How South Korea 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 et al., 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 the needed breadth of skills, regardless of gender, ethnicity, or socioeconomic status.

Based on prior analyses and expert consultations, we selected 11 CS education country, state, and provincial case studies that have 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 and to different levels of success.

This study focuses on CS education in South Korea.[1] Home to some of the world's best CS higher education programs and most successful technology companies, South Korea has made great strides in improving students' CS skills.

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[1] We define CS as the study of both computer hardware and software design including theoretical algorithms, artificial intelligence, and programming (Technopedia, n.d.). CS education can also include elements of computational thinking: a problem-solving approach that involves decomposition, use of algorithms, abstraction, and automation (Wing, 2006). In the South Korean education system, the term "informatics" is equivalent to CS (Lee & Jeongmin, 2021).

Given its success, the country's CS education program deserves close consideration as other education systems work toward similar outcomes.

An overview of CS education in South Korea

Curriculum changes over the last 20 years reflect the importance that the government has placed on CS. As a result of the curriculum changes, South Korea ranked second among 12 participating countries in the 2018 ICILS exam, which assessed computer literacy and computational thinking skills. To achieve this success, South Korea has engaged in quality teacher training, gradual but frequent curriculum updates, and inclusion of disadvantaged students in CS education.

Universities, including the Korean Advanced Institute of Science and Technology (KAIST) and Seoul National University, are home to world-leading CS programs (US News, 2021). These higher education opportunities not only help the technology industry thrive but also incentivize K-12 students to learn about CS. Further, successful technology companies like Samsung give the subject great economic relevance, attracting interest from students and parents alike.

Lessons learned

- A combination of preservice and in-service teacher training provides a steady pipeline of qualified CS teachers.
- Government and NGO stakeholder involvement can be instrumental in helping disadvantaged students learn about and become interested in CS.
- South Korea's thriving digital economy and prestigious reputation in CS higher education prime its K-12 education programs with quality resources and motivate young students to engage in CS education from an early age.

Origins of computer science education

South Korea's history of technological innovation dates to 1962, when the newly formed government issued its initial five-year economic plan. Industry leaders heavily invested in research and development as the government shielded domestic companies from international competition. With the increased industry and research intensity that followed, companies such as Samsung, LG, and Lotte innovated and eventually mass-produced cars, petrochemicals, and perhaps most famously, consumer electronics (Dayton, 2020).

This drive for research and technological innovation extended to education and infrastructure policy. Computing education in Korea was first introduced in the 1970s as a vocational high school subject, before its introduction into elementary and middle schools in the 1980s as "computer literacy." By the 1990s, the country invested $620 million in fiber connections, a significant investment for a relatively small landmass. This gave South Korea some of the world's fastest and cheapest broadband connections, reaching near universal access (Falcon, 2020). In the mid-2000s, the Ministry of Education, Science and Technology [later renamed as the Ministry of Education (MoE)] installed computer labs in schools across the country to make technology-based subjects widely accessible. This infrastructure enabled the MoE to standardize information communication technology (ICT) courses in primary and secondary schools.

Given these developments, South Korea ranked first among Organisation for Economic Co-operation and Development (OECD) countries in computer usage in a 2006 OECD study. However, even though students were computer literate, they did not have the skills to create or improve computer programs (OECD, 2006). To address this issue, the MoE revised the ICT curriculum in 2007 to focus on computational thinking. This curriculum also developed new tools to evaluate students' understanding of computational thinking (Jun et al., 2014). To address the shortcomings that became evident after another set of CS education curriculum reforms in 2009, South Korea's MoE announced changes that emphasized software education in K-12 curricula (MoE Korea, 2014a).

In 2015, a fifth revision to the curriculum aimed to enhance computational thinking, changing the subject from elective to mandatory (Lee et al., 2016). This policy was intended to "strengthen software education in schools for computing education" including algorithms, programming, and modeling according to the MoE (Kim & Kim, 2018; Jun et al., 2014; Cha et al., 2011). In 2018, South Korea's sixth and latest change to the CS curriculum set a goal of establishing digital convergence in educational environments. As such, other subjects now incorporate components of computational thinking. Further, the MoE introduced a new syllabus for CS covering digital literacy, programming, and computational thinking. As part of the changes, CS became compulsory in lower-secondary school and an elective CS course was introduced in upper-secondary school (MoE, 2018).

As the country made advances in CS education, the technology sector has continued to boom. By multiple measures, the South Korean technology sector is among the world's most advanced. For instance, Bloomberg ranked South Korea second in its 2020 Innovation Index for innovative capacity. Likewise, Cornell University's 2019 Global Innovation Index placed South Korea as the 11th most innovative out of 129 countries ranked (Dayton, 2020). Further, various small- and medium-sized companies have emerged that specialize in cutting-edge innovations such as artificial intelligence, cybersecurity, and biotechnology (Dayton, 2020). With such a high-powered and diversified field of technological innovation, job offerings abound for CS professionals in South Korea. This high demand is a clear incentive for students and parents to take an interest in the subject.

Curriculum and course development

As mentioned in 2018, the MoE announced the newest curriculum focused on helping students develop problem-solving and perspectives needed for society (Kim et al., 2021). The reform focused on developing coding, creative expression, and computational thinking for all levels of education (Curran et al., 2019).

Today, at the primary level, students learn about problem-solving, algorithms, programming, and digital ethics. Primary school teachers must teach CS for a minimum of 17 class hours per year and support students to participate in various activities involving simplified programming languages or CS Unplugged materials, which are a collection of free learning activities that teach CS through engaging games and puzzles (Kim & Kim, 2018).

At the lower-secondary level, students learn for a total of 34 class hours, one hour per week, about similar concepts at a more advanced level related to computational thinking and programming languages using digital devices. This is part of a science, technology, and home economics course that is mandatory for one year between 6th and 8th grades (Kim & Kim, 2018).

The upper-secondary school curriculum offers CS as an elective course featuring more advanced classes. It focuses on data science, problem-solving, programming, systems, and culture and ethics (Kim et al., 2021).

Teacher preparedness, professional development, and recruitment

Becoming a teacher in South Korea requires graduating from a four-year teaching program. To obtain a CS certificate, teachers must complete the course requirements of the computer education department at the teachers' colleges. Through this process, preservice teachers receive comprehensive training on high-skill computational thinking elements within the CS curriculum, such as computer architecture, operating systems, programming, algorithms, networking, and multimedia (Choi et al., 2015).

In South Korea, teachers are part of the civil service. The high-status profession even comes with generous benefits and a relatively high salary compared to other countries (Gal et al., 2019; OECD, n.d.). Much like other members of the civil service, the central government assigns them to cities where they are most needed.

For ongoing professional development of CS teachers, the MoE developed a short modular video, a simulation, and augmented reality episodes based on the revised 2015 curriculum. Further, the MoE, developed the "Creativity Trip with Software" textbook for students and teachers. The Ministry of Science and ICT and the Korea Foundation for the Advancement of Science and Creativity developed a 10-module software education textbook that discusses artificial intelligence and unmanned vehicles. The Software Education Curriculum and Research Society introduced voluntary communities among local teachers to conduct research on various topics, including software education activities for students and real-life problem-solving materials (MoE, 2018). By 2018, 60,000 primary school teachers (30 percent of the total) had received training in software education. Additionally, 1,800 middle school teachers who are certified to teach CS will receive additional software education training (Curran et al., 2019).

Stakeholder involvement and inclusion of disadvantaged groups

Government agencies and nonprofit partners run initiatives to help disadvantaged groups such as low-income families, students with disabilities, and girls. However, some disparities in CS education persist.

Students from low-income families lack access to computers that facilitate CS education. To help bridge this divide, the Korea Educational Broadcasting System (EBS), a public broadcasting organization, uses interactive e-learning programs to support students from low-income families. Further, the Frontline Education Platform guides students through self-directed online learning for software education and is free to download. A recent randomized control trial study showed that this kind of computer-assisted learning is a viable way for students to learn, but it is optimized when blended with more traditional learning strategies (Bettinger, 2020).

Inclusive education for special education needs and students with disabilities has been a core issue in South Korea since the mid-1990s. Solving this issue has been a national priority, as South Korean educators and administrators guarantee the rights of disabled and special education needs students to learn equally (Kim, 2013). The nonprofit JA Korea, with the support of Microsoft Korea, runs the "Be a Coding Hero" program that trains young people with disabilities that live in underserved areas in CS and software education.

Finally, the number of male CS college graduates continues to outpace that of females, suggesting a need to engage girls early in CS education (Huyer, 2015). Consequently, several external organizations have introduced initiatives to spark girls' interest in CS. For example, Microsoft's DigiGirlz program, offered in partnership with JA Korea, provides instruction in coding and Internet of Things (IoT) skills to girls in middle and high schools (Microsoft, 2017; Microsoft, 2018).

Conclusion

The technology industry and CS higher education program are prominent and successful in South Korea. CS education is also mandatory in both primary and secondary school, providing students with the chance to engage with a broad range of topics in the field. As such, students have multiple opportunities to develop an interest in CS.

In South Korea, the teaching profession is highly selective and competitive, and teachers form part of the civil service. Teachers in general, including CS teachers, are highly trained before entering the profession and have ample opportunities for ongoing professional development. Lessons from these highly qualified teachers further encourage student engagement in the subject.

Like other countries, those completing more advanced training and working in CS fields in South Korea are not representative of the broader population, indicative of continued interest gaps among groups. However, the South Korean government and stakeholder partners have implemented programs to extend learning opportunities to underrepresented groups, including girls and students with disabilities.

References

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

Bettinger, E., Fairlie, R. W., Kapuza, A., Kardanova, E., Loyalka, P. K., & Zakharov, A. (2020). Does edtech substitute for traditional learning? Experimental estimates of the educational production function. *NBER Working Paper*, (w26967).

Brown, E., & Brown, R. (2020, March 4). *The effect of advanced placement computer science course taking on college enrollment.* West Coast Analytics.

Cha, S. E., Jun, S. J., Kwon, D. Y., Kim, H. S., Kim, S. B., Kim, J. M., Kim, Y. A., Han, S. G., Seo, S. S., Jun, W. C., Kim, H. C., & Lee, W. G. (2011). Measuring achievement of ICT competency for students in Korea. *Computers & Education*, *56*(4), 990–1002. https://doi.org/10.1016/j.compedu.2010.11.003.

Choi, J., An, S., & Lee, Y. (2015). Computing education in Korea—current issues and endeavors. *ACM Transactions on Computing Education*, *15*(2), 1–22. https://doi.org/10.1145/2716311.

Curran, J., Schulz, K., Hogan, A. (2019). *Coding And Computational Thinking What is the Evidence? New South Wales Government*. Retrieved from https://education.nsw.gov.au/content/dam/main-education/teaching-and-learning/education-for-a-changing-world/media/documents/Coding-and-Computational-Report_A.pdf.

Dayton, L. (2020). How South Korea made itself a global innovation leader. *Nature*, *581*(7809), S54-S54.

EBS. (n.d.). About EBS SW. Retrieved from https://www.ebssw.kr/info/intrcn/infoHeaderView.do?tabType=INTRCN&pageIndex=1.

Educational Broadcasting System. (n.d.). Retrieved from https://global.ebs.co.kr/global/introduction/vision.

Falson, E. (2020). Why Is South Korea a global broadband leader? *Electronic Frontier Foundation*, *16*. Retrieved from https://www.eff.org/deeplinks/2020/02/why-south-korea-global-broadband-leader.

Gal, S., Perino, M., & Garfield, L. (2019). The best and worst countries to be a teacher, based on salary. *Business Insider*. Retrieved from https://www.businessinsider.nl/teacher-salaries-by-country-2017-5?international=true&r=US.

Huyer, S. (n.d.). Is the gender gap narrowing in science and engineering? *UNESCO Science Report*.

ICILS. (n.d.). *ICILS 2018 Results*. Retrieved from https://www.iea.nl/news-events/news/icils-2018-results.

JA Korea. (n.d.). Retrieved from https://www.jakorea.org/front/main.do.

Jun, S., Han, S., Kim, H., & Lee, W. (2014). Assessing the computational literacy of elementary students on a national level in Korea. *Educational Assessment, Evaluation and Accountability*, *26*(4), 319-332.

Kim, D.-K., Jeong, D., Lu, L., Debnath, D., & Ming, H. (2015). Opinions on computing education in Korean K-12 System: Higher education perspective. *Computer Science Education*, *25*(4), 371–389. https://doi.org/10.1080/08993408.2016.1140409.

Kim, S., & Kim, H. Y. (2018). A computational thinking curriculum and teacher professional development in South Korea. In *Computational thinking in the STEM disciplines* (pp. 165-178).

Kim, Y. W. (2013, May 31). Inclusive education in Korea: Policy, practice, and challenges. Journal of Policy and Practice in Intellectual Disabilities. https://eric.ed.gov/?id=EJ1014713.

Korean teachers rank 4th in respect: study. (October 6, 2013). *The Korea Herald*. Retrieved from http://www.koreaherald.com/view.php?ud=20131006000200.

Lee, M., & Lee, J. (2021). Enhancing computational thinking skills in informatics in secondary education: The case of South Korea. *Educational Technology Research and Development*, 1-25.

Metropolitan & Provincial Offices of Education. (n.d.). *Metropolitan & Provincial Offices of Education.* Retrieved from http://english.moe.go.kr/sub/info.do?m=0803&s=english.

Microsoft. (2017, November 24). *South Korea's Coding Heroes bring creativity back into the classroom*. Retrieved from https://news.microsoft.com/apac/features/south-koreas-coding-heroes-bring-creativity-back-classroom/.

Microsoft. (2018, December 6). *Partnering for growth: Empowering South Korea's digital future*. Retrieved from https://news.microsoft.com/apac/features/partnering-for-growth-empowering-south-koreas-digital-future/.

Ministry of Education. (2018). White Paper on ICT in Education Korea. Retrieved from https://keris.or.kr/main/cf/fileDownload.do?fileKey=49add0c26539f68b177a706b01f426c7.

OECD. (n.d.). *Korea*. Retrieved from https://gpseducation.oecd.org/CountryProfile?primaryCountry=KOR&treshold=10&topic=TA.

OECD (2006). *Are Students Ready for a Technology-Rich World?: What PISA Studies Tell Us*. Retrieved from https://ictlogy.net/bibliography/reports/projects.php?idp=1764&lang=es.

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).

Technopedia. (n.d.). *Computer Science*. Retrieved from https://www.techopedia.com/definition/592/computer-science.

U.S. News & World Report. (n.d.). *Top computer Science universities in South korea | US News best Global Universities*. U.S. News & World Report. https://www.usnews.com/education/best-global-universities/south-korea/computer-science.

Wing, J. M. (2008). Computational thinking and thinking about computing. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *366*(1881), 3717-3725.