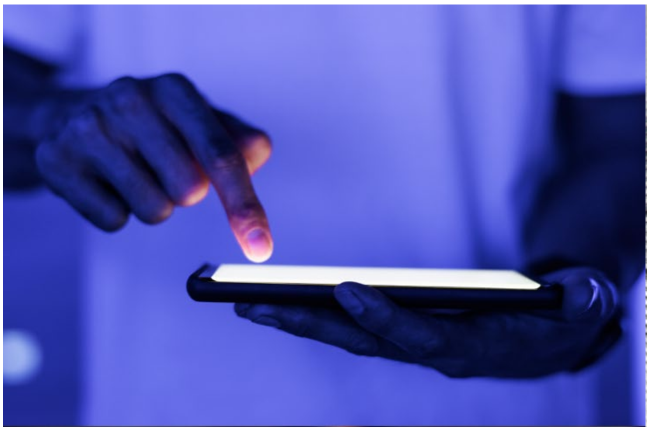
**What knowledge does Computer Science include?**
Firstly, we can link CS to concepts such as programming, algorithms, computer architecture, data science, the Internet and Artificial Intelligence. According to Bonello and Schapachnik (2020), *Computer Science* is a discipline comprising[3]:

1. **Algorithms** is the necessary knowledge to develop effective and systematic solutions for different types of problems. For example, if you think of a GPS, which route should it suggest the

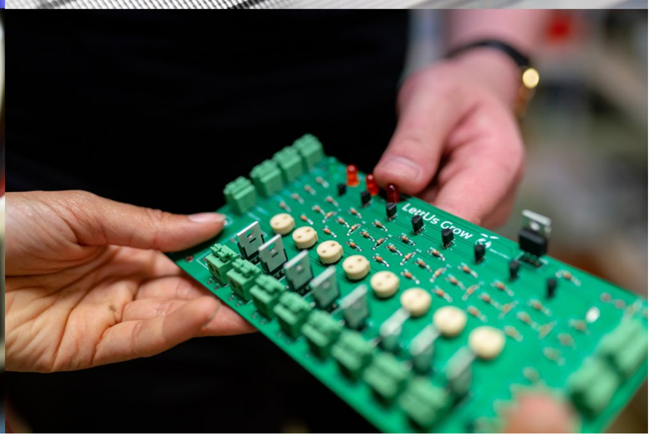
---

2 A *computing device* is a physical device used to perform the computation of diverse kinds (for example, computers, smartphones and smart TVs, tablets, video game consoles, control systems for cars, household appliances, industrial equipment, etc.). This is differentiated from computational devices to distinguish the logic construction—sometimes together with physical elements—used to solve computational problems (for instance, software and specific programs, robotics kits for educational purposes, communication protocols, methodologies and tools related to computational solutions, among others).

3 This list aims to include some of the main areas addressed by CS. Software engineering, formal methods, computer graphics can extend this list.







user among all the possible routes at a specific time and considering traffic conditions?

2. **Programming** is the necessary knowledge to apply algorithms to different languages used by computers. On many occasions, particularly when we talk about “bringing programming to school,” programming includes algorithms.

3. **Data structures and databases** are two areas involving the storage of information in such a way to recover it later and quickly find one data among thousands or millions of other data. One example is a search engine.

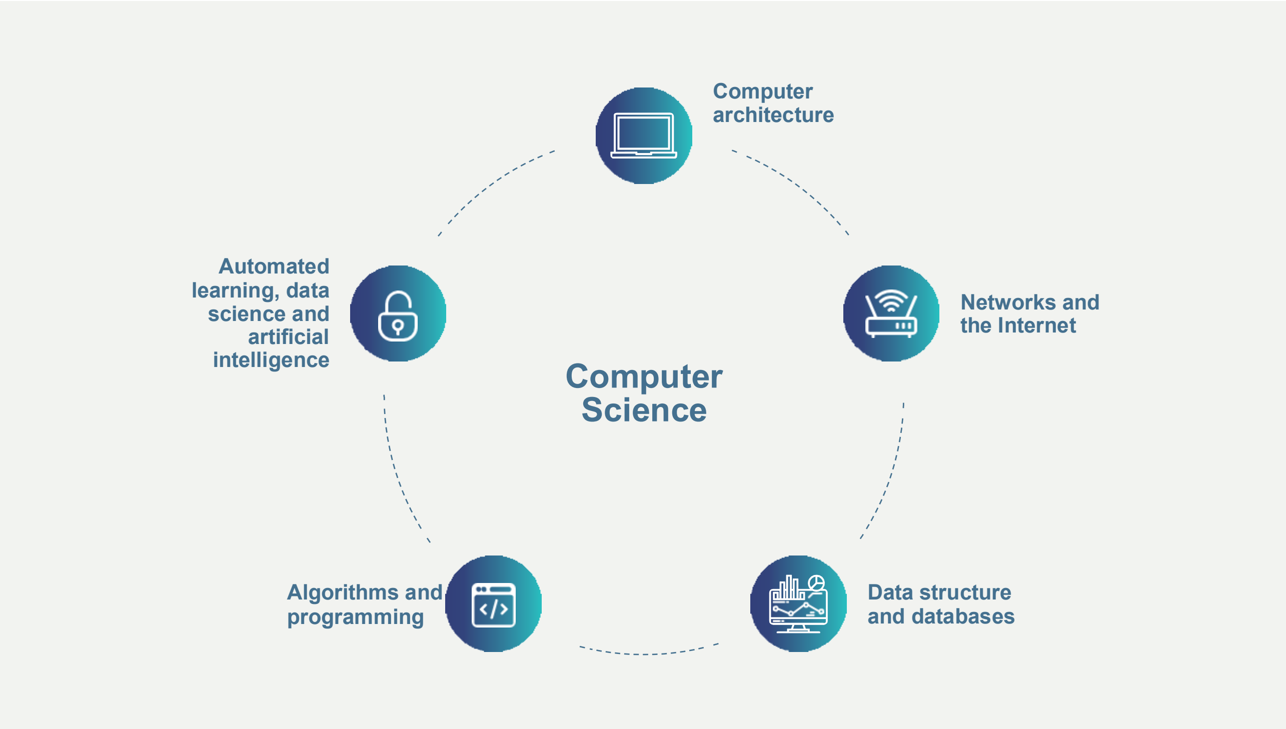
4. **Computer architecture** comprises the elements that define different types of computers and how these elements are developed, considering that their operation and interrelation depend on the combination of simple electric-voltage manipulation.

5. **Computer networks** are the way computers exchange information and run the Internet and applications such as the web, instant messaging, online games, video and audio streaming, etc.

6. **Theoretical foundations** signal differences among various languages, their possibilities and impossibilities, advantages and disadvantages, as well as more specific areas—such as discrete mathematics, and the complexity and computability theory—which study whether problems can be solved with a computer.

7. **Artificial intelligence** involves the combination of the several fields previously described to address complex problems through mechanisms related to human cognition. This includes automated learning, data analysis, information synthesis, voice and image recognition, among others.

Is it reasonable that people frequently use devices and computational tools for different activities without understanding how they work? Is it possible to affirm that the school prepares us for social life if it does not include the necessary knowledge to understand such an increasingly important phenomenon in today’s life? Who is responsible for democratizing access to this knowledge, which is currently essential for developing and exercising citizens’ rights?



# Why is it important to address CS at school?

Digital and computational technology[4] is crucial for our everyday life. Thus, rules governing society shall change to regulate new ways of communication, manufacturing, property, safety, law, etc. The advances in technology have also led to new crimes such as grooming, phishing, among others.

We can affirm that regulations follow changes. Although this is not exclusively caused by the lack of disciplinary information among society and leaders, it negatively affects the problem. This is caused by the temporal span between facts and when regulations become in force, as well as the adequate capacity to adopt rules and control their compliance. Education in computational technology should be thought as education for a civic, ethical, responsible and sovereign life.

[4] There is a difference between “computational” and “digital” since the first concept refers to processing information, and the second concept is one way of representing information.

**Society’s knowledge of CS goes beyond the skilled use of devices and computational tools.**

Understanding computational technology means that CS should be a hot topic for society to appropriate, value, understand and transform CS to solve problems and innovate. This requires more than mere dissemination: it involves relating CS to other knowledge and disciplines.

From the perspective of teaching for understanding purposes (Boix Mansilla and Gardner, 2005), addressing this discipline at schools means that students go beyond intuitive beliefs, build a rich and coherent conceptual network (content), understand the way to gain and validate knowledge (method), know the purposes and interests guiding the discipline (purpose) and know the system of symbols (means of communication).

**Currently, there is a disconnection between the centrality of digital technology—to transform manufacturing, health, business, citizen engagement, access to information and knowledge, and thus, access to rights—and the educational offer focused on training citizens in this subject matter..**

One way to measure this problem is by assessing students' competencies in understanding and using Informational and Communicational Technology (ICT) beyond its primary purposes. The International Computer and Information Literacy Study (ICILS) of the International Association for the Evaluation of Educational Achievement (IEA) assesses such competencies of students in grade 8 (average age of 13.5 years) from different countries, considering two areas: digital literacy and computational thinking[5].

**Digital literacy** refers to the use of computers to search, handle, produce (create) and exchange (communicate and share) information. In the framework of the assessment, **computational thinking** is defined as the ability to recognize problems or aspects of life that may be mitigated or solved with computational technology. Therefore, it comprises two elements: conceptualization of problems and operationalization of solutions (Fraillon *et al.*, 2020).

Computational thinking was optional for the countries participating in the ICILS 2018. The study also assessed the use of computers and digital tools for students' and teachers' learning, as well as their attitudes toward the use of ICT. The participants of the study were Germany, Korea, Denmark, Finland, France, Italy, Kazakhstan, Luxembourg, Portugal, the United States, and only two Latin American countries: Chile and Uruguay.

Regarding digital literacy, the findings revealed that most of the students had a functional working knowledge of computers as tools and could use them under direct instructions to make explicit information searches. However, only 21% of students showed that they had the capacity to work independently when using computers for information gathering and just 2% showed they had evaluative judgment when searching for information online and creating informative displays. Additionally, the findings revealed there were considerable differences in performance within each country. Even in countries with high levels of digital literacy, more than one-quarter of students only showed basic use abilities.

Eight countries participated in computational thinking: Korea, Denmark, the United States, Finland, France, Germany, Luxembourg and Portugal. In this regard, a considerable proportion of students (approximately one-third) could only complete the most basic tasks, revealing a high difference in results within the countries.

Overall, most students know how to handle ICT, but only a minority can identify computational problems and design programmable solutions, which is key to Computer Science (Denning *et al.,* 1989).

**In this context, the role of educational systems in socially sharing this knowledge is crucial. For most young individuals, the school is the only place where they can have access to this knowledge and practice.**

The inclusion of this knowledge in the country's mandatory curriculum responds to one of the following reasons:

a. the aim to democratize the access of citizens to computational knowledge;
b. the need to mitigate the gap in digital knowledge, contributing to the gender gap, and
c. the will to encourage choosing computer-related careers and the number of professionals trained in this area to strengthen technological sovereignty.

5 To know the stance of the initiative related to computational thinking, see "*Diez preguntas frecuentes (y urgentes) sobre Pensamiento Computacional*" [Ten Frequent (and Urgent) Questions on Computational Thinking], written by Fernando Schapachnik and María Belén Bonello through the following link: bit.ly/3nhEJ9c.

## Rights

In the last few years, governments have increasingly discussed the regulation of artificial intelligence, net neutrality, e-voting or the possibility to act against fake news. There were notorious cases of different companies using databases to manipulate social media and influence the results of elections (Clavero, 2018). Another example is the use of facial recognition systems to identify suspects aimed at recognizing and overseeing politicians, union leaders and journalists (CELS, 2022).

During the COVID-19 pandemic, the use of private data by the public sector was questioned (ANCCOM, 2020) in relation to platforms that traced, located, detected and early prevented cases (Harari, 2020). However, there were scarce questions surrounding how corporations use private data for commercial purposes.

According to several national reports, digital transactions have considerably increased during this period. Cybercrimes have soared by 300%, including fraud, phishing, identity theft, ransomware, harassment and unauthorized access to bank accounts and email addresses. A large percentage of these crimes affected the youth and involved bribery and sexual harassment (UFECI, 2021).

Without knowledge of CS, people are vulnerable and excluded from public discussions. Thus, people become an easy prey for cybercrime and opinions by experts and people who claim to be so. How is it possible to decode the interests at stake?

Technological sovereignty and development in democracy involve reaching social consensus based on the uses of technology, understanding its development, limits and risks, and the creation of a professional ecosystem that may critically assess its opportunities to **neutralize threats and fulfill its potential**. For all this, we need technologists, as well as lawyers, business managers, different professionals and citizens who understand CS without being experts. This is why teaching this at schools is incredibly important to democratize knowledge and practices.

## Gender

The Ministries of Education from different countries are concerned about this digital divide. This is even emphasized when gender in Computing comes into play.

According to a UNESCO report (2019a), **inequality in the access to equipment, Internet and knowledge** contributes to the digital divide. This inequality impacts the gender gap: since women and gender-diverse communities have fewer opportunities to frequently and systemically be in contact with this knowledge, they have fewer opportunities to have an interest in these topics, be professionally trained and work in this area. Thus, these groups are less involved in developing technology, knowledge and information, and accessing qualified and well-paid job positions offered in the sector.

As women and gender-diverse communities have less access to digital technology, their economic development, social engagement and leadership opportunities are negatively affected. In 2016, from the 38 countries of the Organisation for Economic Co-operation and Development (OECD), only 28% of Science, Technology, Engineering and Mathematics (STEM) students at college were women. In 2015, Argentina informed that only 25% of Engineering and Applied Sciences students were women. In addition, only 15% of women were considering pursuing a career in programming (Szenkman and Lotito, 2020). In 2020, less than 18% of students were women in computing-related careers. However, this percentage was almost 62% in other careers (Marino *et al*., 2023).

Today, women and girls are **25% less likely** than men to know how to leverage digital technology for basic purposes, **4 times less likely** to know how to programme computers and **13 times less likely** to file for a technology patent.

At a moment when every sector is becoming a technology sector, these gaps should make policymakers, educators and everyday citizens "blush" in alarm (UNESCO, 2019b).

Technological development teams are mainly formed by men, so there are still many voices to be heard. More women and gender diversity are needed in this field to participate in decision-making and contribute to developing technology with their subjectivity.

Based on literature regarding the relationship between girls and technology, Sultan, Axell and Hallström (2019) find that gender differences in attitudes and behaviors are relatively small at early ages. However, these differences increase as students grow, approximately from the age of 10. Additionally, several studies show that girls lose interest in STEM subjects as they grow up compared to boys.

**Table 1.** Subjects by students according to gender, 2020

| Subject | Students | | | % of students | | |
|---|---|---|---|---|---|---|
| | Male | Female | Total | % Male | % Female | % Total |
| Computer Science | 90,595 | 19,730 | 110,325 | 82.1 | 17.9 | 100 |
| Other subjects from the curriculum | 839,459 | 1,353,817 | 2,193,276 | 38.3 | 61.7 | 100 |

**Source:** Sadosky Foundation based on sources from the Secretariat of University Policies

According to research in the UK (Barker and Aspray, 2006), 10 and 11-year-old girls and boys had almost the same engagement with STEM content (boys: 75%; girls: 72%). However, at the age of 18, this percentage falls to 33% for boys and 19% for girls based on their participation in higher-education STEM studies.

ICILS (2018) results also confirm differences in girls' and boys' attitudes towards ICT. Women frequently use ICT for school tasks, for example, searching for information or creating digital content. Men, on the other hand, show more confidence in performing specialized tasks such as changing computer settings or programming.

The reproduction of stereotypes culturally assigned to gender leads to differences in the use and appropriation of knowledge. This makes women and gender-diverse communities distant from this field[6].

**The school can contribute to change this tendency by making teachers and families rethink their perceptions and beliefs in this matter**. It is also necessary to reflect on performance expectations at stake, raise visibility of the historic engagement of women and diverse communities in the field of computer sciences from a gender perspective.

## Set to work

Given massive changes and the significant impact of digital technology in contemporary societies, it is difficult to foresee how the future will be in the mid and short-term. An ICT sector based on local research and development is a strategic advantage over these changes.

Besides, the demand for services and products depending on digital and computational technology rises in giant strides and requires more trained professionals. However, employment rates are negative in the sector. In other words, more job positions are offered than occupied every year.

[6] See research: *¿Y las mujeres dónde están?* https://program.ar/ wp-content/uploads/2021/03/Informe-sobre-Genero.pdf

Although employment in the sector of informatics services[7] has increased in Argentina, there is still a significant gap. In 2022, it was not possible to occupy 15,000[8] job positions. Changes in the work sphere during the pandemic contributed to the already-existent endemic problems. With this new scenario, it is imperative to understand and renew the relationship between educational trajectories and social-productive dynamics.

This landscape is also drastic in Latin America. According to the Coursera Global Skills Report (2021), 17 out of 23 countries in Latin America and the Caribbean have a "lagging" skill level of business, technology and data science[9]. Thus, the need for professionals to engage in the sovereign development of technology is another reason to strengthen the training of young people and inspire vocation for ICT at schools.

**The Program.AR Initiative encourages digital and computational technology as a mandatory subject at school. Knowing how computers and applications are used is necessary but not enough. Students must understand how technology works to have a critical perspective on it, to transform it or create new technology. They should know how they are developed, and which are the potential and risks.** Students should have a critical perspective to use, appropriate and change technology. Thus, students need to learn and understand how these devices work and are developed, as well as their potential.

The ability to perform tasks independently mirrors this knowledge. Some examples include recognizing and developing solutions for computational problems; developing, modifying, testing and improving programs; or identifying and communicating issues with the use of devices.

Training in this field aims to promote critical decision-making on the use of technology in an ever-changing context. In addition, it prepares students for a world where most work activities are mainstreamed by technology.

---

[7] See article in Argentina.gob.ar: bit.ly/3M2Y20H

[8] See article *Iprofesional*, January 2022: bit.ly/3FL28Gt

[9] The report includes 102 countries, 80% of people who have used Coursera. Latin America and the Caribbean include 14.5 million people with an average age of 31. Women represent 49%. Skills assessed include Business (practice and day-to-day running of a business), Technology (creation, maintenance, and scaling of computer systems and software) and Data Science (capturing and utilizing the data for decision-making). https://www.coursera.org/skills-reports/global

# Which countries have already made it? How?

Countries that had taken the challenge of including CS in the classroom had to tackle many tasks. For example, analyzing which tasks and content were a top priority, defining the teaching approach, how to train teachers, and deciding if contents should be transversal or one stand-alone subject. Addressing this discipline was completely new in the field of compulsory education. Consequently, there were no models to be followed.

The experiences of ten countries were described in a report written by Martínez (2020) for the ADELA[10] network. These countries were **Australia, Brazil, Spain, the United States, Estonia, Finland, England, Israel, Poland and Singapore**. The report analyzed the main reasons to include this field in the classroom, the history of the programs, whether the programs depended on public or private organizations, their place in the curriculum, the teaching approach and teacher preparation.

[10] ADELA is a network of public policy-makers, research centers, universities and think tanks from Latin America and the Caribbean. ADELA aims to foster good practices in digital education and the development of public policies based on evidence.

### Digital inequality and deficiencies in the social productive system are the main problems to be solved

In most of the cases, the countries have prepared previous reports including CS teaching. The social problem, which triggers the need to prepare such reports, is related to inequalities among students or deficiencies in the social and productive system.

In the cases of Australia, Finland, Poland and Singapore, there was a need to address economic, environmental and social problems through information systems. Additionally, productivity and employment had to be improved in Estonia, Finland, Singapore and Poland. In this regard, the youth and unemployed people had to be incorporated into the labor market. In other words, the inclusion of people in the digital productive world was a common problem in these countries.

England and the United States identified a low enrollment in ICT and STEM university degrees. In the case of the United States, most people enrolled were white men.

## The public policy of CS teaching in schools is relatively new

It is not easy to identify when CS teaching programs began in schools in each country. However, it is possible to find isolated instances of teaching this content, whether in schools or informal educational institutions. In the report prepared for ADELA, the starting point was the year in which CS teaching became a state policy. This is related to the design of policies and actions aimed at raising the number of young people that have access to this knowledge.

Some countries' policies include designing curricular programs, training teachers and allocating budgets for specific teaching resources. Intervention varies according to the educational tradition of each country.

Table 2 shows when programs addressing CS in these countries started based on the above criteria.

**Table 2.** Starting year of CS teaching programs in the countries analyzed

| Beginning in 1985 Reforms in 1999 and 2008 | Beginning in 1999 Reforms in 2011 and 2016 | 2008 | 2012 | 2014 | 2016 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|
| Poland | Israel | United States | Estonia | England Singapore | Finland Australia | Spain | Brazil |

Based on this table, we can see that two of the countries analyzed have a long tradition of including CS in the educational system: Poland and Israel. However, the trend to teach CS in schools does not exceed ten years in most countries. In the case of countries with longer traditions, there have been reforms for the last 15 years. Overall, we can infer that teaching CS as a program guided by countries through different actions is relatively new.

## Most of the programs depend on national Ministries of Education

The national Ministry of Education leads the introduction of CS teaching in schools in seven of the countries analyzed: Israel, England, Australia, Finland, Brazil, Poland and Spain. In these countries, the Government has been responsible for the design and continuous implementation of the program. The aim is strongly related to increasing the number of people interested in STEM and ICT careers.

Reforms have been centered on the curriculum, financing equipment and teacher training.

However, there are some exceptions. In the United States, CS teaching is led by universities, and the country contributes with subsidies. Estonia has a foundation supported by national funds. Finally, in Singapore, CS teaching is led by the Ministry of Communications, supported by the Ministry of Education, Science and Universities.

## CS in the curriculum

The relation between the formal educational system and CS teaching involves at least two curricular spheres: a compulsory nature (a requirement for graduation) and content organization (how content is organized in the curriculum). According to the literature on introducing CS in schools, this relation triggers tension, which is reflected in the decisions made by the countries analyzed (table 3). Based on this table, only one country (Spain) has addressed CS combining compulsory content in primary school and the first years of secondary education, and as an elective subject in the last years of secondary school.

**Table 3.** Compulsory nature and content organization of CS in each country

| Content organization | Compulsory | Elective |
|---|---|---|
| Subject or stand-alone subject | Australia<br>Finland<br>England<br>Israel<br>Poland | United States<br>Spain (secondary)<br>Singapore (secondary) |
| Transversal or integrated | Brazil<br>Spain (primary, integrated in Math)<br>Finland (integrated in Math) | Estonia |
| Extracurricular | | Singapore<br>Estonia |

These contents are compulsory in the curriculum of seven countries and elective in the other three countries analyzed (Estonia, Singapore and the United States).

In Singapore, where CS is elective, these contents are introduced playfully from preschool. In this way, the Government expects it will increase the possibility of choosing these subjects in secondary school. The United States follows a similar approach. The subject is offered as introductory and is aimed at exploring and creating technology. This is based on the hypothesis that an introductory and exploratory approach may lead students to choose traditional computing subjects. In the case of Israel, the proposal has changed over time. Although compulsory and elective instances have been combined, the trend is to broaden inclusion at lower levels and generalize the teaching of this content.

England incorporates compulsory content in formal schooling. Then, students may optionally deepen their knowledge during the last years of secondary education. In Finland, these contents are compulsory in primary and the first years of secondary school, that is, from grades 1 to 9 (from 6 to 15 years old).

Regarding curricular organization, four countries choose a transversal or integrated approach. The remaining countries have a stand-alone subject or include these contents in an existing subject (such as Technology), which is redesigned to address CS.

In the countries where the Ministry of Education guides the introduction of these contents in schools, CS teaching is compulsory (at least, in one educational level). In turn, contents are elective if foundations or universities introduce this knowledge.

Overall, we can ensure opportunities for everybody if this knowledge is clearly explicit and its content is part of the mandatory curriculum. In this regard, England, Finland[11] and Israel are models with precise definitions.

## Exploratory, problem-solving and project development approaches to introduce CS

To include CS, seven of the countries analyzed have chosen a didactic approach, which is characterized by exploration, inquiries, problem-solving and project development (Australia, Spain, the United States, Singapore, Finland, Poland, Israel and England). In these cases, students play an active role to gain knowledge.

[11] Although technological content is transversal in Finland, CS is included in two specific subjects. Thus, its teaching is ensured.

Such teaching approaches aim to spark interest and delve into knowledge. Additionally, this type of teaching develops high-level thinking, such as exploring solutions, applying and transferring concepts to different contexts, creating devices or analyzing and assessing alternatives.

Regarding content, in all cases, CS concepts are introduced by teaching programming using different languages and devices. In some countries, students are first engaged in the use of digital technologies (Spain, Singapore and Poland). Then, they continue developing algorithmic thinking through programming. Secondary and middle school focus on problem-solving. In this way, there are different degrees of alternatives.

## Block-based coding and tangible projects as main tools

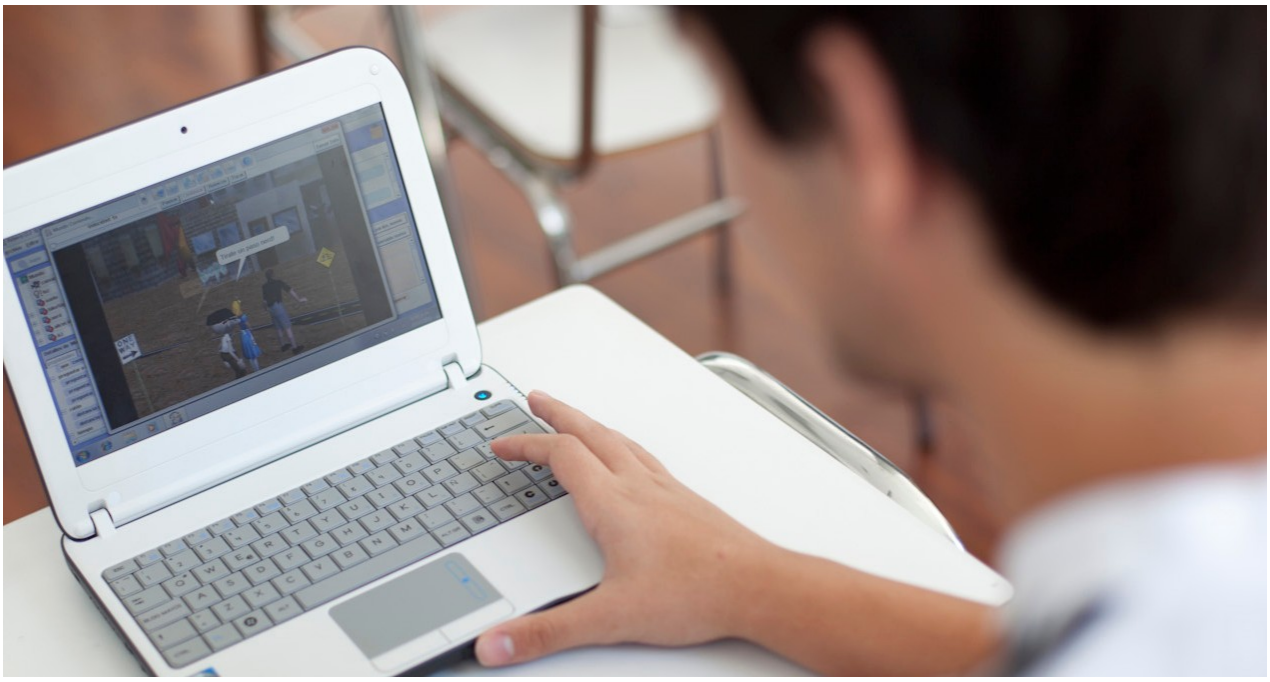
Generally, the countries have proposed introducing CS with unplugged programming and block-based coding activities. In the case of preschool and primary school, the use of devices is frequent (Australia, the United States, Spain, Estonia, England, Finland and Singapore). In secondary school, many countries offer programming languages used in the industry. The requirement is to have, at least, two different types of languages to focus computing concepts.

## Few countries offer systematic and thorough teacher training

In Israel and Poland, CS teaching has formal requirements regarding teacher training organized by the country. These countries also have the most extended trajectory in including this type of content.

In the case of Israel, universities, training institutes and the Israeli National Center for Teachers of Computer Science are responsible for teacher training. There is a range of training programs of different duration, proposals and training designs.

The Israeli National Center for Teachers of Computer Science includes a network of teachers, prepares and shares teaching resources, conducts research and disseminates teachers' experiences. Both Poland and Israel highly demand and value curricular and pedagogical training. CS teachers shall hold degrees related to this field and have at least two years of pedagogical training. This requirement, together with the aim to generalize teaching in primary and secondary education, has led Israel to propose professional training and provide scholarships to professionals in the software industry to fill the positions due to a lack of trained teachers.



In Finland, teachers in primary and secondary education are required to have a 5-year university degree and educational research. Graduates are required to do a master's degree. Then, the country provides additional financing so that local governments can provide teacher training in CS. Universities are responsible for providing this training. For example, the University of Helsinki has the Innokas network, which is managed by the Faculty of Educational Sciences. This network offers teacher training across the country. The country also financed two-year mentoring programs so that teachers could implement the 2016 reform.

Estonia also proposes a diverse model, and universities offer short courses and longer specializations. For the remaining seven countries, teacher training is optional. It depends on the teacher's interest or if the school requires specific preparation to introduce CS.

The case of England is interesting. Although the nation intensely participated in defining the curriculum, the market was initially responsible for teacher training. However, many schools did not adopt the curriculum because there were no trained teachers. There was a decision to train teachers as leaders to support other teachers during site-training while introducing the subject.

Given the deficiency in teacher training, the National Center for Computing Education was created in 2019. It is funded by the nation and supporting partners. Its mission is providing teacher training to teach computing content.

The most rigorous models of teacher training include pedagogical and curricular preparation. They also combine theoretical knowledge and teacher practice.

The Israeli and American models are the most documented. The former combines theoretical classes with teacher practices, which are simultaneous during pre-service training. The latter is an intensive training course with a duration of 40 hours, followed by annual meetings to address concepts related to computing, teaching and equity. Training consists of micro lessons, where teachers can put the curriculum into practice during training to reflect on teaching and learning.

## What were the challenges?

The UNESCO report (2019a) lists the challenges related to including Computing—or CS—in the curriculum of more than 16 countries across the five continents:

1. It is possible to note **a lack of clear understanding of CS as an academic discipline**.
2. The **need to differentiate CS as a subject in the curriculum** is controversial or misunderstood.
3. It is **difficult to implement computational thinking, a core element of CS, in schools** due to its complexity.
4. The **development of CS curricula is hindered by the lack of empirical evidence of students' learning** to define and sequence content.
5. **Previous ICT curricula do not prepare students to be trained in CS** at university level or professionally.
6. **Integrating CS and other subjects in the curriculum** has been ineffective.
7. **Teacher training to offer updated CS knowledge** is a challenge, given the quality of the content and the number of suitable human resources.
8. It is **difficult to identify and allocate additional resources** to teach CS.

Overall, the **lack of people's general understanding of specific knowledge impacts education** in different ways. Firstly, it is difficult for participants from relevant areas to make decisions to structure the inclusion of such knowledge appropriately and argumentatively. It is necessary to reach a consensus among the persons responsible for educational transformation. This lack of general understanding also hinders the structure and development of teachers who are (and will be) in the classrooms since a reduced number of experts should define the preparation of many professionals in the short term.

In addition, the lack of general knowledge related to the specific discipline complicates discussions and slows changes down. This happens because the current challenge is confused with the inclusion of digital technology in general education and the different meanings of digital literacy[12].

[12] Regarding the meanings of digital literacy, see C. Martínez, P. Martínez López, M. Gómez, M. Borchardt, M. Garzón (2022): "*Hacia un currículo emancipador de las Ciencias de la Computación*" [Towards an emancipated CS curriculum]. Revista Latinoamericana de Economía y Sociedad Digital. Available at: bit. ly/3Z7eorL

The misunderstanding of what CS content implies and the lack of teachers to reach every student led to the idea of integrating this content in the curriculum, in a general and non-specific way. The idea of "transversal" seemed a possible solution to a complex problem.

The UNESCO report concludes that there are no short-term strategies to address the challenge of innovation comprehensively and universally. Thus, there is a need to **design a road map with clear goals and plan a gradual implementation with the participation and training of decision-makers who are crucial to sustain a mid and long-term policy**.

CHAPTER 2

# Computer Science in Argentine schools: initial context and challenges

The global overview is a reference to analyze what happens in Argentina in terms of CS inclusion in the classroom and public policies developed so far.

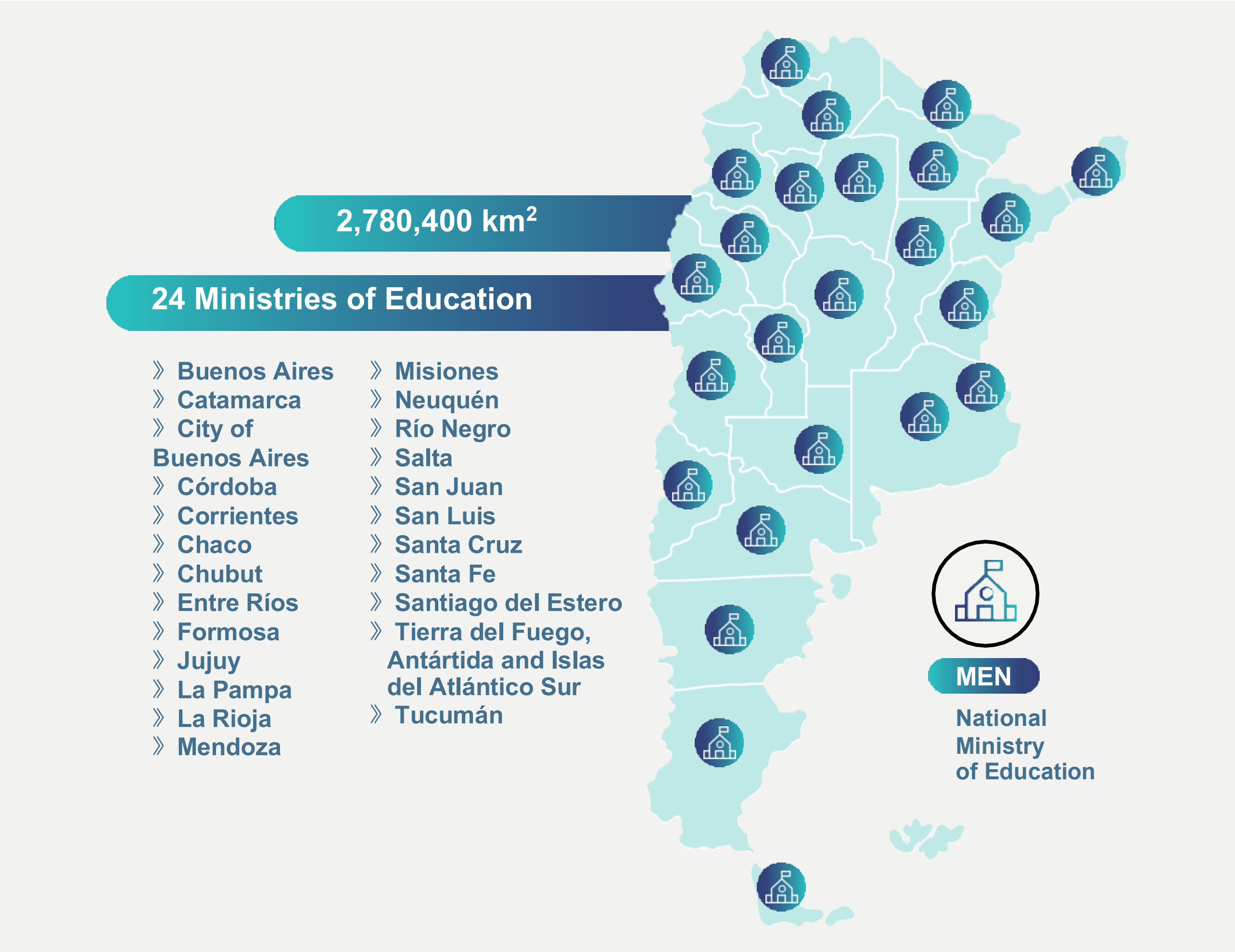
This chapter intends to capture a complex and dynamic process that includes many participants.

In Argentine schools, CS teaching is across the corner. However, there is a path full of obstacles to overcome. As explained in the previous chapter, to achieve such goal, it is necessary to modify the teaching framework and (in-service and pre-service) teacher training, acquire equipment and ensure Internet connection in schools, prepare teaching resources and guidelines for the classroom, training leading teams and surveillance, among others.

All the above should be achieved in a territory of 2,780,400 km². In 2022, the educational system served **7.8 million students in compulsory levels** (preschool, primary and secondary), distributed in **more than 46,000 schools** under **24 jurisdictional Ministries of Education**.

Important challenges are still to be faced.

**Picture 1** The educational system in Argentina




# The educational system in Argentina

The Argentine educational system is federal. It consists of the **National Ministry of Education**, under the **Executive Branch**, 23 provincial Ministries of Education and the Ministry of Education for the City of Buenos Aires. These organizations make the ***Consejo Federal de Educación*** (CFE) [Federal Board of Education], headed by the National Ministry of Education. The CFE aims to reach a consensus on the general guidelines for public policies, including the *Núcelos de Aprendizaje Prioritarios* (NAP) [Learning Priorities Cores] by area of knowledge.

The National Ministry of Education is responsible for developing the educational policy in Argentina and controlling its compliance. In addition, it designs and implements compensatory policies regarding wages, infrastructure and equipment to reduce inequality arising from social and economic disparities among jurisdictions.

Jurisdictional ministries define the curriculum for the mandatory levels, organization of pre-service teacher training and school management. These actions are based on the guidelines developed by the CFE.

In 2022, 46,000 state-managed public schools served 7.8 million boys, girls and teenagers. Out of this number, 1.2 million attended preschool, 3.6 million were in primary education and 3 million attended secondary school.

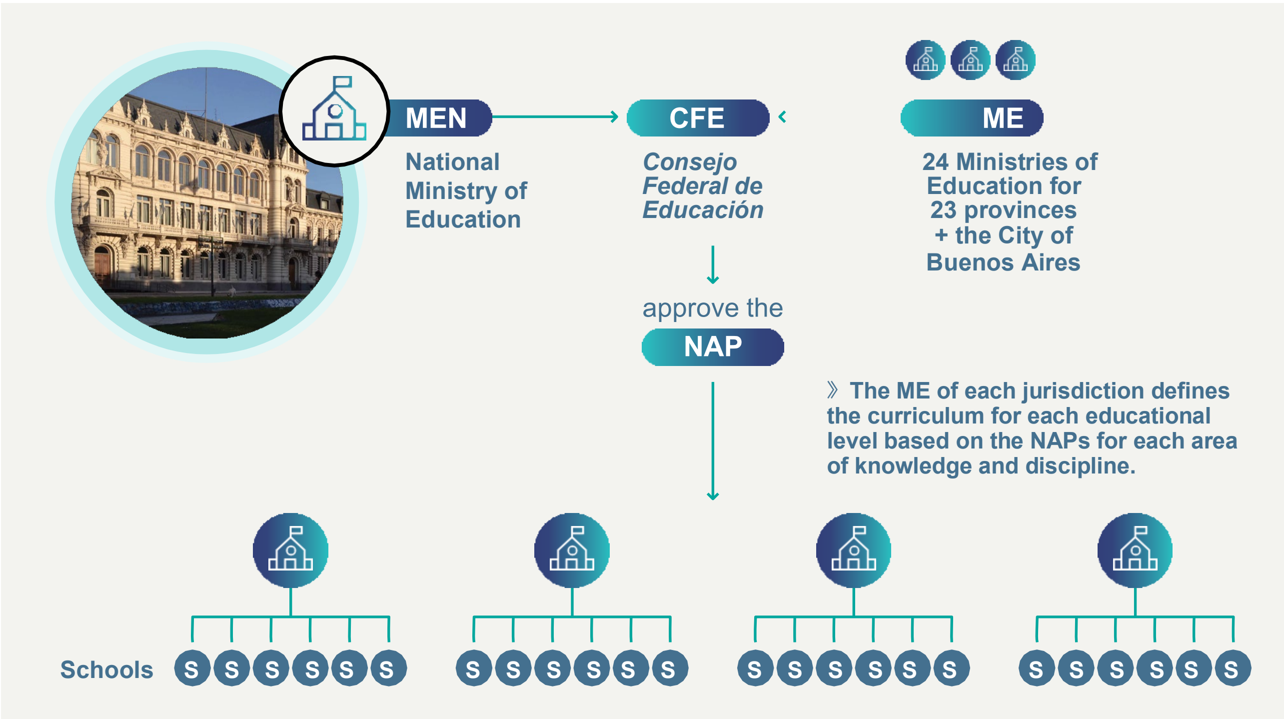
Approximately 16,000 schools belonged to preschool, 19,000 to the primary level and 11,000 to secondary education. In addition, there were around 16,000 private schools attended by almost 3 million students.

Regarding teachers, 550,000 worked in public schools and around 175,000 in private schools[13]. Approximately 40,000 teachers[14] taught content related to Computing and Technology.

[13] Data from the *Sistema de Consulta de Datos e Indicadores Educativos* [System of Educational Data and Indicators] (SICDIE): https://data.educacion.gob.ar/

[14] Number of teachers instructing computing-related subjects. This information is based on estimates made in 2019 by the Directorate of Educational Information of the Argentine Ministry of Education.

**Picture 2.** Argentine educational system




# History of Computer Science in Argentine schools

In Argentina, the field of Computing appeared in the sixties. Firstly, in the Public University for scientific purposes; then, in big companies to manage business and processes; and finally, in schools. However, **how did it start?** Here, we present the history of how Computing was introduced in the classrooms. Martínez (2022) identified four milestones, which are linked to different needs or goals.

## Technical-operative concept and learning by constructing

This concept prevailed at the end of the seventies and the beginning of the eighties. It aimed to train students to operate machines and develop computer programs for the available hardware. It was not focused on fixed concepts that went beyond technical aspects or were transferred to different computable devices. On the contrary, the focus was **teaching the language of programming used at that historical time for the technical capabilities available**.

This perspective did not consider the obsolescence of machines or languages. The effort was training students in capabilities that would be replaced later.

In the educational system, this was translated into teaching Basic and Pascal at the secondary level. Numbers, or words in some cases, could be manipulated through the calculation of programs. It was not technically possible to manipulate images, sound, videos, etc., as we can do today.

In this context, the decision to introduce computers in schools was guided to **prepare students for the labor market**. Thus, it is not surprising that the first experiences were in technical schools with a long tradition of teaching for factories and the industry. At that time, computers were exclusively used in big companies, government offices, and there were only a few uses in universities for educational purposes.

From the mid-eighties, most private schools started to teach programming as an extracurricular subject. That provided an offer different from public schools. However, no official curricular developments were found.

Then, the Logo language appeared. It was designed to teach programming to children. The person gave orders to an object—a turtle—through commands for movement and drawing geometric shapes. Its creator, Seymour Papert, focused on constructing math concepts based on children's cognitive development. The Logo language formalized mathematical thinking at an early age.

The pedagogical perspective of learning by construction accompanied the introduction of Logo. This perspective became strong in the late eighties in Argentina. Academics, teachers, foundations and even public officers promoted a change in schooling based on the "New School" trends and developmental psychology.

In this new paradigm, students were expected to build significant knowledge by exploring the world and solving problems.

In this sense, computing was seen as a tool to promote thinking. At the same time, more computers were used at home. Technological advances and access to equipment led to pedagogical innovation.

## The concept of utility

During the last decade of the 20$^{th}$ century, it was considered that incorporating ICT in schools was necessary for people to access culture and the labor market. Equipment, teacher training and the model of a new learning tool were part of educational policies aimed to promote the introduction of computers in schools. With new technological monopolies, the logic of teaching utility in school was imposed, mainly office automation.

From this point of view, the computer is a **tool used to support traditional educational activities. However, it is not considered a device to expand cognition**. Thus, there was a need to use word processors, spreadsheets and presentations since they would replace more traditional means. Computing was more integrated into traditional teaching tasks, such as presenting information on a board to motivate students or reading texts, rather than in pedagogical innovations that imply using the network, learning by projects, designing and creating products, etc.

This experience led to the idea that it is not necessary to have specialists or teachers trained in the discipline to teach Computing.

## An integrating approach

At the beginning of the new millennium, schools had a range of computing tools and resources with huge educational potential. Some of them were designed especially for education (educational software), while others enriched teaching in all the subjects.

As computers had more processing capacity, new materials and didactic proposals were created. Additionally, the introduction of the Internet created a bias exclusively towards communication and access to information. Consequently, CS conceptual contributions and didactic developments faded away. A focus on the access to information led to an instrumental approach. This excluded the concept of computing and was separated from programming and its languages.

**Technology started to be considered as a tool, a way to access and represent information, which boosted the learning of different disciplines.**

This integrating approach did not include CS as first-order knowledge. However, it was a significant advance compared to the utility paradigm of the previous decade.

Within this framework, digital technology is a tool to update didactic proposals, consolidate learning of Language, Math and Sciences, and strengthen the relationship between the school and students. During this time, there was a massive distribution of computers under the model 1 laptop per child. In Argentina, this program was called *Conectar Igualdad*.

## What is *Conectar Igualdad*?

The program was a national policy developed in Argentina in 2010. It was implemented by the Presidency, the National Administration of Social Security (ANSES), the National Ministry of Education, the Cabinet and the Ministry of Federal Planning for Public Investment and Services.

*Conectar Igualdad* was a federal initiative of digital inclusion aimed at recovering and valuing public schools to reduce digital, educational and social gaps in the country.

It **provided millions of netbooks to students and teachers** at public secondary schools, special education and teacher preparation institutes.

Additionally, it **developed digital content to use as didactic proposals and fostered teacher training to change paradigms, models, as well as learning and teaching processes**.

### Some numbers

» **More than 5.3 million netbooks** were provided across the country.
» **Technological floors** were installed in **more than 23,600 schools.**
» **More than 1,000 adaptable technological kits** were provided in schools of special education.[1]

The initiative was canceled from 2016 to 2020. In 2021, it was brought again in a different format.

[1] See bit.ly/409owBO

This plan mainly aimed to provide one computer to each student at public secondary schools and teachers. In the case of primary schools, it provided carts with laptops. The website educ.ar and the *Instituto Nacional de Formación Docente* [National Institute of Teacher Training] offered short courses and updates related to the use of technology in the classroom for education in general.

The program was a bet to develop ICT vocation and higher-education studies. It was designed to contribute to national development and technological sovereignty.

Although the availability of equipment was a *sine qua non* condition to address computational technology, the pedagogical approach was centered on the provision and use of resources.

## Digital and computational literacy approach

**At the beginning of 2010, schools needed to have access to different digital knowledge**. This included using technology, understanding how it worked and, mainly, developing new technology. Thus, people would have better possibilities to understand and participate in different areas of social life.

This knowledge is related to general—not professional—training. That is why it is necessary to discuss how this should be addressed in schools and not as exclusive content of technical schools. Discussions include the appropriate epistemological delimitation, the relevant time for its introduction in schools, teacher training required to lead this learning process in the classroom, the type of necessary equipment for each educational level, and the need—or not—of specific room in the curriculum. This was translated into a range of national educational resolutions to organize the introduction of digital, and then computational, literacy at all the levels of compulsory education across the country.

**Picture 3.** Regulations on the education of digital and computational technology

**2006**

**National Education Law 26206:**

- Development of capabilities to manage new languages developed by ICT (Section 11)
- Integration of essential curricular contents (Section 88)

**2011**

**Resolution CFE 135/11 - Resolution CFE 141/11:**

- NAPs for technological education
- Inclusion of computational technical processes and means in technologies to be studied

**2015**

**Resolution CFE 263/15:**

- “Teaching and learning programming are strategically important during compulsory education”

**2018**

**Resolution CFE 343/18:**

- NAPs of digital education, programming and robotics to be included in all levels of the educational system

Since 2006, the National Ministry of Education set out the first guidelines for digital literacy and programming content in schools through different regulations.

Section 11, Chapter II, of the National Education Law 26206 included the teaching of technology ("Purposes of the national educational policy"). It also provided for the need to "develop the necessary capabilities to manage new languages developed by information and communication technologies" and "promote the learning of critical scientific knowledge to understand and participate in contemporary society."

In 2011, NAPs for technological education were set. Among technologies under study, computational technical processes and means were included.

Then, the CFE passed a resolution in 2015 which stated that "teaching programming is strategically important." Finally, in 2018, NAPs for digital education, programming and robotics were approved to be included at all levels of the educational system pursuant to Resolution CFE 343/18.

This was highly important to reintroduce the relevance of teaching CS content in the classroom. However, several main aspects were not clear.

For instance, the epistemological delimitation proposed, the advances defined to address knowledge in the classroom, the designation of a specific curricular subject, provision of resources, and counseling to provinces to modify the curricula of preschool, primary, secondary and higher-education levels, as necessary.

## Towards a full unfolding of Computer Science in schools

The Program.AR Initiative identified a range of necessary conditions to bring CS to schools, considering the characteristics of the Argentine educational system:

1. As a field of knowledge, CS should **have a social and educational value** to be addressed by educational organizations engaged in decision-making (in Argentina: Ministries of Education and the CFE).

2. **NAPs** should be developed, particularly the ones including CS. The CFE should approve such NAPs.

3. Make progress in **in-service teacher training** in this discipline[15] .

4. **Framework for compulsory education** should be developed, defining the level of integration and mandatory nature, as well as its follow-up.

5. **Curriculum should be adapted** for pre-service teacher preparation.

6. **Teaching resources** should be created to **guide teachers in the classroom**, facilitating their tasks.

7. Educational institutions should have **equipment and computing infrastructure** to teach and learn CS in schools.

8. The implementation of policies should be **followed up and assessed** for future improvements and reforms.

To understand the status of the conditions and their progress, the Program.AR Initiative requested a study from Quántitas Foundation (Scasso *et al.,* 2018; Scasso *et al.,* 2019). Such study aimed to measure the valuation[16] of the topic from the perspective of direct and indirect stakeholders involved in educational policy and the effective development[17] of CS teaching in schools from 2015 to 2018.

---

[15] "Teacher" includes teachers in activity and in the process of training, as well as other stakeholders of the educational system (public educational policy-makers, supervisors, leading teams, etc.).

[16] "Valuation" means social processes related to building meaning: it includes social imaginary, already-formed concepts and social representations around the object. This view of valorization refers to stakeholders' identification of how relevant computational thinking is as a key capability in learning and the strategic importance of this knowledge in society. This means its inclusion in compulsory education and its presence as a possible vocation for teenagers.

[17] It refers to achieving specific actions based on a group of ideas or principles. In other words, to what extent stakeholders change their behavior based on explicit intentions. In our context, it refers to observation and the behaviors of teachers, students and politicians in situations consistent with the explicit purposes of including CS in schools.

The results of the study showed that, in 2015, there was a low valuation by society and Ministries. The effective development of policies to teach CS in schools was scarce.

From a social perspective, it was possible to note the low public presence of the topic in massive and specialized means of communication. This was reflected in its low inclusion in the social public agenda and the agenda of educational policies. In 2015, society did not perceive CS inclusion in the classrooms as urgent or important, at least, at the level of public opinion. However, students showed intermediary-level interest and willingness towards CS. This was generally expected since this topic is interesting for teenagers.

Regarding effective development, there was a low level of institutionalization of the policy to include CS at the national and jurisdictional levels. The actions taken by Ministries were scarce, focused on specific issues and without general guidance.

The number of people enrolled in CS degrees was low. Although it seemed students had a certain interest in studying programming-related degrees, enrollment started to fall in the previous years of 2015. Overall, student enrollment presented a long-standing stationary behavior. In 2015, there was a low number of teachers and staff trained to teach CS in the classroom. Additionally, it was concentrated on schools with a specific orientation.

Jurisdictional initiatives to teach CS in the classrooms were scarce. In the few cases identified, there was low institutionalization. Finally, educational institutions did not have equipment and connectivity infrastructure.

**Towards 2018, the picture of CS inclusion in the classroom changed.** The research performed by Quántitas Foundation showed the progress achieved.

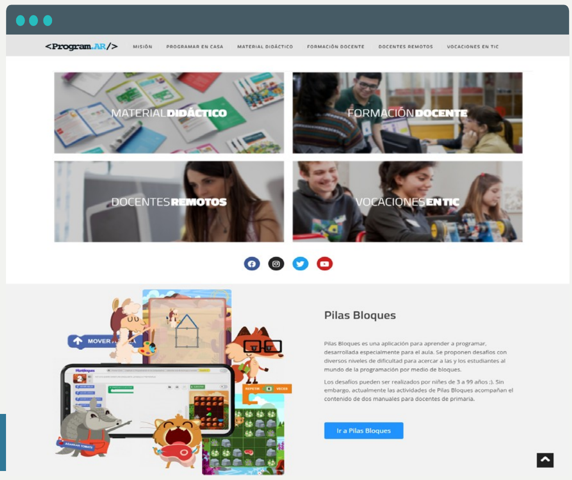
- **Society's perception of teaching programming** in compulsory education increased and it was viewed as an important topic for development.
- It was possible to identify **educational public-policy actions**, which were guided towards this direction and institutionally consolidated.
- Some jurisdictions made progress in **including programming in their curriculum**.
- It was possible to identify **pending challenges related to the creation of teaching resources based on these frameworks**.
- The **paradigm of teaching programming was more present** in jurisdictional Ministries of Education, compared to other ICT perspectives such as digital literacy or office automation.
- These changes led to some **progress in training for teachers, principals and supervisors**. Still, it was not enough.
- The stationary trend of enrollment to computing-related degrees changed. There was an **increased demand for enrollment**, especially in the last years.

The changes identified in the study made by Quántitas Foundation from 2015 to 218 cannot be directly or exclusively attributed to the Program.AR Initiative. However, this national program undoubtedly had an impact on such changes. Different plans of action and their results will be described in the following chapter.

# Program.AR Initiative

It was developed in 2013, based on an idea from the Sadosky Foundation and the former National Ministry of Science, Technology and Productive Innovation. It included the collaboration of the Argentine Cabinet, the Ministry of Education and other institutions such as educ.ar and *Conectar Igualdad*.

The work of these organizations, together with the country, was ruled by the common goal of achieving CS inclusion in schools as a way of emancipated appropriation of computing technology.




<Program.AR/>

https://program.ar/

## Dr. Manuel Sadosky Foundation

It is a public-private organization dependent on the Ministry of Science and Technology and Argentine Chambers of Software (CESSI, CICOMRA).

It was created in 2009, and it aims to favor the connection between the scientific-technological system and productive structure in issues related to Information and Communication Technology (ICT).

The Foundation has the following areas:
- Technological Relations
- Counseling for Software Projects for Public Organizations
- Data Science and Artificial Intelligence
- Program.AR and Vocation in ICT
- Security in ICT
- ICT for Peace, Justice and Robust Organizations

Fundación Sadosky

https://www.fundacionsadosky.org.ar/

The area "Vocation in ICT" from the Sadosky Foundation had been working on different initiatives before Program.AR, which was the starting point for its development. Some of these initiatives were ***Desafío Dale Aceptar***, the **website *Estudiar Computación*** and workshops of Vocation for ICT.

## Ministry of Science, Technology and Innovation

It was created in 2007 to promote and strengthen research as well as change the national productive matrix. Thus, building knowledge will be a strategic development to optimize Argentine competence in international markets.

Today, the Ministry of Science seeks to make Argentine science and technology federal. It supports the creation, counseling and strategic relation of national and regional policies and priorities promoting the development of scientific, technological and innovative activities in different jurisdictions across the country.

Ministerio de Ciencia, Tecnología e Innovación Argentina

https://www.argentina.gob.a

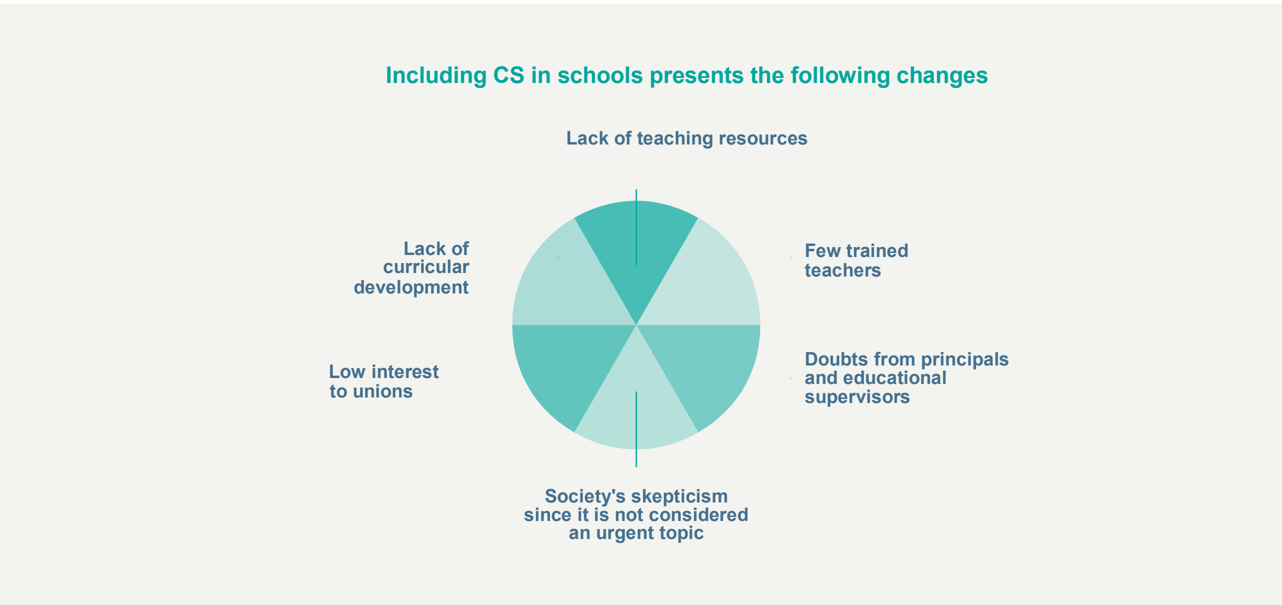
CHAPTER 3

# Program.AR: plan of action

Since its beginning, the Program.AR Initiative has sought to answer the following questions. Which plan of action is necessary for an educational program to expand the teaching of technology in schools, in a country with a federal educational system, with a teaching community that is not trained in CS and organized around hundreds of unions? How can we achieve these goals in a context where Computer Science is a challenge? How can we link the need for training focused on citizens' engagement and exercise of rights to the production sector's demand for young people from technological areas?

Program.AR identified six challenges to set the conditions to include CS in Argentine schools. These challenges included awareness of society in general and the educational community in particular; teacher training and a network for exchange; availability of didactic resources; and systematization and dissemination of experiences.

**Picture 4.** Challenges of CS inclusion in schools according to the Program.AR Initiative



In 2015, **Program.AR joined the program for infrastructure development aimed at promoting entrepreneurship capacity**, supported by the Development Bank of Latin America and the Caribbean (CAF), to ensure actions for the next four years. The Agency dependent on the Ministry of Science, Technology and Productive Innovation was responsible for its execution.

This allowed the Sadosky Foundation to strengthen and expand the plan of action set in 2013. Moreover, due to its partial autonomy, it could continue working on the program despite the changes in government.

Program.AR's plan of action aimed at setting the conditions to possibly include Computer Science in schools was and is:

- **Awareness**
- **Teacher training**
- **Development of teaching resources**
- **Building knowledge**
- **Technical counseling**

## How can Computer Science be part of the agenda?

The concept of **raising awareness** was aimed at generating interest to the teaching community, secondary students, educational management teams and society in general. Program.AR noted that it was necessary to offer a wide range of engagement activities.

### Program.AR forums

Between 2013 and 2015, five forums were organized in different regions across the country. These forums invited the academic and teaching community, companies from the sector, developers, NGOs and the society to jointly discuss the strategy to include CS in the classroom. There were different workshops related to teaching programming and its uses, as well as conferences on the importance of the topic of exercising citizenship. Additionally, there was a place for reflection, with hackathons.

**Program.AR forums in numbers**

**Five forums were organized in five regions across the country:**

**5 regions**

- **Province of Buenos Aires (Quilmes)**
- **Center (Córdoba)**
- **Northeast (Resistencia)**
- **Cuyo (Mendoza)**
- **Patagonia (Río Gallegos)**

**+1,500 participants**

## Workshops in secondary schools: vocation for ICT

Program.AR provides programming workshops in secondary schools across the country. The goal is to promote the election of computing-related careers.

As explained in the previous chapters, the software industry has been showing negative unemployment rates year by year. This fact supported the Initiative.

The workshops, organized together with public Argentine universities, were aimed at challenging the prejudices and concepts of computing-related careers, reducing the distance between secondary school and the university, and promoting interest in this type of study.

### Visits at schools in numbers[18]

**+ 30,000 students** participated in the workshops

**+ 605 schools**

**+ 63 universities** as allies

[18] The data included in this and the following tables was updated as of November 2022.

**Picture 5.** Workshops and forums provided by Program.AR in the country

### Universities

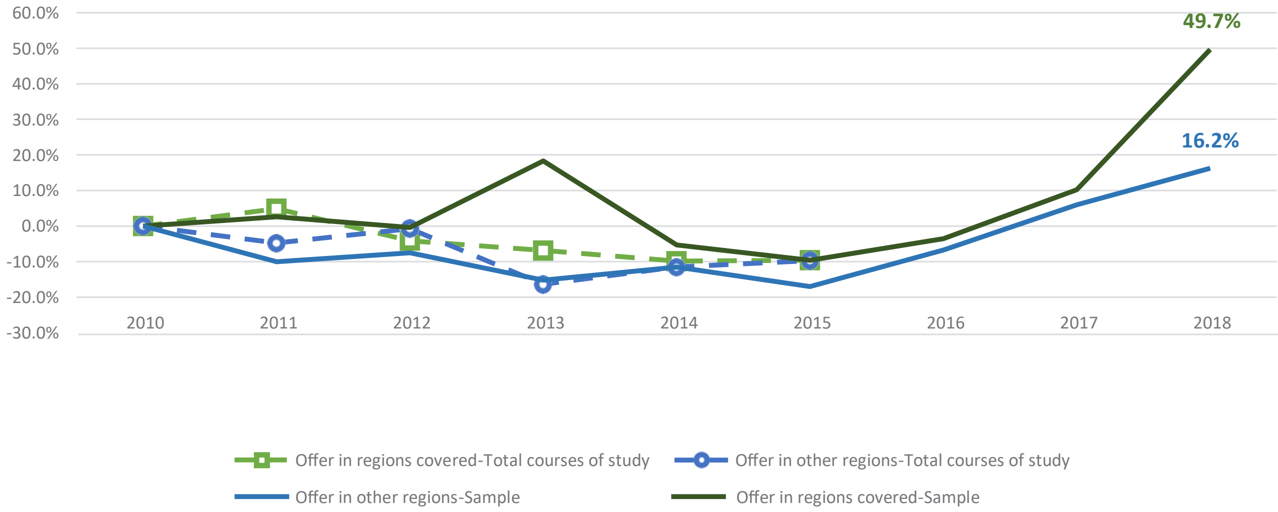
- Universidad Nacional de Jujuy (UNJu)
- Universidad Tecnológica Nacional - Facultad Regional Resistencia (UTN-FRR)
- Universidad Nacional de Misiones (UNaM)
- Universidad Nacional de Tucumán (UNT)
- Universidad Nacional del Nordeste (UNNE)
- Universidad Tecnológica Nacional - Facultad Regional Santa Fe (UTN-FRSF)
- Universidad Nacional del Litoral (UNL)
- Universidad Nacional de San Juan (UNSJ)
- Universidad Nacional de Córdoba (UNC)
- Universidad Nacional de Río Cuarto (UNRC)
- Universidad Tecnológica Nacional - Facultad Regional Córdoba (UTN-FRC)
- Universidad Autónoma de Entre Ríos (UADER)
- Universidad de La Punta (ULP)
- Universidad Nacional de San Luis (UNSL)
- Universidad Nacional de Villa Mercedes (UNViMe)
- Universidad del Aconcagua (UAC)
- Universidad Tecnológica Nacional - Facultad Regional Mendoza (UTN-FRM)
- Universidad Nacional de Hurlingham (UNaHur)
- Universidad Nacional de La Matanza (UNLaM)
- Universidad Nacional de Lanús (UNLa)
- Universidad Nacional de Luján (UNLu)
- Universidad Nacional de San Martín (UNSAM)
- Universidad Nacional del Centro de la Provincia de Buenos Aires (UNCPBA)
- Universidad Nacional del Sur (UNS)
- Universidad Nacional Noroeste Buenos Aires (UNNOBA)
- Universidad Nacional de Avellaneda (UNDAV)
- Universidad Nacional de Mar del Plata (UNMdP)
- Universidad Nacional de Moreno (UNM)
- Universidad Nacional de José C Paz (UNPAZ)
- Universidad de Buenos Aires (UBA)
- Universidad Nacional de La Pampa (UNLPam)
- Universidad Nacional del Comahue (UNCOMA)
- Universidad Nacional de Río Negro (UNRN)
- Universidad Nacional de la Patagonia San Juan Bosco (UNPSJB)
- Universidad Nacional de la Patagonia Austral - Sede Caleta Olivia (UNPA-UACO)

Groups of computing students were formed in each university. Program.AR trained these teams to offer programming workshops to students attending public secondary schools. Goals included developing a simple cellphone app, discovering which university degrees were free of charge and provided near their homes, and knowing the benefits of the ICT sector.

This Initiative was the basis of a relationship with universities, which was strategic to fulfill Program.AR goals. This relationship was enriched over the years, leading to more complex and innovative activities. Universities were key participants in this program. According to a baseline report from 2015-2018 on the number of people enrolled in university/institute degrees related to CS teaching, there is descriptive evidence that the workshops in secondary schools may have contributed to increasing enrollment. This was achieved by approaching the university to secondary education. In the regions where Program.AR offered these activities, enrollment increased three times more than in the rest of the regions[19], related to 2010 (see figure 6).

[19] According to the baseline report from 2015-2018, information includes a sample of 22 courses of study related to Computer Science in the regions covered by Program.AR. The sample also included 26 courses of study in other regions not covered by Program.AR.

**Picture 6.** Growth rate of the total number of new people enrolled in CS-related degrees. Year 2010 = Base 0




**Source:** Scasso, Marino, Colobini and Bortolotto (2019)

### *Estudiar Computación*

*Estudiar Computación* is a website created to gather relevant information about computing-related degrees. This information includes which are the degrees available, what are their differences, where people can study, and scholarships available. It aims to collect and clearly organize the content in an appealing interactive federal map. Universities and training institutes are also included.

*Estudiar Computación* was enriched by videos of professionals' testimonies about life stories, labor development and prospects. The goal is to know more about such technology professionals and eliminate prejudices and myths.

The website is mainly for Argentinian teenagers and young adults, families, teachers or career advisors who can contribute to teenagers' decision-making.

### Presence in public spaces

The Initiative was present at different fairs and events of technology and education to raise society's awareness of the importance of including computing in schools, create a positive impact and increase Program.AR credibility in the field. There was also ongoing action so that the Initiative could be present in the press and social media.

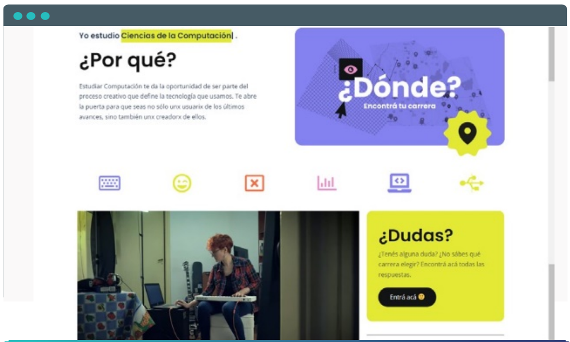
- ***Tecnópolis*** is a major exhibition of science, technology, industry and art organized by the Argentine Ministry of Culture. There were two exhibition stands for Program.AR to share the initiatives in an interesting, concise and playful way with students, teachers and families. It also participated in talks and conferences.
- **Hour of Code** is a global annual campaign organized by Program.AR and Code.org in Argentina so that boys and girls can have the possibility to learn programming through games.
- ***Educando el Cerebro*** is a project aimed at teachers for every level, students and the public. Members of the Program.AR Initiative provided talks about programming in the classroom, among other topics.
- **Conferences on Computer Science** organized by national universities in Córdoba Capital, Río Cuarto, Rosario and San Luis.

[20] Data from Google Analytics.

***Estudiar Computación* website in numbers**

**+ 30,000** visits since its creation[20]

**+ 560** specializations, degrees and technical degrees to study in Argentina




https://www.estudiarcomputacion.gob.ar/

**Social media and the press in numbers**


<Program.AR/>

**+ 27,950 followers** in Facebook

**+ 6,666 followers** in Twitter

**+ 5,500 followers** in YouTube

**+ 4,242 followers** in Instagram

**+ 100 publications** by year in major means of communication

# How can we address the lack of teachers and educational leaders trained in Computer Science?

In Argentina, **teacher training** is provided by:

- the *Instituto Nacional de Formación Docente* (INFoD) [National Institute of Teacher Training] and the *Institutos de Formación Docente* (IFD) [Teacher Training Institutes] of each province;
- public universities.

Considering the country's size, the complexity of the federal educational system and the fact that including CS in the classroom will take some time, the Program.AR Initiative provided short courses for teachers, such as "Programming and its teaching," and other courses aimed at principals. Due to its success, the Initiative designed more complex and longer proposals, for example, higher-level specializations or courses of study.

**INFoD**

It was created by the National Educational Law in 2006. The National Ministry of Education, in agreement with the 24 provinces, set essential criteria for training graduated teachers across the country. Training is provided through National Plans for Teacher Training, designed for the primary and secondary levels.

The INFoD plans and implements policies of in-service teacher training in the country. Pursuant to the National Plan for Teacher Training (Resolution CFE 286/16), these policies are based on educational justice, valuation of teachers, practice centrality and updates in teaching. The policies were developed by a joint federal agreement among the stakeholders engaged (specialists, unions, other ministries and NGOs), and research evidence. The provincial IFDs are dependent on the Ministries of Education of different jurisdictions and propose their own teacher training offer.

National public universities provide teacher training (they are independent regarding management and academic level, but depend on the budgets allocated by the National Ministry of Education). Provincial public universities also provide teacher training (which depend on the budgets allocated by the Ministry of Education of each province). In these cases, teachers are allowed to work in secondary schools, higher-education institutions and universities.

**Picture 7.** Teacher training in Argentina

**How is teacher training structured?**

**INFoD** + **IFD**

***Instituto Nacional de Formación Docente***

》 Aimed at professional development and academic upgrading for training teams in provincial IFDs.

***Institutos de Formación Docente in each province***

》 Dependent on the Ministries of Education of each jurisdiction. They propose their own pre-service teacher training offer.

**Universities**

》 Teachers allowed to work in secondary schools, higher-education institutions and universities.

Calls for teachers of computing degrees at public universities was the first strategy for teacher development.

Universities were considered strategic partners since they are located across the country and are experts in the field.

Program.AR had already been working with some universities in “Vocation for ICT” workshops, which were run in secondary schools.

Then, there was a need to build a network of different teacher training Institutes. There was an open call for universities and Teacher Training Institutes to work together in teacher development design. This led to a relationship between the Program.AR Initiative and the teacher training system. In this sense, universities provided expert knowledge in the field to develop training proposals. Additionally, the IFDs focused on in-service and pre-service teacher training for professionals of the primary and secondary levels.

The next step was thinking of pre-service teacher training for Computer Science teaching. This meant a complex scenario. As already described, IFDs are responsible for teacher training and depend on the Ministries of each jurisdiction. With no clear definition of how this content should be addressed in the classroom, there would be no reason for each province to deal with the design and implementation of this training. There was also a need to decide between adapting the already-existing training in Computing or Technology or creating new training proposals.

To make some progress, it was decided to work in four ways:

- Designing a **program of pre-service teacher training for Computer Science teaching** with the Universidad Nacional Pedagógica (UNIPE). This is the only national university in charge of exclusively training teachers in the country.
- Providing **additional curricular programs to Technology teachers** in the jurisdictions that decided to include this content in the classroom (for example: Neuquén and Chaco).
- Designing and implementing a **teacher development program centered on programming for all Technology teachers in secondary schools**. The program is unique in the country and was approved by a Resolution of the Distance Education Department from the National Ministry of Education.
- Working with jurisdictions to **create programs of teacher training for Computer Science teaching** (Neuquén) or modify existing training programs in Technology (Mendoza).

## Teacher training in numbers

**+ 7,900 teachers**

trained in different ways by Program.AR

**+2,300 principals**

trained in different ways by Program.AR

## What are the characteristics of teacher training proposals made by Program.AR?

- **Addressing the teaching of CS** and other disciplinary content specific to the area.
- **Discussing the reasons to include knowledge related to CS in the classroom** as relevant social knowledge.
- **Adequate pedagogical strategies**.
- **Delimitation of relevant content** for each level.
- **Resources to be used** based on equipment, connectivity and previous knowledge.
- **Indicators** to assess learning.
- **Different training programs** based on participants and their role in the educational system (teachers for all levels, teachers in practice, pedagogical teams, principals).
- A **variety of training trajectories**, with a duration from 40 to 2,800 hours, focused on learning by inquiry. Their pedagogical proposals are designed according to roles and practice.
- The will to create **local capabilities in all the jurisdictions**. In this way, training offers may continue independently beyond their initial link to the Initiative.[21]

---

[21] Identifying stakeholders in the regions is a strategy to appropriate knowledge, the approach and the Initiative. This will lead to capabilities in the jurisdictions to replicate teacher training in Computer Science. This proposal is aimed at professional teams designated by the jurisdiction, who need training in computing-related careers. The teams take a course to be later taught together with the Sadosky Foundation. The goal is to know and analyze the activities based on didactic approach, content sequencing and available tools. In this regard, students design and assess activities.

## How can we address the lack of teaching resources and material to teach Computer Science?

Program.AR developed a wide range of resources in different formats to teach Computer Science for different audiences. Resources include books for teachers, curriculum for subjects oriented to the topic, digital tools and audiovisual material to teach programming.

### Annual teaching plans and booklets

Given the lack of local teaching resources, Program.AR created its first booklet for teachers in 2015: "*Actividades para aprender a programar*" (Activities to Learn Programming).

This material addressed new technologies and proposed lesson plans to work with programming at all educational levels.

- In preschool, it offered a lesson plan based on three projects with a duration of 12 hours.
- In primary school, there were activities to learn programming by using *Pilas Bloques*[22] .

In the same year, given the reform of the secondary level, the City of Buenos Aires incorporated CS content into the ICT subject taught in 3° and 4° grades of secondary school (*TI3* and *TI4*)[23]. However, teachers were not trained in the discipline and there was no institutional support or materials.

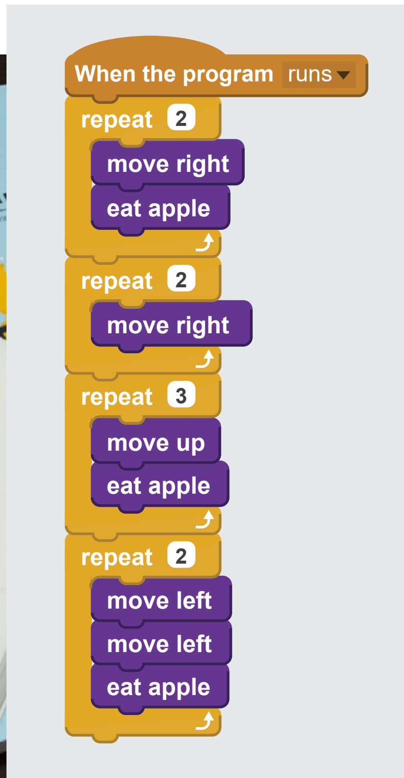
Thus, Program.AR created material for secondary schools based on an annual teaching plan for the ICT subject[24]. This was accomplished by following

---

[22] See https://pilasbloques.program.ar/

[23] Teaching plans can be downloaded at bit.ly/3nugPYn | bit.ly/3ZDpdlT

[24] Presentation of the curriculum for the City of Buenos Aires at https://youtu.be/6UgwciDdVhI

curriculum guidelines set by the Ministry of Education for the City of Buenos Aires[25].

These activities were the basis of a more challenging, innovative and unique project in the country and the region: creating a complete collection of textbooks for the primary and secondary levels.

## "*Ciencias de la Computación en el Aula*" (Computer Science in the classroom): A collection of textbooks for teachers

The first collection of textbooks to teach Computer Science was launched in 2020. The collection was aimed at teachers of primary and secondary schools, and was printed by Argentine publishing houses. The textbooks were published digitally between 2018 and 2019, and can be downloaded. Moreover, they were printed and distributed free of charge in all the country[26]. The books for teachers include detailed lesson plans and worksheets for students.

[25] See the curriculum for the City of Buenos Aires at bit.ly/3LUyEd9

[26] Schoolbooks can be downloaded at bit.ly/40JVqbN | bit.ly/3nu7HDb | bit.ly/40JWxbt | bit. ly/40A8NeY

They address programming, digital citizenship, computer systems and the Internet. The topics vary in complexity according to the level. The activities promote inquiry, problem-solving, strategy sharing, and debate of possible solutions. Such activities may or may not require the use of computers.

The collection was jointly prepared by different national universities, namely the Universidad Nacional de La Plata, Córdoba, Quilmes and Centro de la Provincia de Buenos Aires.

The participation involved a public call aimed at universities to build multidisciplinary teams of experts in Computer Science and Education Science.
The goal was to create original content on topics that had not been handled before, even in countries with more expertise in the field.

The material elaborated by the universities was later sent to a team of editors, designers, illustrators, proofreaders and members of Program.AR.
This team of experts contributed with correctness, coherence and design to complete a consistence and high-quality collection.

This project meant an excellent opportunity for Program.AR: the possibility of having local expertise, strengthening the relationship with universities, and being a pioneer in the publishing field to teach CS at the primary and secondary levels. The collection also led to setting concepts, work and quality as a model for other initiatives.

## The collection in numbers

**+ 90,000 total** downloads

**+ 8,000 books** physically distributed

**+ 3,500 teachers** reached

## Platforms

In the eighties, the famous Logo and its turtle (created by Papert) were new for teaching programming. However, Scratch (developed by the Massachusetts Institute of Technology) allowed boys and girls to learn programming without knowing the syntax.

When Program.AR began, many of the available tools had some limitations to be used in the country. They were not in Spanish, translations were poor, and there were not powerful computers and permanent connectivity—difficult to ensure in the Argentine territory. Most importantly, they did not fulfill the Initiative's expectations.

Thus, Program.AR promoted the development of platforms to teach programming in the classroom based on the expected disciplinary didactic approach.

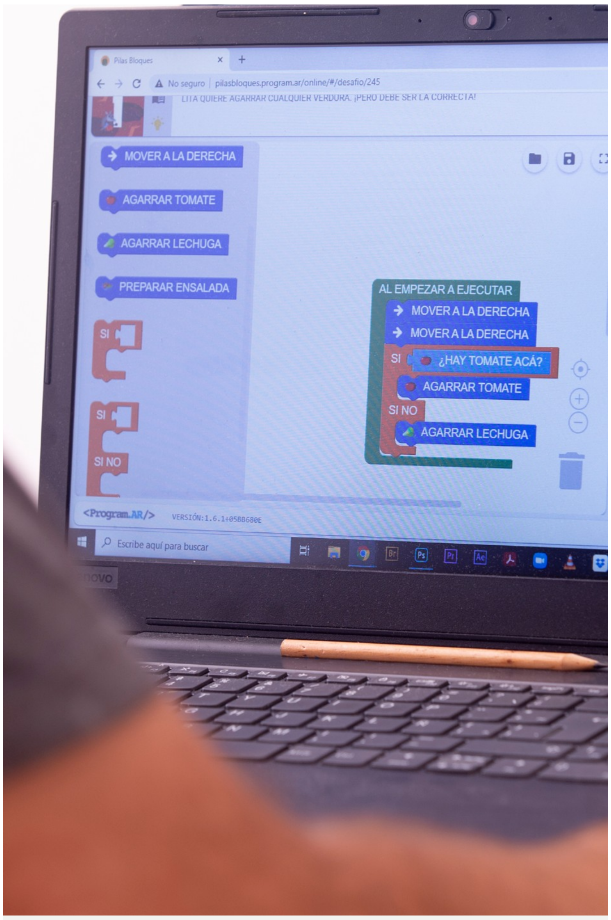
The proposals have one common ground. They are environments based on instructions represented by building blocks to learn and teach programming, avoiding the pitfalls of syntax. Moreover, they are freely available and free of charge. They can be downloaded and used without Internet connection. Some of them can even be used in cell phones.

### *Pilas Bloques*: an own tool

It is a tool to efficiently and playfully teach and learn programming. It includes challenges with different complexity levels for children and teenagers to know the world of programming. The tool promotes knowledge in the programming field for students.

It was specially designed for the classroom to support teachers and students in teaching and learning programming in schools. It is supplementary to the lesson plans included in the textbooks and booklets. The tool is installed in the Huayra operating system, developed for schools in Argentina.

Program.AR developed *Pilas Bloques* in the country. It is freely available and free of charge. It can be downloaded and used with no Internet connection. It is available in Spanish, Portuguese and English.




### *Pilas Bloques* in numbers

**+ 1,600,000 users** of this tool

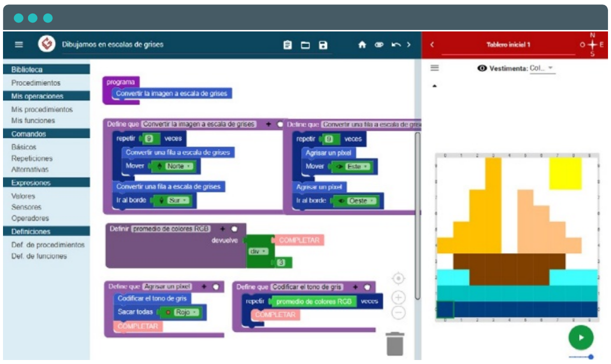
**+ 31,000 downloads**

**+ 49 million visits** in the platform

**+ 140 challenges** for boys and girls at school

**Gobstones: another way to learn programming**

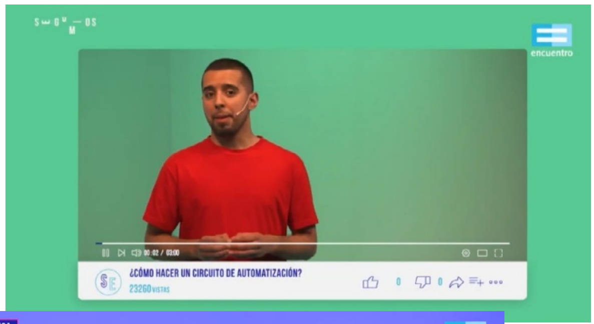
A team from the Universidad Nacional de Quilmes designed the Gobstones language. It addresses repetition, procedures and conditionals, among other concepts. It aims to teach programming to beginners. Program.AR financed this project and included activities in the book *Manual para Docentes del Primer Ciclo de Secundaria* (Manual for Teachers of the First Years of Secondary School) to offer several tools.

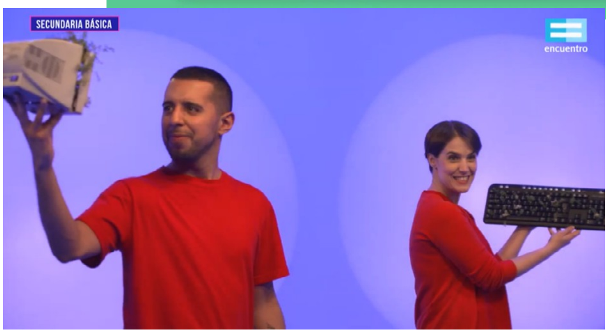


https://gobstones.github.io/

There are different ways of working in GobstonesWeb: GobstonesJr (block-based programming), GobstonesSr (text-based programming) and GobstonesTeacher (for teachers to prepare activities).

## Audiovisual material




In 2020, as per the request of the National Ministry of Education, Program.AR designed TV programs, printed booklets and radio programs on CS within the framework of Technological Education in secondary schools. The request was part of the strategy developed by the nation to ensure pedagogical continuity during the COVID-19 pandemic.

Program.AR produced eight TV programs, four booklets and eleven radio programs on programming, computer organization, networks and the Internet, digital citizenship and automation[27].

[27] Available at https://program.ar/material-didactico/#material-audiovisua

# How can we address the lack of knowledge in Computer Science?

Computer Science grew rapidly. The discipline is only 100 years and currently affects every human activity.

When we think of including this young discipline in schools, this may be the reason why there is no consensus on what should be included, which vocabulary should be used and how it should be taught.

In the 21st century, the educational community started reaching an agreement. However, there is still a long path to follow to clarify topics, priorities, specificity, etc.

In 2018, actions for scientific production related to CS teaching in schools were encouraged. This was based on recommendations by international literature regarding the four main areas of a successful policy on CS inclusion (teacher training, preparation of teachers' trainers, creation of teaching resources and research).

## JADiPro and JADiCC

In collaboration with the network of universities, the first *Jornadas Argentinas de Didáctica de la Programación* (JADiPro) (Argentine Conference on Programming Teaching) was held in 2018 at the Universidad Nacional de Quilmes[28].

The Conference aimed to promote research, publication of papers, sharing experiences of different topics such as CS teaching tools and environments; different educational levels; strategies, formats and content of teacher development; teachers' perceptions on CS teaching; link between programming and cognitive development, and impact of CS teaching on the digital gap.

The event was positive and fostered the relationship between teachers to strengthen their exchange network.

The same Conference was held in the City of Córdoba[29] the following year. The event was canceled in 2020 due to the COVID-19 pandemic. In 2021, the event was held virtually. The name of the Conference changed to *Jornadas Argentinas de la Didáctica de las Ciencias de la Computación* (JADiCC) (Argentine Conference on Computer Science Teaching)[30].

**Picture 8.** Topics addressed in the Conferences

**A Teaching of general programming**

- Analysis of content and programming teaching
- Different experiences with strategies for teaching programming in primary and secondary schools, and universities
- Topics related to the use of robotics as a tool to teach programming
- Use of other teaching tools (tangible programming, demotics, unplugged activities, etc.)

**B Teaching of Computer Science in universities**

- Research on computational thinking, time management, didactic approaches in initial subjects, etc.

**C Programming teaching environments**

- Topics related to programming learning environments (descriptions, critical analyses, classifications, etc.)

**D Computing and society**

- Gender diversity in the enrollment of different courses and students' attitudes (gap analysis, actions to improve the situation etc.)
- Modes of teaching Computer Science in schools (specific subject, transversal subject, etc.)
- Curriculum for CS teaching in different provinces

[28] See event at bit.ly/3JRvjZU

[29] See event at https://jadipro.unc.edu.ar/

[30] See event at https://jadicc.Program.AR/

According to Program.AR, programming is an important element of CS, but it is not the only one. Thus, the Conference's name was modified. Computer Science also includes computer architecture, network operation, and artificial intelligence, among others.

If people do not know this content, there is a limited understanding of reality. Thus, people are not able to actively participate in current discussions about the relationship between technology and society. Computer Science should be included in different levels of schooling from a broad disciplinary perspective. For this reason, the name of the Conference changed.

In 2021, the educational community considerably grew from 500 to 1,000 participants. The number of articles and posters also increased. Both local and international keynote speakers (from Latin America and the United States) participated in the Conference.

In 2022, JADiCC was held in a hybrid format at the Universidad Nacional del Nordeste, city of Corrientes[31].

Program.AR promotes scientific research[32] on relevant aspects to update and expand its plan of action. Along these years, it has fostered research on the low presence of women in computing degrees, the impact of programming teaching in children's executive functions, results of short courses in CS focused on labor, and CS inclusion in schooling in the Latin American region.

[31] See event at https://jadicc2022.unne.edu.ar/

[32] Such research is described in the Appendix. Related publications can be found on the "*Observatorio*" webpage at curriculum.program.ar.

# How can we support educational management teams to design and implement the necessary changes to include Computer Science in schools?

Program.AR technically advises local governments willing to undertake changes related to CS inclusion in their systems. This means including knowledge of programming, technological infrastructure, data, technology impact, computing and digital citizenship at primary and secondary levels.

The set of actions taken by Program.AR involves all the participants in the educational system, who are engaged in any educational innovation. This may include decision-making, government, persons engaged in policy implementation, and the classroom itself. In this way, there will be a broader overview of the necessary changes. Additionally, different participants will make their commitment depending on the role they play in the road map for transformation.

Program.AR also supports the implementation of the policies defined by Resolutions CFE 263/15 and 343/18.

## Key tools

**Courses for authorities**

A course was designed to reflect on academic and public policies regarding CS inclusion in the formal educational system. The goal was to raise awareness of the need to include CS in the classroom among educational authorities of different provinces across the country. The course was provided virtually in three instances. The participants included teams of educational, curricular and technological management, teams of teacher training management in different jurisdictions, unions' representatives, representatives of teachers engaged in technological and computing teaching, and universities from the network of the Program.AR Initiative.

These activities were also provided to organizations promoting CS teaching in other countries, such as the Kodea Foundation from Chile and the team of Computational Thinking Program of Ceibal in Uruguay.

This course addresses the epistemological distinction between Computer Science and other content related to computing technology[33]. It also shows the relevance of this knowledge to exercise contemporary citizenship and the role of schools in raising awareness of rights. It includes experiences from other countries and Argentine provinces regarding CS inclusion at the primary and secondary levels[34] . Finally, it provides didactic resources to address this knowledge[35].

**Diagnostic matrix, road map and curricular proposal to formulate educational policies**

Program.AR has designed a range of tools to clarify epistemological questions and support jurisdictions in updating their curriculum. Such tools include a diagnostic matrix to assess each province's context regarding the topic, a road map with different aspects to implement transformation, and a curricular proposal to guide the creation and updating of curriculum.

Program.AR proposes an initial diagnosis based on several questions related to four main dimensions:

1. Management and planning
2. CS in curricular development
3. Teacher professional development
4. ICT resources and infrastructure

Based on each jurisdiction's current situation of these four dimensions, Program.AR prepares a road map with the necessary actions to achieve the expected goal.

[33] https://youtu.be/0wYPZdzHZCk

[34] https://youtu.be/o5qINFb1ytQ

[35] https://youtu.be/1S0txqH9vZU

**Picture 10.** Diagnostic matrix

## Management and planning

» Is there a project in place to include CS in the jurisdiction?

» Which stakeholders should participate?

» Which procedures should be implemented for stakeholders' participation?

» What are the goals of the educational transformation?

» What are the conditions?

» Is there a demand or consensus in the educational community (teachers, parents, students) regarding this need?

» Can a road map be designed for such educational transformation? Which aspects should it include?

» Can the plan be reflected on a standard or rule?

» How should it be communicated?

## Teacher professional development

» In the jurisdiction, are there teacher training Institutes that prepare teachers to address computing in the classroom? And technology?

» What is the profile of professionals currently preparing teachers in computing or technology?

» Are there instances of teacher development in computing or technology in the jurisdiction?

» Who teaches computing or technology in the classroom?

» How many professionals would be needed to ensure each student of the public educational system has access to this knowledge?

» How possible is it for Institutes preparing teachers in computing or technology to offer teacher development or pre-service training to bring CS into the classroom?

## CS in curricular development

» Is CS present in the classroom?

» Which is the place of "technology" and "computing" in the curriculum?

» In the jurisdiction, what are the consequences of modifying the content of an existing subject, creating a new curricular subject or including the content in another subject?

» Are there specialists in the jurisdiction to work in the curriculum?

» Are there specialists in the jurisdiction to work in teaching proposals for each level?

» Can you measure the efforts to create material?

» Do you know any references the jurisdiction may use?

## ICT resources and infrastructure

» Are there equipment and maintenance for public schools in the jurisdiction? Does the jurisdiction receive funds from a governmental program?

» How are Institutes covered?

» Where are Institutes located?

» Is there intranet?

» Is there Internet connection? What are the characteristics (bandwidth, connection type, etc.)?

» How are resources distributed? What is the criterion?

**Picture 11.** Road map and milestones

- Updates on the new epistemological delimitation provided to officers engaged in educational management
- Definition of the relation between CS and the curriculum
- Updates on curricular content
- Teacher development and in-service training
- Pre-service teacher training
- Updates and training on the new content for principals

The curricular proposal serves as a guiding instrument so that jurisdictions can develop their own CS curriculum. This arises from the continued work of the last ten years of the Program.AR team and researchers from other organizations.

The proposal shows the CS knowledge that students are expected to acquire in compulsory education. The aim is to effectively exercise rights in a society organized around digital and computational technology. Appropriating this knowledge means performing a set of tasks that involve computational practices and disciplinary contents framed in teaching proposals, which are relevant to understanding today's world.

The scope of the content by area and computational practices depend on the educational grade and level. The approach mirrors a spiral with the knowledge expected to be acquired.

The full curricular proposal[36] is at https://curriculum.program.ar. Through the Initiative, a repository of educational resources is created, including freely available material to teach and learn CS. This aims to increase the number of users and delve into the curricular proposal from a global perspective. On the website, we can search by level, area and knowledge (based on the existing curricular proposal). It is possible to make searches by labels, format, recipient and types of discourse.

[36] See curricular proposal at bit.ly/3M1Q1ci

**Picture 12.** Curricular proposal

| Area | Citizenship and computing | Programming | Technological infrastructure | Data and artificial intelligence |
|---|---|---|---|---|
| Pillars | » Digital identity<br>» Strategies to use the Internet safely<br>» Computing and society | » Problem-solving through programming<br>» Information representation in computational problem-solving<br>» Data and data structure | » Computer organization and architecture<br>» Operating system<br>» Networks and the Internet | » Data collection and modeling<br>» Data science, artificial intelligence and automated learning |
| Practices | Computational practices | | | |

CHAPTER 4

# New lessons and challenges

We have already described the importance of including CS in schools and the main actions driven by Program.AR over a decade.

Thus, we have many lessons and reflections on the design and implementation of policies over the years and what is still pending. We want this experience to be helpful for all decision-makers and public policymakers who are facing similar challenges in the region. Thus, this chapter summarizes the main challenges and lessons.

## Coming to an understanding of what is Computer Science and the need to include this content in the curriculum

Countries addressing CS inclusion in the classroom face one major challenge: reaching essential agreements on content, the need to include CS in their curricula, what should be taught and in which educational level.

The international overview described in chapter 1 shows that including CS in compulsory schooling is relatively new. There is still no consensus regarding the epistemological delimitation of CS to introduce this knowledge in the classroom and how to do it.

In turn, countries that define CS as general capabilities and skills tend to include CS in other knowledge areas. Finally, countries defining CS as a discipline include them in a specific subject. In each case, the definition directly affects selection of contents, teaching approaches and teacher training required.

Within this framework, the Program.AR Initiative has significantly contributed to make progress in these agreements. It also promoted CS as stand-alone knowledge, and some jurisdictions need to update their Technological Education subject to address this specific content. Several actions were simultaneously taken, such as developing tools, teaching resources, teacher training programs, training and counseling for policymakers in public education, improving knowledge and raising awareness of many stakeholders. This allowed CS to be part of the public political agenda.

It should be noted that the Sadosky Foundation led all these actions. Interestingly, the Sadosky Foundation comes from the field of science and technology, outside the educational system. In fact, other countries from the region, such as Costa Rica, Chile or Uruguay, share the same feature[37].

[37] In Costa Rica, the Omar Dengo Foundation, together with the Ministry of Education, has led the design and implementation of the National Computing Program in schools. In the case of Chile, Ideo Digital, a strategic alliance between the Kodea Foundation and the BHP Foundation, has promoted the inclusion of CS in schools within the framework of the “National Plan of Digital Languages”. Finally, in Uruguay, Ceibal, a state center of educational innovation through digital technologies, was responsible for the policy of comprehensively adopting technology in education.

In this regard, there are some advantages, for example, an approach to the discipline, more innovation capabilities, certain management autonomy and the possibility of keeping track despite the changes in government. However, policymakers need to **make the Initiative their own so that it can** transform the educational offer universally and sustain it over time.

## Working across the country, forging alliances locally

As is the case of Argentina, federal and segmented educational systems pose additional challenges to think and implement educational policies and bring CS teaching into schools. Given that content, implementation and teacher training depend on each jurisdiction, it is necessary to consider the agreements reached, the context and the capabilities of each province. In this regard, the strategy was to raise awareness and develop skills across the nation to be present in every jurisdiction.

In this regard, different regional forums were organized. The goal was to engage several participants from other areas: educational authorities from each level, ministerial officers, school supervisors and principals, teachers, universities and companies. This action contributed to appropriating the Initiative at a decentralized level; thus, it would not be considered as “centralized”.

On the other hand, it was crucial to create partnerships locally to develop skills across the territory. The strategy was creating progressive partnerships with public universities and, then, with Teacher Training Institutes (IFDs), which are present in every jurisdiction. The partnerships with universities led to a) bringing academic knowledge from the national system of science and technology and b) making teams to continue developing the discipline as a subject matter and training teachers and educational staff in all the country.

The Initiative also proposed joining efforts through the collaborative work between universities and IFDs; this is, CS understanding and pedagogical knowledge. One example of such work is the development of graduate and postgraduate courses. This led to a great advantage: an innovative and comprehensive proposal. However, it also meant some difficulties, such as the effort and time to reach consensus on training goals among actors with different experiences and expertise.

Overall, the Program.AR forums and the partnerships between universities and IFDs were a key to include this topic in the public political agenda, both at provincial and municipal levels.

## Timely training of teachers and principals, and provision of effective tools

Addressing the challenge of including CS in schooling brings difficult challenges. Can we propose a new subject to a provincial Ministry of Education if there are no teachers trained in such discipline?
Can we recommend a province to offer a teaching degree if there are no job opportunities because there is no such subject in the curriculum? Thus, there is one crucial element to introduce and maintain CS teaching in schools: addressing the lack of teachers trained in the discipline and the importance of timely training, together with including the subject in the curriculum.

The Program.AR Initiative developed and/or financed the design and implementation of different training opportunities. The aim is to prepare teachers regarding content and didactics. This would set the conditions so that teachers can be trained in all the provinces. At the same time, it simultaneously leads to discussing and raising awareness among different participants of the educational system to drive curricular changes.
In the beginning, this was implemented by providing short courses, whereby teachers could oversee a classroom for a short period of time. All the above fostered discussions with the Ministries of Education to drive curricular changes.

Program.AR developed skills across the country to provide teacher training, make proposals and share knowledge. Through public calls to universities from all over the country, it was possible to create groups of CS research and teaching in the country. This also led to setting the basis to introduce the Initiative in every jurisdiction by training teachers and staff to develop didactic resources.

Consequently, Program.AR reached 23 out of 24 jurisdictions and trained almost 8,000 teachers and more than 2,000 principals. Some surveys on the training programs show a significant valuation of the technical quality of the programs due to the didactic approach and the quality of the content (Scasso et al., 2019).

It is also necessary to provide teachers with teaching resources to support teaching plans and classes. Within this framework, the Initiative is mainly characterized by the great effort made to adapt guidelines and international experiences to the local context and needs. The creation of its own tools and resources were a great achievement.

As previously described, there were no CS textbooks for teachers in Argentina until 2020 (and, in general, around the world). The Program.AR Initiative was a pioneer in the field. Textbooks are adapted to the context and organized by educational level and age. They include goals, lesson plans and detailed orientations to manage classes (including annual teaching plans for more than 50 classes). Thus, teachers were more prepared and confident in the classroom. Based on surveys made to teachers on the use of such textbooks, these resources solve the lack of teaching resources in the field. They can be used in different contexts, and teachers can select and adapt the activities (Scasso *et al.*, 2021).

Overall, teachers of all levels in every jurisdiction use the textbooks elaborated by Program.AR to teach CS. They are also used by several Latin American countries (Paraguay, Costa Rica and Brazil). The material developed for a Latin American context is the basis for other countries to assess what they can use and adapt in their context.

## Building collaborative networks and learning communities at the national and international levels

In order to improve disciplinary knowledge for its implementation, we need collaborative networks and a community of people interested in thinking and developing proposals to teach CS. Partnerships with universities and the organization of meetings and conferences contributed to building such networks. In this way, many participants across the country were engaged.

Additionally, great efforts were made to achieve international collaboration. Firstly, this contributed to considering and adapting developments and lessons from other initiatives. Secondly, it was possible to be recognized abroad.

One example was working with Code.org in the "Hour of Code". This activity encouraged people to spend some minutes playing with programming[38]. Moreover, Program.AR also worked with Ceibal (Uruguay), which is a prestigious agency in the field globally. Both entities keep working together to propose content and a teaching model. Some international judges assessed university calls.

Thanks to these activities, the Initiative achieved international recognition. Thus, some of the resources have been translated into different languages and adapted to teaching contexts.

## Developing a monitoring strategy and ongoing assessment to base decisions

Monitoring and assessing implementation and results are crucial to improve decision-making. This is especially the case of recently implemented initiatives with not much evidence.

Within the Program.AR Initiative, external agencies assessed teacher training programs, workshops in secondary schools and textbooks for CS teaching.

[38] The United States developed this initiative and was highly used at the beginning of 2010.

Some of the techniques to collect data included surveys to teachers and officers, class observations, and administrative records. Such assessments focused on analyzing the processes, implementation and some initial or intermediate outcomes. The main goal was to collect information to improve practices and strengthen plans of action.

## Having sustained resources, leadership and multidisciplinary teams over time

It is clear that teaching CS in schools, considering quality and innovation, is a challenge that requires several sustained plans of action. For that reason, investing in (human and material) resources and time is crucial to implementing and assessing actions, learning, and making the necessary changes.

A multidisciplinary team over time was key to implement Program.AR, take continuous actions and achieve such results. As the Initiative is new and disruptive, its development may take some time. In such a context, having robust teams to work with is highly important.

Moreover, having a specific budget is also vital to perform all the required actions since it is not possible to bring CS into schools with short-term strategies[39].

## Some lessons from the pandemic

The COVID-19 pandemic was disruptive around the world. Working and studying from home became mandatory during lockdown, at least until vaccines were massive. Thus, it was necessary to rethink the plan of action in the light of this new context.

Both capital and knowledge allowed us to respond quickly. Firstly, the program “Program.AR at home” was implemented (the existing content was adapted). The content of teacher training programs was provided virtually so that universities could continue with their academic programs. Workshops for secondary school students were redesigned to be provided remotely. New learning was acquired from this experience, broadening the latest plans of action. For instance, learning about virtual classes combining synchronous and asynchronous lessons allowed us to engage other participants to exclusively provide virtual courses[40].

[39] Financing by the Development Bank of Latin America and the Caribbean allowed Program.AR to be independent from the changes in government in Argentina. It also supported the continuity of the plan of action.

[40] In 2020, the “Programming and Teaching” course was offered virtually by the *Instituto Nacional de Formación Docente*, with a duration of 120 hours. The course was named “Strategies for Programming Teaching I, II and III.”

Another example was “CS Remote Classes”, whereby the teacher remotely taught the discipline together with a specialist in the field. This was an adaptation of the work by the Sadosky Foundation and Ceibal (Uruguay). One of the main advantages of this modality is the possibility of mitigating the lack of teachers trained in the discipline since specialists participate virtually. This also contributes to training classroom teachers who are working with specialists in the field. However, this experience showed that a program with such characteristics requires infrastructure and equipment. These are not ensured in Argentina to develop the program successfully and homogeneously in different institutions.

## Scalability challenges

Program.AR has weathered the storm to incorporate CS teaching in the Argentine educational system. It has also promoted innovative proposals and learning to be leveraged by other countries in the region. However, the main pending challenge is to massively expand the Initiative to reach the whole world of students with top quality.

For that reason, there are still some core issues to be addressed. Firstly, although CS was introduced into compulsory education through a formal rule (NAP of digital schooling, programming and robotics), specific implementation in the curriculum depends on each jurisdiction in a federal country such as Argentina.

Heterogeneous contexts within its own territory should also be considered. Since the ability to deploy (knowledge and human) resources varies among jurisdictions, it is necessary to provide differentiated advice and specific resources so that each jurisdiction can face such challenges.

A strong relationship between Program.AR and the provincial Ministries of Education were a milestone to legitimize actions. However, the National Ministry of Education needs to play a major role in reaching scalability in the educational system considering heterogeneity.

Addressing the need for teacher training scalability is another crucial challenge. This is necessary to expand good-quality CS teaching and faithful to the learning goals set. For such purposes, it would be important to have an overview of current teacher training capabilities.

In this way, it would be possible to develop plans of action and allocate resources effectively to cover pre-service teacher training, professional development and the implementation of curricular guidelines in the classroom.

It would be favorable if national assessments were made to account for the Initiative implementation and results across the country. Information on whether the actions contribute to developing students' learning and how actions impact on closing gender and socioeconomic gaps is strategic to inform decisions aimed at adjusting or improving future plans.

Overall, policy scalability requires a mid and long-term strategy. Moreover, it is crucial that key decision-makers make the educational system their own and have the resources to implement policies. The Program.AR Initiative's ten-year journey sets a robust basis for knowledge and learning. It will serve as an instrument to guide future decision-making in Argentina and other countries of the region that are facing the same challenge.

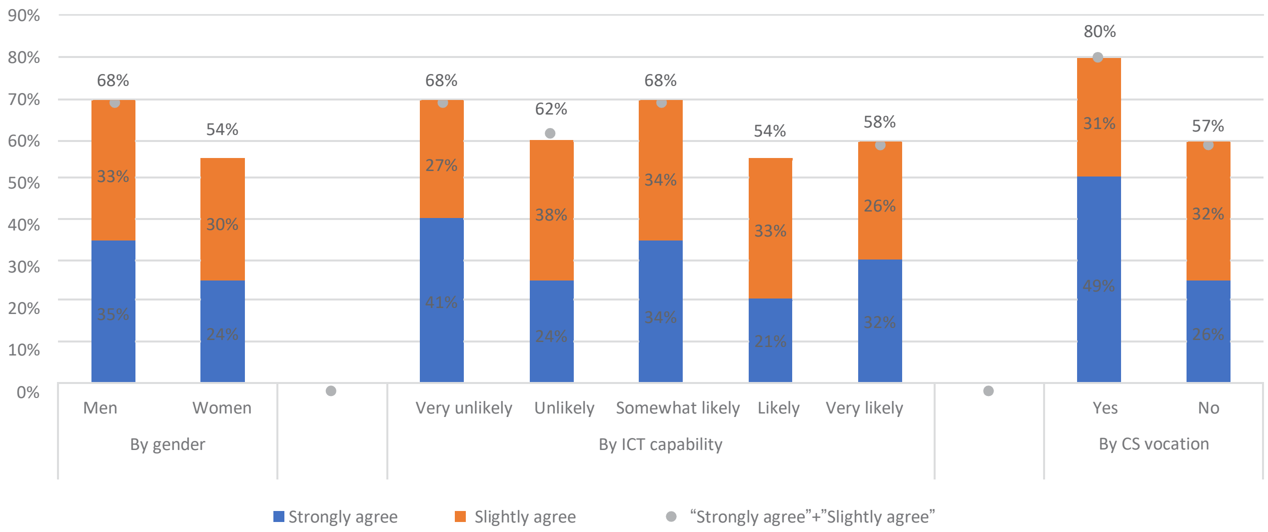
# Scope of Program.AR

## “Vocation for ICT” workshops for students: results and opportunities

Workshops were assessed in 2019.
The assessment (Scasso *et al.*, 2019) focused on the characteristic and systematic valuation of the development and adoption of strategies in the country. It highlighted relevance, institutional relationships among local participants and how the groups involved valued the Initiative.[1]

[1] A field research was conducted in four jurisdictions, including 750 surveys made to the workshop coordinators and students from secondary school.

**Picture 13.** Percentage of students’ answers to
“This course encouraged me to know more about the topic” - 2018




**Source:** Scasso, Marino, Colobini and Bortolotto (2019)

According to the assessment, one of the main results was that students were able to know which free-of-charge university degrees were available and meet a mentor to ask for information and clarify doubts. This relationship fosters teenagers' interest in the topic. In addition, it allows them to make effective decisions so that vocation is materialized in a degree enrollment.

The workshop was highly valued, specifically by a group of students with intermediate knowledge of computing technology.

Finally, the workshop is an additional motivation for students who explicitly state some vocation for Computer Science to delve into the topic. At the same time, almost half of students who do not foresee getting involved in these topics find the workshop as a driver to spark interest in programming. After the course, a significant percentage from the first group performed actions to expand their knowledge in the area compared to the remaining groups.

Thus, the course serves as a driver for those who are interested in this field of knowledge.

Additionally, the assessment shows wide gender gaps regarding the interest in the topic, development of ICT capabilities, proposal assessment and tendency to CS vocation. In all variables, men state more interest in and use of ICT than women.

Concerning students' experience, students find the workshops to be successful due to three factors: they are entertaining, helpful and clear.

**Table 4.** Percentage of students who answered, "After the workshop, I...". Percentage by gender and positive tendency towards CS vocation - 2018

| | **By gender** | | **By CS vocation** | |
|---|---|---|---|---|
| | Male | Female | No | Yes |
| I searched for more information about programming | 23.1% | 7.6% | 10.5% | 35.2% |
| I searched for university degrees related to programming | 11.6% | 1.7% | 3.2% | 18.5% |
| I searched for additional courses related to programming | 15.7% | 5.1% | 5.3% | 29.6% |
| I installed a programming software on my computer | 24.8% | 9.3% | 13.7% | 27.8% |
| I changed my personal passwords | 19.0% | 12.7% | 13.7% | 24.1% |

**Source:** Scasso, Marino, Colobini and Bortolotto (2019)

# Courses, specialization and teacher training programs: results and opportunities

## Course for teachers: “Programming and its Teaching”

Teacher training courses were pioneers in addressing programming teaching in Argentina. Such programs are provided by public universities, which are part of the Program.AR community.

The course has a duration of 100 hours, including practice. It is offer both virtually and in-person and has several synchronous meetings. The universities providing the course are responsible for managing the recognition of these programs by the Department of Higher Education in each province, as well as the scoring for teacher certification.

In 2018, an external assessment was made regarding the course provided in ten provinces by 16 universities. Around 1,500 teachers participated in such assessments (Scasso *et al.*, 2019).
The assessment showed that “Programming and its Teaching” courses are highly valued by teachers, even in the case of teachers who do not teach of subjects related to computing, technology or programming.

According to the teachers surveyed, the course is very different from other training programs and it provides innovative tools to teach students, which exceeds traditional proposals. Consequently, programming teaching is considered a channel to share knowledge that goes beyond disciplinary content. Teachers positively value the teaching strategies and the didactic approach.

The performance of the teachers in charge of the course was highlighted, especially their knowledge and personal willingness. The participants stated that the course content was relevant, updated and thoroughly selected.

### “Programming and its Teaching” in numbers

**+ 4,500**
**participants**

**7**
**editions**

**23**
**provinces**

Moreover, it is possible to note that teachers reinforce the importance of teaching programming in compulsory education.

For example, after the course, teachers are more convinced that teaching programming does not need to be based on a specific environment if it is focused on concepts—and not on instruments. In this way, the Initiative is different from other policies implemented.

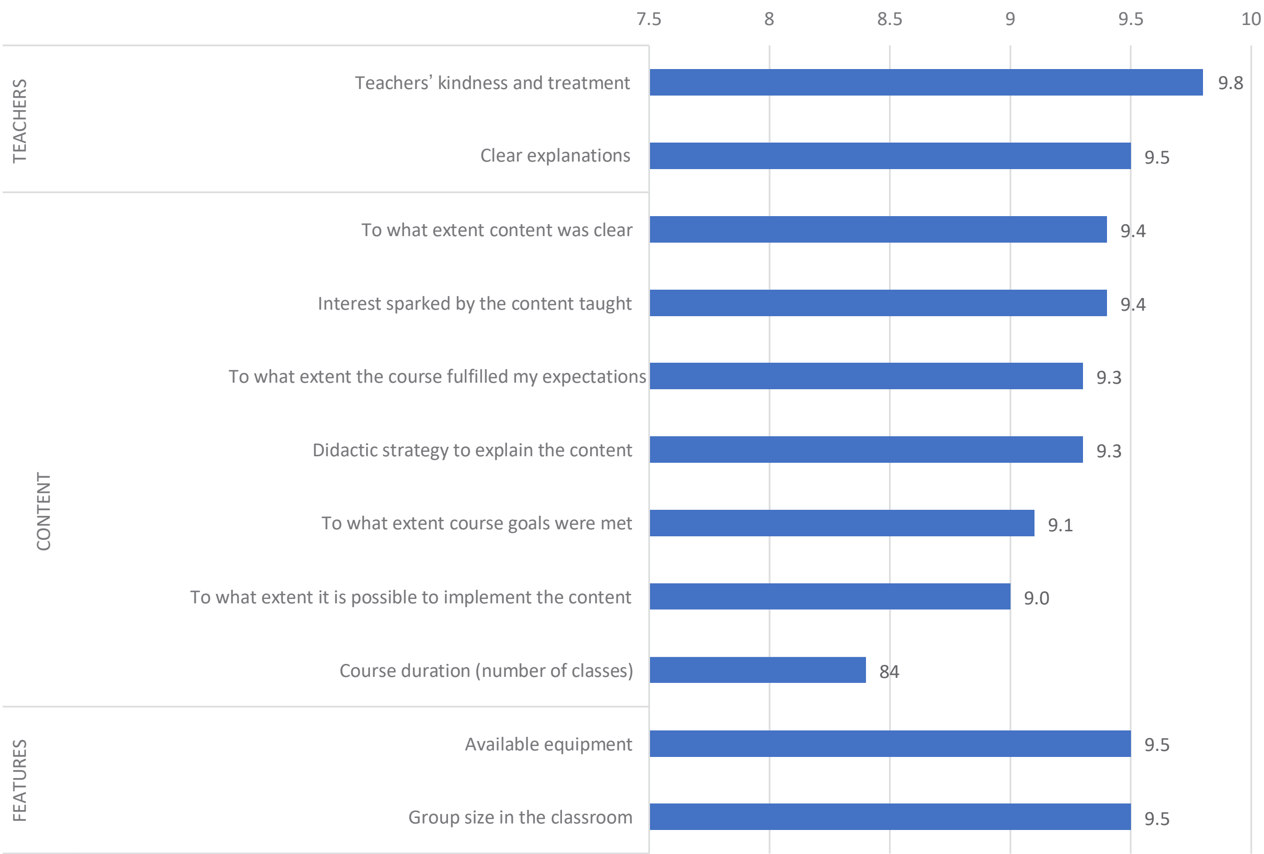
Finally, the assessment showed that the Program.AR plan of action, and the workshops in secondary schools, are strategies to highlight the importance of sharing this knowledge. It also achieves a high level of engagement.

Implementing the Initiative in different contexts confirms that it is possible to apply these proposals in a variety of contexts without losing identity.

In conclusion, the technical design and territorial management of the Program.AR Initiative are the main strength of the training program. The combination of both leads to innovative, effective and adequate instances in context.

Territorial presence is a key element to strengthen the dialog between what is general and what is local. It also fosters reflection on work processes among the stakeholders involved.

**Picture 14.** Average score given by participants regarding course teachers, content and characteristics (from 1 to 10)




**Source:** Scasso, Marino, Colobini and Bortolotto (2019)

**Table 5.** Percentage of participants grading the following statements with “Strongly agree” or “Slightly agree”. Questionnaire at the beginning and end of the course

| | Percentage | | |
|---|---|---|---|
| | Initial survey | Final survey | Difference |
| Every student should have basic Computer Science concepts, regardless of the orientation. | 95% | 96% | 1% |
| Learning Computer Science in compulsory education is as important as learning Language and Math. | 91% | 96% | 4% |
| Computer Science principles may be taught without being based on the use of specific technology. | 79% | 89% | 10% |
| Computer Science teaching in secondary school should focus on the use of word processors, spreadsheets and other tools required by the labor market. | 70% | 38% | -32% |
| The computer is not essential to learn Computer Science; it is just a tool. | 56% | 72% | 16% |
| Computer Science tools and capabilities become obsolete in the light of technological advances. | 51% | 40% | -11% |
| Generally, men find it easier to learn Computer Science. | 26% | 22% | -5% |
| Generally, creative people have more limitations to learn Computer Science. | 20% | 19% | -1% |

**Source:** Scasso, Marino, Colobini and Bortolotto (2019)

## Course for leading teams

Program.AR designed a training program aimed at teams leading educational institutes who want to understand the reasons and particular challenges of CS inclusion in the classroom. This is framed in the context of educational transformation due to digital technologies.

The different editions were provided by the UNESCO International Institute for Educational Planning, the National Ministry of Education, the Ministries of Education of Entre Ríos, San Juan, Santa Fe and Tierra del Fuego, and the *Instituto Nacional de Fomación Docente*.

### Course provided to leading teams in numbers

**+ 2,300**
**participants**

**6**
**editions**

**in all**
**the provinces**

These editions included repetitions of content, activities proposed and a virtual modality.

The course is currently aimed at providing tools for institutional analyses and a conceptual framework to strengthen the roles of educational leading teams. The goal is to support and boost significant CS content in institutions.

Through this course, participants will be able to identify CS knowledge, understand its relevance to exercise rights in the 21st century, differentiate this knowledge from other instrumental uses related to ICT, and set criteria to select teaching resources to teach CS in primary and secondary school.

## Higher-education specialization

Higher education specializations are original educational trajectories. Eight universities, together with eight *Institutos de Formación Docentes*, designed such specializations under the Program.AR advice. The provinces of Buenos Aires, Entre Ríos, Córdoba, Neuquén and Santa Fe participated.

The initiative has different particularities. In 2016, Program.AR promoted specializations in CS teaching. For such purpose, there was an open call addressed at universities and *Institutos de Formación Docentes* in every jurisdiction. The condition was that both institutions should apply together.

A group of international judges evaluated many institutes. The applications of the following cities were selected: Córdoba, Concepción del Uruguay, Río Cuarto, Rosario, Neuquén, La Plata, Lanús and Tandil.

Each pair of institutions (university and the *Instituto de Formación Docente*) built a work team, developed a teaching proposal, selected material and bibliography, prepared schedules, appointed teachers for each module, managed the approval by the Department of Higher Education dependent on each Ministry of Education and provided the specialization course. The technical team from Program.AR monitored, assisted, financed and supported each stage.

The Ministries of Education approved each project and provided scores for teacher certification. Curricula are available to be replicated in these or other jurisdictions[1].

Specializations addressed programming and algorithms, information and data representation, security, networks and the Internet and computer architecture. All the projects focused on algorithms and programming. At least four modules addressed such topics, regardless of the teachers' level or training. Overall, between 120 and 200 hours were aimed at these topics in two years. All the specializations had a duration of 400 hours, and 80% of such total was taught in person.

In 2019, four of these experiences were assessed: Rosario, Córdoba, Río Cuarto and Concepción del Uruguay (Scasso *et al.,* 2019). Different information was analyzed by combining different methodologies. Thus, this helped to develop the specializations and identify strengths and improvements. Moreover, it measured the results based on two factors: participants' satisfaction with the proposal and specific contributions taught in the course. Based on the assessment, it is possible to summarize three outcomes:

- **Knowledge**: participants were examined[2] to identify positive learning results. Learning was more evident in the recognition of didactic strategies than in some disciplinary content. For example, there were some difficulties in working with codes.

- **Bringing content into the classroom**: there was enormous capability to materialize the content addressed in the specialization course into actions for the classroom. All the participants were supported when bringing the content into the classroom to build confidence.

---

[1] Specialization curricula available at bit. ly/3JU5yb9.

[2] To assess participants' knowledge, a standardized examination was prepared and implemented in the last two months of the specialization. A description of criteria and procedures considered to prepare such assessment is included.

- **Sense**: teachers and participants shared convictions regarding the importance of incorporating programming in compulsory education and pre-service teacher training. Moreover, they agreed that activities can be conducted despite limited technological resources. In turn, there are different opinions regarding the relevance of computational thinking.

### Specializations in numbers

**+ 1,000 teachers**

**in primary and secondary school**

**5 provinces**

## Responsible parties

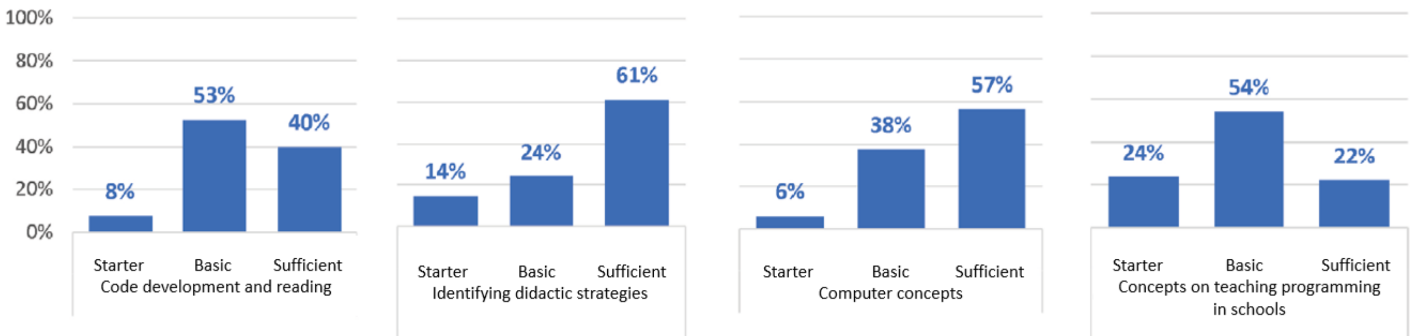
**Primary level:**

- Universidad Nacional de Rosario and Escuela Normal Superior No. 36 “Mariano Moreno”
- Universidad de Río Cuarto and Instituto Superior Ramon Menendez Pidal
- Universidad del Centro de la PBA and IFD No. 166, Escuela Normal Superior “Gral. José de San Martín”

**Secondary level:**

- Universidad Nacional de Córdoba e IFD Simón Bolívar
- Universidad Nacional del Comahue e IFD No. 6
- Universidad Nacional de La Plata e IFD No. 95
- Universidad Nacional de Lanús e IFD y Técnica No. 24 “Dr. Bernardo Houssay”
- Universidad Provincial de Entre Ríos y la Escuela Normal Superior “Mariano Moreno”

**Picture 15.** Percentage of participants based on exam performance




**Source:** Scasso, Cura, Marino and Kaplan (2019)

**Table 6.** Percentage of participants who worked with content in the classroom

| | Total |
|---|---|
| Algorithms | 10% |
| Computer assembling and disassembling / Hardware | 27% |
| Apps, (generic, operative system, Office Online) software | 9% |
| Logical/computational thinking | 21% |
| Programming concepts | 24% |
| Other programming languages | 6% |
| Block-based programming | 43% |
| CS concepts | 9% |
| Problem-solving | 14% |
| Robotics | 9% |
| Math / Operations | 7% |
| Other | 14% |

## Informatics Education Degree

Together with the Universidad Pedagógica Nacional (UNIPE), Program.AR designed the first Informatics Education Degree in Computer Science teaching[3]. The name Informatics Education Degree (*Profesorado en Informática*) follows the naming convention for degrees. This course of study lasts four years and is oriented to pre-service teaching training.

The proposal is innovative. It arises from the need to meet the demand for specialized teachers while CS is being incorporated into the compulsory educational trajectories at the secondary level in different jurisdictions. The degree is provided in the City of Buenos Aires, and it was created in 2015.

[3] Curriculum of the informatics education degree (UNIPE) available at https://unipe.edu.ar/formacion/carreras/profesorados/item/655-profesorado-en-informatica.

The degree proposes a balance among general training, discipline knowledge, pedagogical training and professional practice.

Disciplinary knowledge is divided into seven areas:

1. Programming
2. Technological infrastructure (hardware, operating systems and networks)
3. Data (data basis, data science, and artificial intelligence)
4. Math in Computer Science
5. Computer Science teaching
6. Technology, society and digital citizenship
7. Computer system theory

Programming is the main area since it is the basis for the other ones. Moreover, it provides the necessary practical skills and experience to run projects in the classroom.

One-quarter of the total 1,600 hours aimed at disciplinary training is exclusively to address programming teaching, computer organization and the Internet, data science and digital citizenship.

There are also elective subjects that contribute to teachers' general training. One characteristic is that this content is innovative, but there is no consensus on its mandatory nature among academic groups.

## Professional development for Technology Education teachers focused on Programming

The professional development program of Technology Education focused on Programming is the first official program recognized by the *Comisión Federal de Registro y Evaluación Permanente de las Ofertas de Educación a Distancia* [Federal Office of Registration and Continued Assessment of Distance Education Programs] Pursuant to Decision 2698/2022, this program should be provided by the *Instituto Nacional de Formación Docente* from 2022 to 2027.

The program seeks to deepen the knowledge of Technology Education teachers and related curricular subjects to strengthen professional practices to teach Programming.

This program is provided virtually and lasts one year. It is aimed at Technology Education teachers across the country, considering social and cultural diversity, local particularities and the needs of different people and institutions of the Argentine educational system.

The course is organized into two main areas:

- considering programming **as part of a broader discipline**, that is, Computer Science,
- understanding the **impact of digital technology and computing** in social development.

The methodology covers teachers' need to know which content should be taught.

It also addresses how teachers can introduce this content to teenagers significantly, based on specific didactic strategies to teach programming.

This is accomplished through programming workshops. Such workshops propose problem-solving by inquiry, reading, critical thinking and reflections in context to understand and appropriate new concepts, such as presenting robust and well-based arguments.

Different activities to teach programming are conducted with no computers or in other environments, which may be used online or offline.

## Computer Science textbooks: analyses of their use in the classroom

The book collection was assessed in 2020 through surveys, focus groups and class observations. The final report was published in 2021. (Scasso *et al.,* 2021).

The findings of such assessment can be summarized as follows:

- The books solve the lack of material, facilitating the **inclusion of content for less trained teachers**.

- The distribution of textbooks and printed copies **was federal** since it represented how teachers are distributed in all the jurisdictions.

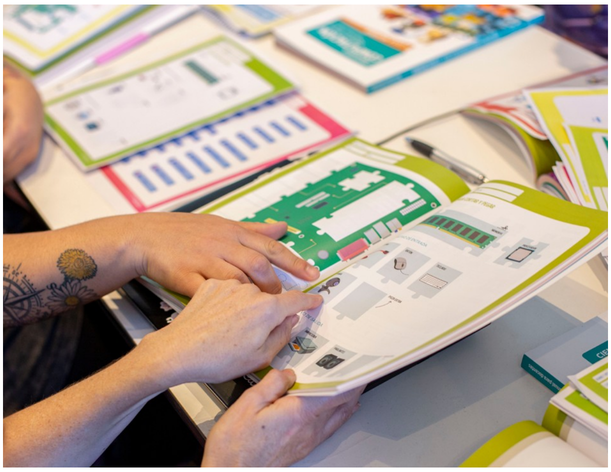
- The books can be **adapted to different contexts**. Although many users of the collection teach subjects related to Computing or ICT in secondary schools, there are also many uses for other curricular subjects. The collection is also adapted to virtual contexts (driven by the COVID-19 pandemic).

- It was possible to identify that the books were **typically used in two ways**:
    a. Firstly, it is used as an **organized compendium of activities**.
    Teachers who are not familiar with the field, such as elementary teachers, select and use certain activities of each lesson plan individually. This entails a higher risk of changing the comprehensive sense of lesson plans.
    b. Secondly, it is used as **content organized in plans**. ICT teachers use lesson plans as presented in the books. They only make some minor changes to the activities proposed.

- The books **mainly serve** as:
    a. facilitator of **class organization and planning**;
    b. tool for teachers less trained in the field to **teach CS content**;
    c. high-quality didactic proposal with **effective activities and lesson plans**;

- The activities proposed in the books **impact positively on students**. In addition, most of the teachers know that the activities "work well", but they do not know the reason why. Thus, they do not recognize the didactics of teaching by enquiring as an asset.

- It is also possible to highlight the **great capability of class organization**:
    a. Regarding **time**, the books propose enough time for each part of the activity. This allows students to reach the expected results. Moreover, teachers can cover all the topics.
    b. In relation to **anticipating difficulties** that may arise during the class, the books allow teachers less trained in the field to feel confident to teach the class. Moreover, teachers' responses to such difficulties are consistent with the didactic approach.



# Program.AR research

Program.AR promotes scientific research on CS teaching in schools. We present a brief *racconto* of research conducted so far.

### *Y las mujeres… ¿dónde están?* (Where are women?)

In 2013, the Sadosky Foundation studied the low presence of women in informatics. A group of sociologists carried out the research, which aimed to understand the phenomenon to design specific public policies or adapt the already-existing ones.
Given there were studies that had widely asked women if they were engaged in the field, it was decided to continue studying women who had not participated yet.

This report arises from surveys made to 627 teenagers from the metropolitan area of the Province of Buenos Aires. The study aimed to analyze male and female teenagers’ perceptions of computing, and compare the results. Teenagers’ perceptions were divided into different pillars: job, higher education, free time and capabilities, computers, computer programs and people developing computer programs. The main conclusion of the report can be summarized as follows:

“The perceptions that deter women from Computer Science are largely established during adolescence, both among men and women”[1].

### Teaching programming may improve executive functions in children from low socioeconomic status

In 2018, the first research[2] on this topic was conducted on five-year-old children from preschool in the metropolitan area of the Province of Buenos Aires.

Executive functions are cognitive processes such as attention, inhibitory control, working memory, flexibility, planning and fluid intelligence. Those are key factors for learning and general life. Poverty may have an impact on executive functions. These functions are trained and dramatically developed at the preschool stage.

---

[1] The report can be downloaded at http://www.fundacionsadosky.org.ar/wp-content/uploads/2014/06/Informe-sobre-Genero-final.pdf.

[2] Hermida, M. J.; Goldin, A. P.; Perez Santangelo, A.; Lipina, S. J., y Schapachnik, F. P. (2022, September 11–14). Effects of teaching programming on executive functions in children from low socioeco- nomic status. 3rd FALAN Congress, Belem, Brazil. https://osf.io/s4h35/?view_only=6bce1ce66daf4855b6d63110bb495132.

It has been suggested that programming teaches "thinking". This occurs because it affects creative and critical thinking, social skills, mathematical thinking and metacognition (but it does not affect language). However, there was no evidence in this regard.

Researchers wonder whether programming can train executive functions in preschool. They also consider the impact of socioeconomic status. Thus, a field experiment was performed in schools of medium socioeconomic status (MSES) and low socioeconomic status (LSES). The study was conducted in a classroom for 5-year-old children. A programming group received programming lesson plans (with Scratch Junior) and a control group received visual art lesson plans. Twelve lessons were designed, tablets were provided and teachers were trained.

Moreover, there were tests before and after the intervention. The findings of the study show that children at MSES have better inhibitory control, fluid intelligence, working memory and attention. On the other hand, attention was better in children attending LSES schools.

The results offer promising exploratory evidence of programming potential to develop other skills. However, as signaled by Hermida, Garzón y Martínez[3], the use of computers to teach does not guarantee learning. Teachers should propose knowledge that students are expected to gain.

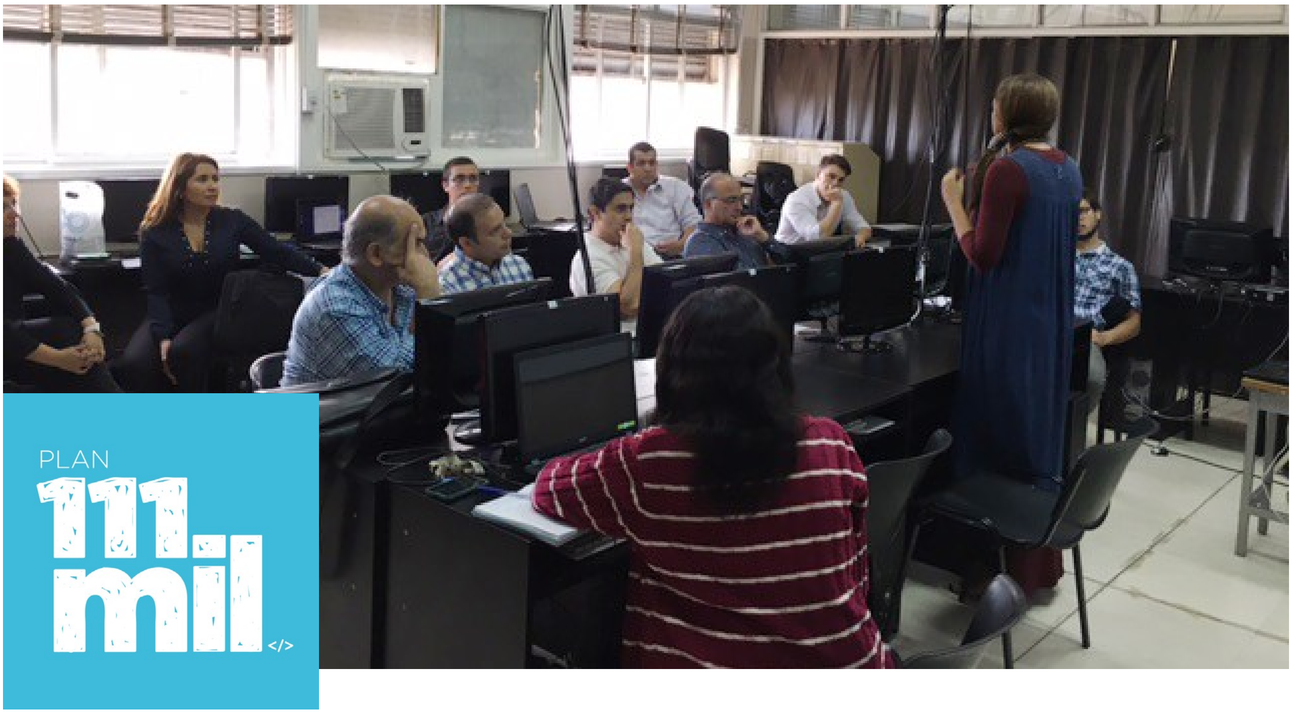
## Report on lack of short training courses for the labor market

In 2016, the *111 Mil* Program was launched. This Program is an eight-month training course for programmers. The goal was to train 100,000 programmers, 10,000 professionals and 1,000 entrepreneurs and get them into the market. It was not only a training proposal, but it also offered specific mechanisms to break into the labor market rapidly.

It was possible to note that the Program attracted a considerable number of participants (more than 126,000) after four years. However, the results were not as expected: only 1.5% of participants accredited the course. This figure increases by 2% if we consider the participants who took an exam without attending the course. Moreover, there were no actions to train professionals and entrepreneurs.

---

[3] See article at https://editorarevistas.mackenzie.br/index.php/ptp/article/view/15617/11624.




Research and data show high levels of dropout and poor access conditions and accreditation for women. In addition, there is no evidence that the participants who were certified could get jobs related to programming. However, it seems that the Program fulfills the goals of certifying professionals' knowledge, who are already in the labor market, and proposing a first approach to programming (without getting into the market) in the case of people with no previous knowledge.

The Program.AR Initiative prepared a report with the main characteristics of the Program and its results. The report was based on different documents, research, statistics and websites related to the launch and dissemination of the Program. It aims to discuss whether short courses are helpful to meeting the market needs regarding professional human resources[4].

### Technology as curriculum content. Study for the UNESCO 2023 Global Education Monitoring Report

In 2022, Program.AR conducted a study on CS inclusion in the curriculum of seven Latin American countries (Brazil, Argentina, Uruguay, Costa Rica, Chile, Paraguay and Cuba).

This research was requested by Global Education Monitoring (GEM) Report, financed by UNESCO[5].

The research aimed to document and analyze educational policies and programs developed by governmental and non-state agencies in such countries. In this regard, it also explores each country's challenges and the actions they perform to achieve CS inclusion in their curricula. In particular, the report identifies:

a. **educational and social problems** addressed by each country by introducing CS in schools (such as digital divide, gender gap, technological sovereignty);
b. **challenges and tensions** derived from curriculum reforms;
c. **curriculum content knowledge** to be incorporated, and
d. **professional development** and other programmatic policy strategies that contribute to including this knowledge in the trajectory.

---

[4] Quántitas Foundation, Characteristics of the *111 Mil* Program (summary): https://fundacionquantitas.com.ar/sitio/wp-content/uploads/2022/01/Caracterizacion-del-programa-111Mil.pdf.

[5] Program.AR submitted the report to the UNESCO in 2022. The UNESCO will publish the report in 2023.

## Research on university computing careers

Program.AR conducted research on university computing careers, students' profiles and how they approached the course of study, their experience and permanence in educational institutions, their relationship with the labor market and their future professional horizons.

The research had two stages. The first stage was making a diagnosis of the situation by addressing the actors, i.e., educational institutions participating in the study and other persons from such institutions. Then, secondary data was used from 2011 to 2020 provided by the Secretary of University Policies. This data allowed Program.AR to determine many indicators. The second stage was focused on the population of students in computing careers. Data was obtained through surveys (more than 1,200) and interviews (24).

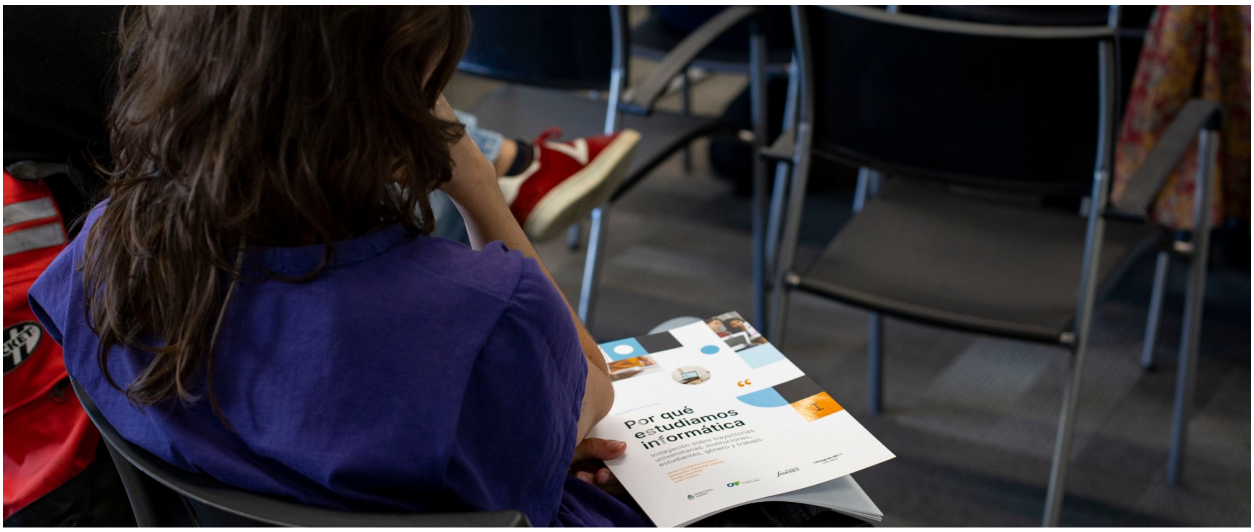
The findings of the research are presented below. Firstly, 80% of (public and private) universities provide some courses of study related to computing. The number of computing careers in public universities increased by 21%. Regarding discipline and offer evolution, postgraduate computing careers slightly increased (2%). In the case of undergraduate careers, the growth was more significant (27%).

Computing students represented almost 5% of the university system in 2020. Women accounted for less than 18%. However, in the remaining system, they represented nearly 62% of the population.

Overall, during the period analyzed, computing students increased by 25%. Men had more representation (27%) than women (19%). It was possible to note that the number of enrollments in computing careers increased, compared to other careers with more woman's representation.

Students were asked if there is gender inequality in their careers. Women agreed with this statement (41%) compared to men (22%). Additionally, women and people with non-masculine gender identities stated they had suffered violence during their experience in university. Violent situations include comments that underestimate or question their skills (25% and 36%, respectively), as well as discriminatory statements regarding their gender or sexual orientation and sexual jokes (21% and 29%, respectively). Although the survey did not delve into the offenders' gender, it was possible to find that 50% were students and 45% were teachers.

Finally, more than half of students are in the labor market and the majority work in ICT. They state that they are satisfied with their workplace and that they have gained the necessary knowledge (in the first years of the course of study) to work independently. Students also recognize that academic institutions favor permanence and graduation through scholarships, mentoring and internships.



# Counseling to Argentine provinces and other countries

## Jurisdictions and type of counseling

Between 2016 and 2022, the provinces of **Tucumán** and **Chaco** developed a pilot project to reorganize secondary schools (UNICEF PLaNEA[1] program). The respective provincial Ministries of Education have updated Technological Education towards a CS teaching project. The Program.AR Initiative has designed educational projects to address the Internet, programming and computer architecture, among other topics. In addition, it has trained Technological Education teachers.

Between 2016 and 2019, the province of **Neuquén**[2] drafted its first curriculum for secondary school according to the *Consejo Federal de Educación* and Law 26206. The province decided to incorporate Computing as part of the curriculum in all modalities of secondary education. Thus, it established a teaching paradigm based on the scientific and technological basis provided by Computer Science field. The Program.AR Initiative has technically advised such design and supported the development of a pre-service teacher training program to train the teachers that will teach the subject.

In 2018, the city of San Rafael, province of **Mendoza**, modified the curriculum of the Technological Education Teaching career. Program.AR has supported such reformulation.

Program.AR has also supported and advised the province of **La Pampa** in 2022. The goal was to reorganize the curricula of subjects related to Technological Education in preschool, primary and secondary education. The provincial government is currently assessing such curricula. In the case of the province of **Tierra del Fuego**, professional development actions were performed. Moreover, a team of teachers' trainers provided training on programming teaching in the Ministry of Education.

[1] bit.ly/3JSDd55

[2] https://www.neuquen.edu.ar/resolucion-146318-diseno-curricular/

## Counseling in other countries

Since 2018, Program.AR has been a strategic partner of the Computational Thinking Program of Ceibal, in **Uruguay**. In the context of this partnership, Program.AR designs the lesson plans of the Computational Thinking weekly lessons for the last three grades of primary education. It also provides guidance on the curriculum for primary and secondary education and it gives 900 weekly programming classes with a team of 100 Argentine teachers trained by the Initiative.

## Program.AR in the COVID-19 pandemic: pilot remote CS classes

In the context of the COVID-19 pandemic, Program.AR developed a program of pilot remote CS classes in Argentina. The goal was to implement pilot remote CS classes aimed at students of the last years of primary school and first years of secondary school during the social, preventive and mandatory distancing.

The pedagogical modality employed in the case of Ceibal in Uruguay was adopted. Within its framework, Program.AR provided programming classes with a teacher who delivered a synchronous weekly class virtually, while the classroom teacher supported the students. This program started in August, 2020. Four Argentine provinces volunteered to participate: Jujuy, Misiones, Chaco and Córdoba.

The program was integrated into formal education. Classes were organized under the project format, with a duration from 8 to 10 weeks. It combined different strategies, such as blended learning, flipped classroom and projects.

Pedagogical pairs consist of one tutor specialized in CS teaching by Program.AR and the classroom teacher, who knows students and can relate the content to previous experiences, and curricular and institutional objectives.

To implement the pilot test, Program.AR organized different teams of pedagogical mentors and technicians in each province. Every provincial Ministry also appointed mentors. Provincial management teams selected schools, teachers and groups.

Table 7 shows the scope of the program.

Remote classes started in September and ended in November 2020. Based on the program assessment, the pedagogical model (pairs) was highly valued, as well as the content and didactic strategies (Scasso *et al.*, 2021).

However, the use of educational platforms was still very limited. There were several difficulties related to the lack of connectivity and equipment for teachers and students, the variety of platforms used, and heterogeneous participation. The pandemic strongly influenced this. In this regard, the number of participants at the beginning decreased. This mainly occurred because children and teenagers were not engaged in school activities.

**Table 7.** Expected and actual scope

| Provinces | Schools | Groups | Students Expected | Participants (students) | Participation % |
|---|---|---|---|---|---|
| Córdoba | 25 | 52 | 1,171 | 462 | 39% |
| Misiones | 14 | 23 | 241 | 161 | 67% |
| Chaco | 28 | 46 | 622 | 420 | 68% |
| Jujuy | 18 | 29 | 673 | 357 | 53% |
| **Total scope expected** | **85** | **150** | **2,707** | **1400** | **52%** |

# References

Agencia de Noticias Ciencias de la Comunicación (ANCCOM), (2020). Available at: http://anccom.sociales.uba.ar/

Barker, L. J., y Aspray, W. (2006). *The state of research on girls and IT*. Available at: https://www.researchgate.net/profile/ Lecia-Barker/publication/253703327_1_The_State_of_Research_on_Girls_and_IT/links/5646049708ae54697f- b9cba8/1-The-State-of-Research-on-Girls-and-IT.pdf

Boix Mansilla y V., Gardner, H. (2005). *¿Cuáles son las cualidades de la comprensión? La enseñanza para la comprensión. Vinculación entre la investigación y la práctica*. Editorial Paidós, Buenos Aires, Argentina.

Bonello, M.B. y Schapachnik, F. (2020). *Diez preguntas frecuentes (y urgentes) sobre pensamiento computacional*. Revista Virtualidad, Educación y Ciencia, Volúmen 11, Número 20. Universidad Nacional de Córdoba. Available at: https://revistas.unc.edu.ar/index.php/vesc/article/view/27453

Borchardt, M.; Bonello, M.; Marés, L.; Martínez, C. y Roggi, I. (2020). *Identificación y análisis de proyectos de enseñanza de pensamiento computacional en educación primaria y media.* Red para la Alianza para la Digitalización de la Educación en Latinoamérica (ADELA). Available at: https://curriculum.program.ar/descargar/LasCienciasDeLaComputacionE nLaEscuela.pdf

Centro de Estudios Legales y Sociales (2022). *El ministerio de seguridad de la Ciudad buscó información biométrica de 7 millones de personas de manera ilegal.* Available at https://www.cels.org.ar/web/2022/04/el-ministerio-de-seguridad-de-la-ciudad-busco-informacion-biometrica-de-7-millones-de-personas-de-manera-ilegal/

Clavero, J. A. (2018). *Posverdad y exposición selectiva a fake news. Algunos ejemplos concretos de Argentina*. Revista Contratexto, Perú.

Coursera Global Skills Report (2022). Available at: Coursera- Global-Skills-Report-2022.pdf

Denning, P. J.; Comer, D. E.; Gries, D.; Mulder, M. C.; Tucker, A.; Turner, A. J. y Young, P. R. (1989). *Computing as a discipline.* Computer, Volume 22, Issue 2. Available at: https://ieeexplore.ieee.org/document/19833

Fraillon, J.; Ainley, J.; Schulz, W.; Friedman T.; Duckworth D. (2020). *Preparing for Life in a Digital World*, IEA International Computer and Information Literacy Study 2018 International Report. Available at: https://link.springer.com/book/10.1007/978-3-030-38781-5

Harari, Y. N. (2020). *The world after coronavirus*. Financial Times. Available at: https://www.ft.com/content/19d90308- 6858-11ea-a3c9-1fe6fedcca75

International Computer and Information Literacy Study (2018). *Technical Report*. International Association for the Evaluation of Educational Achievement (IEA). Available at: https://www.iea.nl/sites/default/files/2020-05/ICILS%202018%20 Technical%20Report-FINAL_0.pdf

Marino, V. (coord.); Sustas, S. E.; Quartulli, D.; Curcio, J. (2023). *Por qué estudiamos informática*. Indagación sobre trayectorias universitarias: instituciones, estudiantes, género y trabajo. Fundación Sadosky, Buenos Aires, Argentina. Available at:

https://program.ar/por-que-estudiamos-informatica/

Martínez, C. (2022). « Una mirada sobre la historia reciente de la computación en la escuela argentina », en el libro *Ciencias de la Computación en la escuela* de Bonello, B. y Schapachnik, F. Siglo XXI. Ciudad de Buenos Aires, Argentina.

Martínez, C.; Martínez López, P.; Gómez, M.; Borchardt, M. y Garzón, M. (2022). *Hacia un currículum emancipador de las Ciencias de la Computación*. Revista Latinoamericana

de Economía y Sociedad Digital. Available at: https://revistalatam.digital/article/220322/?pdf=3554.

Scasso M. (coord.), Giacoponello, M. y Bortolotto G. (2021). *Manuales de didáctica de las Ciencias de la Computación*. Informe de evaluación. Fundación Quántitas. Available at: https://www.fundacionsadosky.org.ar/wp-content/uploads/2022/08/Informe-final-Evaluaci%C3%B3n- manuales.pdf

Scasso, M. (coord.); Marino, V.; Colobini, A. y Bortolotto, G. (2019). *Evaluación de la Iniciativa ProgramAR: cursos de Didáctica de la Programación y talleres en escuelas secundarias*. Fundación Sadosky. Available at: https://www. fundacionsadosky.org.ar/wp-content/uploads/2019/11/ Resumen_Informe-evaluaci%C3%B3n-de-procesos_ Iniciativa-Program.AR_.pdf

Scasso, M. (coord.); Cura, D.; Marino, V. y Kaplan, L. (2019). *Especializaciones en Didáctica de las Ciencias de la Computación*. Evaluación de Procesos y Resultados. Fundación Quántitas. Available at: https://www.fundacionsadosky.org.ar/wp-content/uploads/2020/04/Informe-final-Evaluaci%c3%b3n- especializaciones.pdf

Scasso, M. (coord.); Marino, V.; y Colobini, A. (2019). *Informe de línea de base Iniciativa Program.AR Tendencias 2015 -2018.*

Scasso, M. (coord.); Marino, V.; y Colobini, A. (2018). *Informe de línea de base Iniciativa Program.AR. Resultados del año 2015.*

Schwab, K. (2016). *La cuarta revolución industrial*. Penguin Random House. España.

Sultan, U.; Axell, C.; y Hallström, J. (2019). *What are they doing?: Tool use and self-image of girls aged 9 to12 when engaging in technology education*. Conferencia Nro 37: Pupils› Attitudes Towards Technology, Developing a knowledge economy through technology and engineering education en la Universidad de Malta. Available at: https://www.researchgate.net/publication/333817438_What_are_ they_doing_Tool_use_and_self-image_of_girls_aged_9_ to12_when_engaging_in_technology_education

Szenkman, P. y Lotito, E. (2020). *Mujeres en STEM*. Cómo romper con el círculo vicioso. Documento 224. Centro de Implementación de Políticas Públicas para la Equidad y el Crecimiento. Available at: https://www.cippec.org/wp-content/uploads/2020/11/224-DPP-PS-Mujeres-en-STEM-Szenkman-y-Lotitto-noviembre-2020-1.pdf

Unidad Fiscal Especializada en Ciberdelincuencia (2021). *Informe de gestión de la Unidad Fiscal Especializada en Ciberdelincuencia*. Available at: https://www.mpf.gob.ar/ufeci/files/2021/09/UFECI_informe-pandemia.pdf

UNESCO (2019a). *Descifrar el código: la educación de las niñas y las mujeres en ciencias, tecnología, ingeniería y matemáticas (STEM)*. Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000366649

UNESCO (2019b): *I'd blush if I could: closing gender divides in digital skills through education.* Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura. Available at: https://en.unesco.org/Id-blush-if-I-could

## Argentina standards

National Education Law (2006) Available at: https://www.argentina.gob.ar/sites/default/files/ley-de-educ- nac-58ac89392ea4c.pdf

Resolution by the Consejo Federal de Educación 135/11 (2011). Available at: http://www.bnm.me.gov.ar/giga1/normas/RCFE_135-11.pdf

Resolution by the Consejo Federal de Educación 141/11 (2011). Available at: http://www.bnm.me.gov.ar/giga1/normas/RCFE_141-11.pdf

Resolution by the Consejo Federal de Educación 263/15 (2015). Available at: http://www.bnm.me.gov.ar/giga1/normas/RCFE_263-15.pdf

Resolution by the Consejo Federal de Educación 343/18 (2018). Available at: https://www.argentina.gob.ar/sites/default/files/res_cfe_343_18_0.pdf

DEVELOPMENT BANK
OF LATIN AMERICA
AND THE CARIBBEAN

Fundación
SADOSKY

<Program.AR/>
DIEZ AÑOS

Ministerio de Ciencia,
Tecnología e Innovación
Argentina