How Arkansas implemented its computer science education program

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September 2021

Center for Universal Education at BROOKINGS

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Acknowledgements

The authors are grateful to Anthony Owen, Katie Hendrickson, Michael Hansen, and Kareen Fares for their comments on an earlier draft of this brief.

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Brookings gratefully acknowledges the support provided by Amazon, Atlassian Foundation International, Google, and Microsoft.

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Summary

Computer science (CS) education helps students acquire skills such as computational thinking, problem-solving, and collaboration, among others. It has been linked with higher rates of college enrollment (Brown & Brown, 2020; Salehi et al., 2020), and a recent randomized control trial study also showed that lessons in computational thinking improved student response inhibition, planning, and coding skills (Arfé et., 2020). As 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 analysis and expert consultation, we selected 11 country, state, and provincial CS-education case studies with lessons that can apply broadly 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. As such, we have examined information to extract lessons that can lead to successful implementation. This study will focus on the development of CS education in Arkansas.

While this U.S. state is not typically known for technological advancement, the governor's strong leadership has led to a rapid and inclusive expansion of CS education, drawing praise from media and advocacy groups alike (Nix, 2017). Code.org, the Computer Science Teachers' Association (CSTA), and Expanding Computing Education Pathways (ECEP) Alliance even noted in their 2019 "State of Computer Science Education" report that Arkansas has the largest share of high schools that teach CS (89 percent) of any U.S. state (State of Computer Science Education, 2020). The state also received the Frank Newman Award for State Innovation from the Education Commission in 2020 for its CS education initiative (CS for All, 2020). Given this recognition, the state's CS education

programs deserve close examination as other education systems work toward similar outcomes.

An overview of CS education in Arkansas

With regular funding, bipartisan political support, and strong executive leadership, Arkansas has made considerable progress at improving CS education since the beginning of the Hutchinson gubernatorial administration in 2015. To help guide key policy decisions, Governor Hutchinson appointed task force groups that included representatives from teacher associations, businesses, and government agencies. These stakeholders gave policymakers influential advice on teacher recruitment and training, student engagement activities, and curriculum standards.

The state set up incentives for participation in CS education programs. Since the 2015-16 school year, students have been able to use CS courses to fulfill high school science and mathematics requirements, which has contributed to Arkansas's growing enrollment and improving diversity of CS classes (State of Computer Science Education, 2019; Associated Press, 2021). Arkansas has also developed CS certification for in-service and preservice teachers that encourage educators to participate in training programs (Code.org, 2017; Lang, Galanos, Goode, Seehorn, Trees, Phillips, & Stephenson, 2013). This is one of the more important aspects of this case study, as research has shown teachers to be one of the most important school-side factors in student learning in core academic subjects (Chetty Friedman, & Rockoff, 2014; Rivkin, Hanushek, & Kain, 2005). We posit that this applies to CS as well.

Lessons learned

- Political leadership and stakeholder support are key to securing legislative approval and funding for activities that expand quality CS education.
- Clear certification pathways, financial incentives, and professional advancement opportunities give teachers incentives to attend teacher training.

- A full-time staff of administrators collaborating with a task force of industry representatives, teachers, and parents can enable decisionmakers to account for stakeholder needs and accelerate CS program improvement.
- Offering CS in every school and allowing elective CS courses to satisfy high school graduation and university admission requirements can encourage students to explore their interest in CS.
- By offering CS education to children at an early age, education systems can enable students to develop a strong interest in the subject and prepare them for advanced courses in high school. This progression throughout grades K-12 can inspire the most interested students to specialize in CS.

Origins and motivation

Governor Hutchinson made CS education a key part of his first campaign in 2014 (CS for All, n.d.), even promising to make CS available to all boys and girls in the state through television advertisements. Hutchinson said in his campaign, "Through encouraging computer science and technology as a meaningful career path, we will produce more graduates prepared for the information-based economy that represents a wide-open job market for our young people" (Arkansas Department of Education, 2019). This was likely an effective campaign strategy as national polls indicated that CS education is generally popular among U.S. parents (Google & Gallup, 2016). Hutchinson won the Republican primary contest and then went on to win the general election with 55 percent of the vote. The new governor made CS education an immediate priority.

There was plenty of bipartisan support for CS education within the legislature at the time of Hutchinson's victory. Lawmakers allocated an initial 5 million dollars in 2015 to begin the Arkansas Computer Science Initiative along with 2.5 million dollars in continual annual funding. Soon after, the legislature passed another bill that required all public high schools to offer at least one CS course (Nix, 2017) and for a dedicated initiative staff.

Today, Arkansas mandates that schools offer CS as a cross-curricular subject for the elementary and middle school levels. Meanwhile, high schools must also provide at least one standalone CS course that can satisfy a math, science, or career-focused graduation requirement. In the fall semester of 2020, Hutchinson announced that enrollment in CS courses jumped to over 10,000 students out of about 143,000 total high school students (Arkansas Department of Education, 2021).

Teacher professional development and recruitment

The most challenging aspect of implementing CS education in Arkansas has been training and recruiting enough qualified teachers to meet curriculum requirements (Nix, 2017 and Arkansas Department of Education, 2019). Recognizing this difficulty, the state invested significant resources toward training in-service teachers to fill the immediate need while preparing preservice teachers for long-term CS education.

The Arkansas Department of Education incentivizes in-service teachers to attain certification through teaching CS courses and participating in approved professional development (PD) programs (State of Computer Science Education, 2019). The state also gives stipends to teachers who attain certifications, attend PD and/or enroll at least 10 students in a CS course (State of Computer Science Education, 2019). Since 2016, approximately half of the 30,000 K-12 educators licensed in Arkansas have received some form of training in CS, according to the Arkansas Department of Education Office of Computer Science (CS for Arkansas, 2021). Since 2016, approximately half of the 30,000 K-12 educators licensed in Arkansas have received some form of training in CS, according to the Arkansas Department of Education Office of Computer Science (CS for Arkansas, 2021).

To address longer-term needs, the state added CS skills and knowledge to its elementary teaching standards so preservice teachers would be prepared for cross-curricular lessons that included CS and computational thinking (State of Computer Science Education, 2019). Several Arkansas universities have approved CS education programs, as well. For example, Henderson State University's teaching degree program offers optional CS courses that enable preservice teachers to earn a CS teaching certification. There are even scholarships available to preservice teachers pursuing these certifications as part of their teaching degrees. To attain the license, preservice teachers learn topics like programming, computer networks, and data science. In the last year of

the program, they must also learn about CS pedagogies for a diverse classroom environment (Department of Curriculum & Instruction, n.d.).

Additionally, the Department of Education's CS team launched the Computer Science and Computing Educator Academy in 2021 in partnership with Arkansas Tech University. The Department offers either academic credit hours or certification, along with applicant tuition for both in-service and preservice teachers. Successful applicants learn basic CS concepts, prepare for a CS certification exam, and gain approval to teach high school CS courses (Arkansas Department of Education, n.d.).

Going forward, the Department of Education will support schools to meet the requirements of Act 414 of 2021, which requires every high school in Arkansas to employ at least one certified CS teacher by 2023 (CS for Arkansas, 2021).

Institutional arrangements

The Arkansas Department of Education's Division of Elementary and Secondary Education runs the Computer Science Initiative that consists of a small full-time staff with Anthony Owen leading the initiative as director since 2015. As a former math teacher, Owen incorporates the views of teachers' associations (Nix, 2017), but because of his background in industry and status as an Arkansas lawyer, he values the involvement of numerous other groups in the policymaking process. The Arkansas Department of Education has an Office of Computer Science with four staff members: a director, a lead statewide CS specialist, a program policy advisor, and a program coordinator. In 2021, the Department created a new position, the director of STEM and CS continuum, to focus on the integration of CS into postsecondary education—both college and career tracks.

In 2015, the legislature authorized the Hutchinson administration to form a task force charged with three responsibilities (Arkansas Department of Education, 2019): study the state's technology needs, recommend strategies to meet workforce needs, and research CS courses and content focus. To perform these tasks, the governor's office appointed a 15-member task force made up of Department of Education officials, teacher representatives, academics, and business leaders. The group then produced a report that made informed

suggestions for recruiting and training teachers and engaging students in learning opportunities (State of Arkansas, 2015).

The government has maintained this measured policymaking approach. The most recent task force convened in 2020 to make policy recommendations that would build on previous success and "maintain Arkansas's national leadership on computer science education," with an emphasis on cybersecurity. The resulting report presented 21 specific recommendations relating to K-12 educational pathways and program growth, postsecondary enrollment growth, industry engagement, and outcome measurement (State of Arkansas, 2020).

Anthony Owen commented, "I believe an in-state task force or advisory panel is necessary for any state looking at large-scale implementation. This group should be composed of not only educators and state agency leaders, but also have industry representatives and leaders" (CS for All, n.d.). Given this stakeholder representation, it was possible to use the expertise of business and nonprofit groups while incorporating the perspectives of teachers who acted as gatekeepers to the lessons taught in classrooms (Larke, 2019).

Civil society

The state's business community has long supported the idea of CS education (Nix, 2017). Accelerate Arkansas established itself in 2005 as an organization of 70 private and public sector members dedicated to moving Arkansas into a more innovation- and knowledge-based economy (State of Arkansas, 2018). "We were trying to accomplish getting more kids interested in STEM," said James Hendren, the founding chairman of Accelerate Arkansas. "We've got … a lot of very large companies and a big startup community that needs these kinds of workers." The governor's office credited Accelerate Arkansas in 2018 for setting key objectives for the state's Science and Technology Plan, a document that outlines recommendations for the state to help improve the technology sector (State of Arkansas, 2018). It was helpful for the business community to make their interests known to the government and public, as the economic benefit of a thriving technology sector was a major reason for initiating CS education.

By providing expertise, policy guidance, and funding, technology companies and NGOs have offered support in many aspects of CS education activities. Arkansas administrators have said that they rely on business advocacy organizations for implementation of education programs (CS for All, n.d.). They also specifically credit the CSTA and Code.org's efforts for helping expand CS education. Additionally, Microsoft has played an important role in teacher training by expanding TEALS (Technology Education and Literacy in Schools), a program that helps teachers learn CS subject matter and pedagogy by pairing them with industry volunteers. In addition to TEALS, Microsoft also hosts DigiCamp, a three-day program that exposes young people to CS and offers training to local entrepreneurs. Additionally, Code HS provides one- and two-day in-person PD workshops for teachers. Together, Microsoft and Facebook have provided more than 1 million dollars' worth of resources for teacher training, technological equipment, and student engagement events (Nix, 2017).

The state is looking to deepen its stakeholder partnerships. As recommended by the latest governor-appointed task force, the Department of Education aims to get half of all school districts to form partnerships with universities and business entities to give students opportunities to participate in internships and take college-level CS courses while in high school (Talk Business & Politics staff, 2020).

Curriculum and course development

The Arkansas K-12 curriculum introduces students to CS at an early age, giving them ample opportunity to develop an interest in the subject. Standalone courses become available in later grades as high schools can offer multiple types of CS courses for students that have a special interest.

Starting in 2015, the legislature has required elementary and middle school teachers to embed computational thinking as a cross-curricular subject. As such, teachers integrate five main concepts of computational thinking into their lesson plans (Watson-Fisher, 2019):

1. Problem-solving

2. data and information
3. algorithms and programs
4. computers and communications
5. community, global, and ethical impacts.

By fourth grade, students are introduced to computational thinking concepts, data visualization, algorithmic problem-solving, binary languages, computer literacy, keyboarding, and ethics. By eighth grade, students add more complexity to these topics—solving algorithmic problems, identifying and correcting errors in programs, and creating functions with given parameters.

Middle school students then experience a "coding block" that can be integrated as part of a unit in another course or as a standalone programming class (Howell, 2020). This is meant to give students a chance to discover whether they are interested in CS so they can take more advanced courses in later grades.

High schools must offer at least one “high-quality” CS course of their choosing based on state-provided frameworks. They can choose among four options: CS with an emphasis on programming, mobile application development, robotics, and CS with a networking/hardware emphasis. Additionally, high school students can attain credits for independent study or an internship to learn about CS (Arkansas Bureau of Legislative Research, 2018).

In Arkansas, as in the rest of the United States, two Advanced Placement (AP) courses are available that enable students to earn college credits while in high school. AP Computer Science Principles focuses on ideas that underlie the science of computing and the development of thinking skills. Meanwhile, AP Computer Science A focuses on coding through writing and testing code as students explore concepts like variables, modularity, and control structures (AP Computer Science A: The Course, n.d.). Thirty-six of Arkansas’s 388 high schools had students that passed an AP CS exam in 2020 (Arkansas Department of Education, 2021).

The Arkansas curriculum gives all students a chance to develop an interest in CS, introducing young students to technology and computational thinking. In March

2021, the legislature passed a bill making CS a graduation requirement that will begin with the class entering ninth grade in 2022–2023 (Code HS, 2021). This requirement will further increase the number of students that are exposed to the subject, giving them plenty of opportunities to discover whether they are interested in the subject. Thus, the curriculum has the potential to train students for general problem-solving and for studying CS as an undergraduate major.

Inclusion

Arkansas has made substantial progress in making access to CS education more inclusive. African American students make up 19.6 percent of all students taking CS in high school, a statistic that slightly exceeds the percentage of African Americans among all students. As such, African American students are no longer underrepresented in high school CS education in the state. Though this is an important achievement, there is still progress to be made, as fewer students of color take an AP CS exam every year compared to white students in the state.

The number of girls taking at least one CS class has also increased dramatically, from 223 when classes were first implemented to 3,135 over the 2019-2020 school year. However, enrollment for girls is still much lower than it is for boys. State Director of Computer Science Anthony Owen commented in 2017, "When it comes to computer science enrolment, we are actually close to 30 percent female and [a] little over 70 percent male, which is better than national [statistics] but still horrible" (Nix, 2017). Attempting to make CS education more gender balanced, the state and nonprofit partners have run extracurricular activities to help girls become interested in the subject. For example, Governor Hutchinson, Arkansas First Lady Susan Hutchinson, and Code.org hosted 150 middle school and high school girls at the Girls of Promise Coding Summit at the governor's mansion in 2015 (Alderdice, 2015). Since that event, Girls of Promise has hosted two coding summits every year (2020 and 2021 notwithstanding per the pandemic). The organization holds the summits in various regions to extend the opportunity to all girls across the state (Girls of Promise, n.d.).

The government is also trying to make CS more inclusive for rural students. It has been working with telecommunications providers to make a 25 million dollar

investment in high-speed internet access for rural communities. Providing all students with access to CS education is one of the main drivers of this policy initiative (Watson-Fisher, 2019). The Department of Education and Virtual Arkansas, an online education provider, are working to make free virtual CS classes available for students in schools that could not provide trained teachers (Nix, 2017).

Conclusion

Governor Hutchinson came into office making access to quality CS education a main goal of his administration. Cooperation from the legislature enabled the Department of Education to make great strides with regular funding and a full-time staff. Administrative officials have a hand in policymaking, but the governor and legislature have also included the viewpoints of other stakeholders like teachers and technology industry representatives in several task force groups. The State Director of Computer Science sees these task force groups as critical to improving CS instruction quality and coordinating policy with the economic needs of the state.

Recognizing that teachers are the most important component of CS education, the Arkansas Department of Education prioritized teacher training programs. The state created clear pathways for certification and cash incentives for in-service teachers that participate in training activities. Meanwhile, policymakers have coordinated with state universities to create a sustainable pipeline of qualified teachers by including CS coursework in preservice teacher training programs.

Crucially, the legislature and the Department of Education set up incentives for students and teachers to improve and scale up CS education. CS teachers in high schools have financial incentives to enroll more students in their classes while students can satisfy a mathematics credit by taking CS courses. Further, state universities allow high school electives to satisfy a prerequisite enrollment requirement of admission to undergraduate programs. Today, total enrollment in elective CS courses exceeds 10,000 out of roughly 143,000 total high school students, making Arkansas among the most successful states at enrolling its

students in CS education (State of Computer Science Education, 2019; Arkansas Department of Education, 2021).

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