How Chile implemented its computer science education program

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Summary

Computer science (CS) education helps students acquire skills such as computational thinking, problem-solving, and collaboration. It has been linked with higher rates of college enrollment (Brown & Brown, 2020; Salehi, Wang, Toorawa, & Wieman, 2020), and a recent randomized control trial showed that lessons in computational thinking improved student response inhibition, planning, and coding skills (Arfé et al., 2020). Since these skills take preeminence in the rapidly changing 21st century, CS education promises to significantly enhance student preparedness for the future of work and active citizenship.

CS education can also reduce skills inequality if education systems make a concerted effort to ensure that all students have equitable access to curricula that provide them with the needed breadth of skills—regardless of their gender, ethnicity, or socioeconomic status.

Based on prior analyses and expert consultations, we selected 11 CS-education country, state, and provincial case studies with lessons that can broadly apply to other education systems. These cases come from diverse global regions and circumstances and have implemented CS education programs for various periods of time and to different levels of success. As such, we have examined information to extract lessons that can lead to successful implementation.

This particular study will examine how Chile is training a future workforce of creative problem-solvers to maintain its status as one of the higher-income countries in Latin America. To accomplish this goal, the Ministry of Education designed the National Plan for Digital Languages to prepare students to compete in an increasingly digital global economy. Now in the early stages of implementing this plan, the government seeks to increase the number of students learning about CS and computational thinking in the coming years.

An overview of CS education in Chile

Chile has been preparing its schools, teachers, and students for CS education for many years. The federal education program, Enlaces, introduced digital devices and internet connectivity to nearly all schools in the 1990s and early 2000s. While this infrastructure was not originally intended for CS lessons, educators have used these devices for CS and computational thinking lessons in the last few years. Even more recently, the Ministry of Education's Innovation Center and NGO partners have also run programs and introduced online platforms to train teachers in computational thinking, programming, and project-based learning (Jara et al., 2018). Even without mandating that schools adopt any of these activities, the government estimates that about half of primary schools will offer computational thinking lessons by 2022. Yet, despite the Ministry of Education's and partners' efforts, CS education in Chile has not developed as hoped.

Lessons learned

- Though Enlaces gained more political and financial support over time, it lost flexibility to implement new projects. This may have delayed the progress of CS education.

- The Ministry of Education leans on private companies and nonprofit partners for expertise in teacher training and student engagement activities. However, regular funding and stable training programs, including for preservice teachers, are needed for better quality and more widely available CS education.

- Chile does not require schools to teach CS but encourages and supports educators that want to include the subjects in their classroom activities. While this mitigates the possibility of alienating teachers who are unfamiliar with the subject, it also risks low-scale and unequal access to CS education.

Origins and motivation

The federal education program Enlaces was developed in 1992 as a network of 24 universities, technology companies, and other organizations to equip schools with digital tools and train teachers in their use (Jara et al., 2018; Sánchez & Salinas, 2008). Over the next 15 years, it gained greater funding, broader access to decisionmakers, and a larger geographic footprint—helping the program achieve its founding mission (Severin, 2016). Enlaces provided internet connectivity and digital devices that enabled ICT (information and communication technology) education to take place in virtually all of Chile's 10,000 public and subsidized private schools by 2008 (Severin et al., 2016), helping to lay the initial groundwork for CS in schools years later.

The Kodea Foundation has promoted CS education among young people since 2015, when it started running Hour of Code, a one-hour programming workshop. By 2017, the workshop had reached more than 200,000 students, placing Chile among the top 10 countries for most Hour of Code events, an impressive accomplishment for a relatively small country (Kang, 2018; Jara et al., 2018). Though the Kodea Foundation has been successful at acquainting a lot of teachers and students with programming through Hour of Code, the broader education system still needed to implement more ambitious measures to teach students the discipline of CS.

In 2018, the government opened the Innovation Center to research and design policies to help students develop logical thinking, creativity, and problem-solving skills useful for technological environments. The Center sought to accomplish these goals by designing curricula and training teachers in CS and computational thinking.

In 2018, the Center designed the National Plan for Digital Languages (Plan) to encourage students to develop higher-order skills such as abstraction and decomposition (Jara et al., 2018). The Plan promoted CS instruction in primary and secondary schools by using project-based learning across subjects and by implementing a technology-specific course that included computational thinking and CS (Jara et al., 2018).

The Ministry of Education began the Plan by piloting a training program for 100 teachers. Based on Code.org's Code Studio, the training provided teachers with guides and materials so they could include CS topics in a technology course taught in all primary and secondary schools (Jara et al., 2018). So far, the Digital Languages Program has trained 2,000 primary school teachers (one per school) through a 30-hour learning course to implement the Code.org curriculum in the subject of Technology. Meanwhile, another 890 secondary school teachers from 445 schools have also received kits and training to facilitate robotics workshops.

When launching the Plan, President Piñera announced, "We are investing more than 4.5 billion pesos (6.2 million USD) in implementing this program and, meanwhile, we have contributions from civil society and some very important private companies who are helping with this great task… And why are we putting so much emphasis on teaching programming and digital languages? Because it teaches us how to improve skills, to use our brains and exercise our talents… (and) because it is a great tool for the job market of the future" (Gobierno de Chile, 2018).

Today, schools decide whether to offer CS education and can draw support from the Ministry of Education and nonprofit partners to do so. In implementing the Plan, the Ministry of Education projects that the computational thinking curriculum will reach almost half of all primary schools by the end of 2022. There are no available data to suggest how many schools have started to implement the curriculum. However, according to Ignacio Jara, director of the Teacher Development Center in Chile, the scope of program implementation has not scaled according to the Ministry's projections.

Stakeholder engagement

The Ministry of Education developed partnerships with individual NGOs and private companies to engage more students, especially girls. These initiatives offer the opportunity for hands-on learning projects and programming activities that students can perform from their home computers. Some of the same partners also provide online training platforms for teacher professional development.

Additionally, the Telefónica Foundation has led project-based teacher-professional development for coding skills and pedagogies. In 2018, Formación Abierta, a Telefónica Foundation initiative, trained more than 2,000 teachers in the use of Scratch (Jara et al., 2018). This included a two-day in-person session for principals and three online courses for teachers (Jara et al., 2018). Today, Fundación Telefónica has trained 4,000 teachers with a 60-hour e-learning course in project-based learning to integrate Scratch programming across the curriculum.

Overall, Chile has tried to take advantage of the progress that various NGOs had already made in previous years, including Kodea Foundation efforts to facilitate Hour of Code. Unfortunately, these intentions have not resulted in sustainable alliances in implementing the Plan. To the contrary, the heavy confidence placed on NGO-provided training and resources has been insufficient to motivate more schools and teachers to include CS and computational thinking in classroom learning activities. The experience of decades of educational policies shows that schools require long-lasting and multidimensional support to teachers to achieve successful implementation of CS in the classroom (Reimers, 2020).

Institutional structure

Though Enlaces initially provided the infrastructure to enable ICT education and begin CS education initiatives, it yielded few observable effects on classroom learning or ICT competencies (Sánchez & Salinas, 2008). As Enlaces matured, its broad institutional reach resulted in a large bureaucracy, slower implementation of new programs, and greater dependence on high-level political agendas (Severin, 2016). As a result, the program's inflexibility prevented it from taking on new projects, placing the onus on the central office of the Ministry of Education to take the lead in initiating CS education.

The Ministry of Education maintains control over curricular decisions in all K-12 schools in Chile despite the education system being highly privatized. Local governments manage public schools and private subsidized schools have their own administration even though they receive public funding (Severin, 2016).[1] Still, the Ministry of Education develops quality standards, recognizes education providers (including for subsidized private schools), and provides pedagogical and technical support for schools. Crucially, the Ministry defines curriculum requirements for all public and publicly subsidized private schools (Santiago et al., 2017). Schools then decide how to implement the curriculum and may include additional objectives, programs, and content if they choose (Severin, 2016). CS and computational thinking currently fall into this category of additional content that schools can offer without a requirement to do so.

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[1] About 54% of K-12 students attend private subsidized schools; 36% attend free municipal schools; and the remaining 10% go to unsubsidized private schools (Santiago et al., 2017).

CS curriculum and learning activities

To date, the only CS subject established in the national curriculum is in the new high school curriculum that includes an optional computational thinking course. A technology course is also mandatory for all primary and secondary school students for one or two hours per week. However, this falls short of generally accepted standards of quality CS education. The technology course includes a few elements of computational thinking like problem-solving, but mostly focuses on digital literacy (e.g., learning how to use applications like Microsoft Word or Outlook).

As part of the Plan, the Innovation Center has proposed a more robust CS curriculum that would include an introduction to robotics and block-based programming for primary school students. In secondary school, the proposed curriculum becomes increasingly more advanced, covering topics like coding languages, app development, artificial intelligence, and robotics. Additionally, the Ministry of Education has encouraged schools to include computational thinking in the curriculum as a cross-cutting subject, embedded in science and mathematics.

The Ministry of Education expanded CS education offerings to students in 2019 when the new upper-secondary curriculum established an optional computational thinking course. Consequently, preservice mathematics teachers have started preparing to teach this subject in early 2021.

A key feature of Chile's education policy is that primary and lower-secondary schools are not required to offer CS or computational thinking instruction but have resources available if they choose to do so. The Ministry's Innovation Center supports schools that add CS to their technology coursework by offering training—in addition to the curriculum guidelines—to all public and subsidized private school teachers. Due in part to these resources, the Ministry estimates that 3,000 of about 6,500 primary schools in Chile will offer computational thinking by the end of the current presidential administration in 2022. However, progress toward this goal is questionable, with few computational thinking lessons taking place in primary schools.

By not mandating CS education in primary schools, there is both a benefit and a risk. On one hand, the current approach means that only motivated teachers spend class time teaching CS, and so no time is spent learning from instructors who are unmotivated or unqualified to teach the subject. On the other hand, mere encouragement to include CS in the curriculum risks unequal access to CS education if motivated and qualified teachers are concentrated in wealthier and more urban areas.

Inclusion

From the program's beginning, Enlaces emphasized ICT availability for low-income and rural children. It was first piloted in 21 schools in 1993 in Araucanía, one of the lowest-income regions in the predominantly rural south of Chile. One of the project's early leaders commented: "If it worked (there), then it could work anywhere in Chile" (Severin, 2016). Enlaces was particularly successful at making hardware widely accessible; a survey found that 85% of students attended schools that had internet access in 2004. That figure increased to 96% by 2006 and then 99% by 2009 (Severin, 2016). Though ICT does not equate to CS education, computing infrastructure enables students and teachers to access tools that they can use for programming and computational thinking lessons. It also gives rural teachers opportunities to participate in online training that could otherwise be inaccessible.

Though Chile greatly reduced its digital divide, there are still disparities in access and attitudes regarding CS education along geographic and gender lines. Since the subject is not available in every school, many students who want to learn about CS must rely on extracurricular activities that are more commonly found in cities than in rural areas (Simmonds, Gutierrez, Casanova, Sotomayor, & Hitschfeld, 2019). Further, a survey of 10- to 12-year-old Chilean children revealed sharp contrasts in boys' and girls' attitudes toward CS (Gutierrez, Simmonds, Casanova, Sotomayor, & Hitschfeld, 2018a). Yet, researchers also revealed that exposure to CS in primary school can weaken these biases (Gutierrez et al., 2018a; Gutierrez, Simmonds, Hitschfeld, Casanova, Sotomayor, & Peña-Araya, 2018b). For this reason, Laboratoria, the Kodea Foundation, and other organizations have each established after-school and summer programs for teaching CS specifically to young girls and women.

Conclusion

The Enlaces program trained teachers to use ICTs and gave schools near universal access to computing infrastructure (Severin, 2016). However, as the program matured, it became more dependent on official bureaucratic structures that reduced its flexibility to take on new projects (Severin, 2016). Therefore, Enlaces's institutional arrangements likely hampered its flexibility to implement new initiatives like CS education. The Ministry of Education has tried to fill this void through its Innovation Center, and its many nonprofit partners offer professional development and curricular support for schools and teachers that offer CS and computational thinking. Given all these resources, the government had estimated that about half of primary schools will offer computational thinking lessons by 2022. However, early indications are that progress has thus far been slow. Stable, ongoing training programs with regular funding are needed for all Chilean schools to offer quality CS education.

References

Arfé, B., Vardanega, T., & Ronconi, L. (2020). The effects of coding on children's planning and inhibition skills. *Computers & Education*, *148*, 103807.

Ayuda Mineduc. (n.d.). *Plan Nacional De Lenguajes Digitales*. Retrieved from https://www.ayudamineduc.cl/ficha/plan-nacional-de-lenguajes-digitales.

Brown, E., & Brown, R. (2020, March 4). *The Effect of Advanced Placement Computer Science Course Taking on College Enrollment.* West Coast Analytics.

Centro de Innovacion UC. (n.d.). *The Center*. Retrieved from https://centrodeinnovacion.uc.cl/en/the-center/who-we-are/.

Chile-programa. (n.d.). *Quiénes Somos*. Retrieved from https://www.chileprograma.cl/quienessomos.

Code.org. (n.d.). *Courses*. Retrieved from https://studio.code.org/courses.

Enlaces. (n.d.). *Plan Nacional de Lenguajes Digitales Año 2019*. Retrieved from http://www.enlaces.cl/proyectos/plan-nacional-de-lenguajes-digitales-ano-2019/.

Gobierno de Chile. (2018). "President Piñera introduces the Education Ministry's Innovation Center that will enable programming to be taught in 3,000 schools." Retrieved from https://www.gob.cl/en/news/president-pinera-introduces-education-ministrys-innovation-center-will-enable-programming-be-taught-3000-schools/.

Gobierno de Chile. (n.d.). *¿Qué es el Plan Nacional de Lenguajes Digitales?* Retrieved from https://sitios.mineduc.cl/lenguajesdigitales/que-es-el-plan.html.

Gobierno de Chile. (n.d.). *Desarrollando competencias tecnológicas para nuestra era*. Retrieved from https://www.curriculumnacional.cl/portal/Innovacion/Lineas-de-Innovacion/Pensamiento-computacional/89481:Pensamiento-Computacional.

Gobierno de Chile. (n.d.). *Nuestro compromiso es con la calidad de la educación*. Retrieved from https://www.gob.cl/calidaddelaeducacion/#:~:text=Copy%20link,El%20Plan%20Nacional%20Lenguajes%20Digitales%20es%20la%20primera%20iniciativa%20que,la%20programaci%C3%B3n%20en%20el%20aula.Vidal,%20C.%20L.

Cabezas, C., Parra, J. H., & López, L. P. (2015). Experiencias prácticas con el uso del lenguaje de programación Scratch para desarrollar el pensamiento algorítmico de estudiantes en Chile. *Formación universitaria*, *8*(4), 23-32.

González, F., López, C., & Castro, C. (2018b). Development of Computational Thinking in High School Students: A Case Study in Chile. In *2018 37th International Conference of the Chilean Computer Science Society (SCCC)* (pp. 1-8). IEEE.

Gutierrez, F. J., Simmonds, J., Casanova, C., Sotomayor, C., & Hitschfeld, N. (2018a). Coding or hacking? exploring inaccurate views on computing and computer scientists among K-6 learners in Chile. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education* (pp. 993-998).

Gutierrez, F. J., Simmonds, J., Hitschfeld, N., Casanova, C., Sotomayor, C., & Peña-Araya, V. (2018b). Assessing software development skills among K-6 learners in a project-based workshop with scratch. In *2018 IEEE/ACM 40th International Conference on Software Engineering: Software Engineering Education and Training (ICSE-SEET)* (pp. 98-107). IEEE.

International Association for the Evaluation of Educational Achievement. (n.d.). *TIMSS 2015 Encyclopedia*. Retrieved from http://timssandpirls.bc.edu/timss2015/encyclopedia/countries/chile/.

Jara, I., Hepp, P., & Rodriguez, J. (2018). *Policies and Practices for Teaching Computer Science in Latin America*. Microsoft. https://www.researchgate.net/publication/335611704_Policies_and_Practices_for_Teaching_Computer_Science_in_Latin_America.

Kodea. (n.d). *Memoria Corporativa 2020*. Retrieved from https://www.kodea.org/en/home_en/.

Laboratoria. (n.d.). *En Laboratoria mujeres y organizaciones aprenden de forma continua y se adaptan al cambio, la clave para crecer en la era digital*. Retrieved from https://www.laboratoria.la/.

Reimers, F. M. (2020). Thinking Multidimensionally About Ambitious Educational Change. In *Audacious Education Purposes. How Governments Transform the Goals of Education Systems* (pp. 1-46).

Salehi, S., Wang, K. D., Toorawa, R., & Wieman, C. (2020, February). Can Majoring in Computer Science Improve General Problem-solving Skills? *In Proceedings of the 51st ACM Technical Symposium on Computer Science Education* (pp. 156-161).

Sánchez, J., & Salinas, A. (2008). ICT & learning in Chilean schools: Lessons learned. *Computers & Education*, *51*(4), 1621-1633.

Santiago, P., Fiszbein, A., Jaramillo, S. G., & Radinger, T. (2017). *OECD Reviews of School Resources: Chile 2017*. OECD Publishing. 2, rue Andre Pascal, F-75775 Paris Cedex 16, France.

Se abre convocatoria para llevar la programación y el pensamiento computacional a las escuelas. (2018). Retrieved from https://magallanes.mineduc.cl/2018/12/11/se-abre-convocatoria-para-llevar-la-programacion-y-el-pensamiento-computacional-a-las-escuelas/.

Severin, E. (2016). *Building and sustaining national ICT/education agencies: Lessons from Chile (Enlaces)*. World Bank.

Simmonds, J., Gutierrez, F. J., Casanova, C., Sotomayor, C., & Hitschfeld, N. (2019, February). A Teacher Workshop for Introducing Computational Thinking in Rural and Vulnerable Environments. In *Proceedings of the 50th ACM Technical Symposium on Computer Science Education* (pp. 1143-114).