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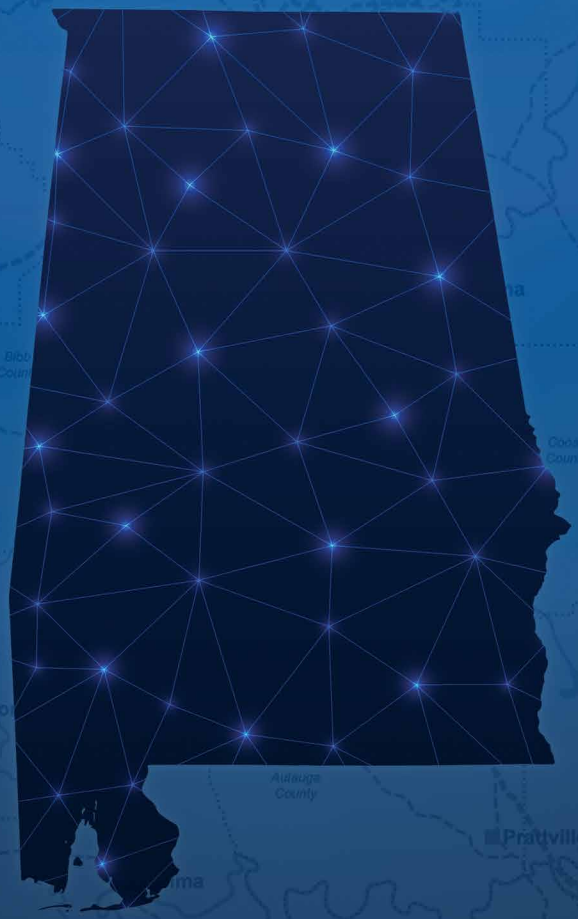

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6. Alabama Broadband for Education

SOFOKLIS GOULAS, CHUNPING HAN, AND MARGARET E. RAYMOND

This paper was prepared with support from student fellows Kiara Coleman (Tuskegee University); Karthik Reddy, Hannah Rodgers, Emily Schramek (University of Alabama); Shannon Yan (Stanford University).

EXECUTIVE SUMMARY

Many critical building blocks are already in place that position Alabama for significant change in the way it educates its public school students. Public elementary and secondary schools in Alabama are almost universally equipped with broadband internet in instructional classrooms. Teachers and administrators have some familiarity and expertise with digitally based tools, though these tools' use to support instruction is not as robust as for administrative functions. The expansion of support to teachers in their instructional roles is both technically and programmatically feasible.

The digital divide in Alabama is real, recognized, and ready to be fully redressed. Commitments to statewide deployment of broadband networks already exist, with strong starts in construction underway. Further state fiscal commitments and the opportunity for support from the American Rescue Plan and national infrastructure funds will create a onetime moment to rapidly deploy broadband to unserved communities and accelerate the time to impact the lives of K–12 students for decades to come. Once these resources are deployed, many other uses of the network can deliver additional streams of benefits in health care, job training, civic engagement, and public safety. The social return on broadband investment for public K–12 education alone exceeds 200 percent.

Recommendations

1. Make access to broadband by K–12 students and their families a top priority when awarding subsidies to telecom providers for the construction of new broadband facilities in unserved areas. Universal access will immediately elevate the ability of K–12 students to learn when they are not in school, effectively closing the "homework gap." Ubiquitous access will also stimulate novel approaches to in-school instruction, since students will be able to engage in activities when not in school.

2. Extend the eligibility for programs to support subscriptions for internet in order to cover the bandwidth of new broadband networks and ensure that all citizens can take advantage of the digital social and economic offerings.

3. Concentrate greater focus on educators' professional development, creating generalized competence and new pathways to mastery of digital education resources for personalized instruction, student support, and educator professional communities.

Introduction

Improving public education in Alabama is critical if the state aims to improve its outlook for the future. What students learn today in elementary and secondary schools directly affects the quality of the labor force five to forty years into the future, which in turn directly affects the economic and social well-being of the entire state. Gains in the level of student learning in Alabama would have one of the highest payoffs of any of the options the Alabama Innovation Commission might consider. To that end, a team from Stanford and two Alabama universities investigated ways to realize substantial improvement in educational attainment for Alabama K–12 students.

The need for better student outcomes was known before the coronavirus pandemic. Efforts to raise student learning were underway for some time, with many noteworthy results. The pandemic, however, sharpened the contours of the problem. In Alabama, as in other states, the coronavirus pandemic highlighted preexisting disparities in the opportunity for high-quality K–12 education across Alabama. It also revealed that students face unequal access to telecommunications infrastructure that could support learning in the digital environment when students are not in classrooms.

Despite the challenges it introduced, the pandemic has not been entirely negative in its impact. It prompted policy makers and educators to respond swiftly, demonstrating a novel capacity for action. It also prompted new allocations of public funds—on top of ongoing commitments—to expand access to broadband internet facilities and to provide subsidies for subscribers with limited financial resources. These effects brought forward the possibility of modifying how K–12 education is organized and delivered in Alabama in ways that quickly and significantly can raise student achievement.

The Alabama Innovation Commission has a seizable moment to alter dramatically the trajectory of the state's public education system in order to realize better outcomes for students, educators, and the state as a whole. This briefing paper presents a proposal to elevate the performance of Alabama public schools by greatly expanding the state's reliance on digitally based instructional resources and rapidly building teacher competence with individualized student learning plans. Making it a priority to rapidly deploy broadband internet facilities and provide needs-based support for internet service subscriptions in communities with significant populations of K–12 students will form the foundation for transforming schools into centers of digitally supported curriculum and instruction. Closing the homework gap would also create ancillary benefits in health care, employment, and public safety.

This proposal rests on strong efforts already underway in Alabama; shifts in focus and priorities will make it possible to achieve gains in student outcomes more rapidly and more equitably than is currently happening. Adopting the recommendations in this proposal will ensure more equitable access to high-quality digital education resources and support a greater share of students finishing high school ready to pursue further training or education. With modest gains in high school graduation and postsecondary program completion, a future stream of economic benefits in the state will *more than repay* the required investment on a reasonable schedule and build enduring improvements to the state economic climate beyond K–12 education.

This briefing paper begins with a detailed description of the Alabama K–12 landscape. We present original analysis from interviews with over two dozen Alabama school district superintendents about current availability and use of broadband within schools, which serves as the motivation for the proposal that follows. Estimates of the future economic impact of the proposal and suggestions for implementation conclude the paper.

The Issue

The bottom line is this: the public education system in Alabama falls short of providing the results that are needed if the state is to realize its other development goals.

Alabama public schools educate the majority of youths in the state and therefore have the largest share of responsibility for developing human capital of all public institutions. Despite years of effort and several significant initiatives, the level of knowledge and skills of students in Alabama public schools is not on par with that of other states in the region or the national average.

There are numerous consequences to the state from having underperforming schools. A brief list includes:

1. Lower student achievement leads to weaker labor force participation.

2. Lower student achievement depresses wages and career progression.

3. People who are undereducated are less capable of experimenting and innovating with products and processes.

4. Lower student achievement slows Alabama's economic growth.

5. Underperforming schools cloud the reputation of the state in other parts of the world.

6. Underperforming schools dampen the chance to recruit outside employers to operate in Alabama.

7. Underperforming schools hinder the likelihood of substantial gains in status and rewards for educators.

Many of these effects translate to lower state revenues and higher requirements for state support over a person's work life and retirement years. Several have strong, negative effects on other state priorities, such as expansion of the employer base or building innovation hubs around the state. Finally, while each effect has its own ripples through the citizens and communities in Alabama, none of these address the important considerations of educational equity and social justice, which adds further to the urgency of the situation.

How can state leaders dramatically and rapidly improve student learning in Alabama? Alabama K–12 schools stand at a critical pivot point. Improving the outcomes for students in Alabama cannot rely solely on delivering more on previous solutions. Traditional models of K–12 public schools face increasing pressure due to shortages of qualified teachers, especially in science, technology, engineering, and mathematics (STEM), so simply maintaining the status quo is a challenge in many districts. Efforts to cultivate a stronger teacher pipeline within the state require both diversification and realignment of teacher prep programs, which themselves face budgetary and operational constraints that inhibit rapid transformation.

While there will always be a need for teachers and administrators, Alabama leaders have a moment of opportunity to choose a path forward that blends local educators with the growing global array of high-quality instructional resources that are available in digital form. The chance to augment the hard work of educators with world-class education supports can significantly elevate the quality of student-centered instruction. That path, however, requires a commitment to ensuring all students and educators—regardless of location or income—have access to high-speed broadband internet to support learning in school and in their homes.

The Current Landscape for K–12 Education in Alabama

Policy leaders face a dual challenge with the current condition of public education in Alabama. First, the knowledge and skills that students develop in Alabama schools is insufficient for the demands of twenty-first-century life. Second, the considerable efforts and resources addressing the problem to date have not moved the needle. Each side of the problem deserves further delineation.

Student Learning

By many measures, Alabama public schools do not support the level of learning that readies graduates for further investment in their human capital, whether through training, military service, or postsecondary education. Alabama has remained below the national average for over two decades at both the fourth and, for over a decade, the eighth-grade levels.

Table 1. Proficiency rates for Alabama K–12 students, 2018–19 assessments

Student group	*Percent proficient*	
	Reading	*Math*
All students	45.27*	46.52
Asian	64.57	78.73
American Indian	30.38	38.27
Black	28.08	28.04
Hispanic	28.94	37.16
White	55.08*	56.25

**Student groups that met academic targets listed in the Alabama Final Consolidated State Plan, approved in 2019 by the United States Department of Education to comply with Every Student Succeeds Act requirements.*

Source: https://www.alabamaachieves.org/reports-data/.

We examined the proficiency rates for Alabama public school students. In 2018–19, 45 percent of Alabama K–12 students were proficient in reading and 47 percent were proficient in math. As shown in table 1, there is dramatic variation in proficiency rates across Alabama school districts and student groups and subgroups by as much as 34 percentage points in reading and 50 percentage points in math. Similar disparities exist for low-income students. It also bears noting that the most recent results (measured before the pandemic) fall short of the targets established in the state's approved plan under the federal Elementary and Secondary Education Act, as amended by the Every Student Succeeds Act of 2015.

Proficiency rates are particularly worrisome for Alabama high school students. In the 2018–2019 state assessments, 42 percent of Alabama high schoolers were rated proficient in reading and math, respectively. These numbers are hard to equate with a four-year cohort graduation rate in 2021 of 92 percent and a designation of College and Career Readiness for 75 percent of graduates.

The quality of K–12 schools has wider impacts across the state. It is holding down university ratings, which are directly tied to innovation and state productivity. The best in the state, Auburn University, is ranked number 97 in the nation, with an 81 percent acceptance rate. The next highest ranking in the state is a tie at number 143 for Samford University and the University of Alabama, with acceptance rates of 83 percent and 85 percent, respectively, primarily from in-state applicants.[1]

School Improvement Efforts

Alabama policy leaders deserve recognition and commendation for their extensive array of efforts in pursuit of improved academic performance of K–12 students.

Many changes have already occurred. It is fair to say that every aspect of K–12 school design and delivery is under review, and dozens of working groups and committees are working on facets of the system simultaneously. A few of these deserve special mention:

- Extensive content review and consultation with classroom educators led to the adoption of new learning standards in math and reading.[2]
- Districts and schools across the state were given new systems for tracking student effort and learning.[3]
- New pay programs have been designed to address teacher turnover in STEM subjects.
- Efforts to address teacher shortages are being piloted with novel forms of distance education.
- A multiyear commitment to professional development is underway for teachers and administrators in early reading.

While these efforts are commendable, the impact on student learning is not apparent. In addition, major problems persist: Teacher shortages have grown due to accelerating rates of teacher retirement. In June 2021, the Alabama State Department of Education (ALSDE) listed 2,700 jobs for certified teachers on its jobs board.[4] Before and during the pandemic, gaps in instructional readiness of teachers have been noted, especially as concerned the use of digital resources in preparing and delivering lessons.[5] Perhaps of greatest concern, there is no definition or regular measurement of the quality and impact of instruction.[6] Statewide efforts to address this shortage began but were overwhelmed by the pandemic's demands on educators and administrators.

Teachers' own knowledge and teaching skills need to be aligned with student abilities at the *students'* point of readiness to create engaged learning. Even without performance measures on teachers, it is safe to assume there is wide variation in the quality of teaching that occurs in Alabama classrooms. Supporting teachers and their pedagogy and delivering high-quality personalized instruction to K–12 students are dual priorities moving forward, pandemic or not.

Broadband Internet Infrastructure in Alabama

Robust broadband capacity has been recognized as vital to the future of Alabama.[7] The Broadband Alabama Strategy, revised in 2019, stresses the importance of a modern system to support the labor force, education, commerce/finance, health care, civic engagement, and emergency services. Of these expected impacts, only training/employment development

and education have the potential to grow the economy. The rest create limited-duration returns on their related costs.

When Governor Kay Ivey chose to focus on expanding the scope of broadband infrastructure in Alabama, it was with eyes wide open. Alabama ranks thirty-eighth in the nation in broadband penetration. Significant disparities exist in the accessibility of broadband internet, defined as 100 Mbps download/10 Mbps upload.[8] Even before the pandemic, the problem of "digital deserts" was known and understood. Over 226,000 residents have no terrestrial internet service of any kind. Even where terrestrial telecom facilities exist, much of the physical plant cannot support the technical requirements for video streaming and multiperson use. When the criterion of high transmission speed for both downloads and uploads is added, the number of stranded Alabamians rises to 415,000. Income and geography play large roles, but even in metro areas, 30 percent of households lack access to high-speed internet/broadband.[9] Across the state, only 44 percent have access to "affordable" service of $60 a month or less; this contrasts with the national average of 51 percent.[10]

The cost of fully deploying broadband has been estimated by the Alabama Department of Economic and Community Affairs (ADECA) to be between $4 billion and $6 billion.[11] State leaders have taken several steps to expand the broadband infrastructure in Alabama. Enactment of the Alabama Broadband Accessibility Act in 2018, with amendments a year later in Act 2019-327, established the Alabama Broadband Accessibility Fund and a budget of $47.4 million through 2021 to subsidize construction projects and serve previously unserved or underserved communities. Through 2020, $47.1 million in new construction had been committed at an average cost of $788 per new connection.[12] The efforts by state programs to stimulate additional deployment of fiber networks has made inroads, but there remain large areas of Alabama that are yet unable to join the broadband age.

The advent of the pandemic prompted even more investment, specifically to subsidize internet service subscriptions for students and their families. ADECA created Alabama Broadband Connectivity for Students (ABC for Students) and helped over 200,000 school-aged children connect and participate in remote learning. As the program sunsetted at the end of the 2020–21 school year, families became eligible for the federally subsidized Emergency Broadband Benefit Program. In addition, the Federal Communications Commission (FCC) committed $7.17 billion to the Emergency Connectivity Fund in order for schools and libraries to afford more physical connections, digital learning devices, and affordable service plans throughout the 2021–22 school year.[13]

Even with these responsive programs, students across the state were stranded if they lived in areas without service. ALSDE took strong measures to address the gap, including wiring school buses for mobile Wi-Fi, but many students still faced challenges.

We know that access to affordable internet can have significant impact on student learning. Increased access in the United States and globally has improved both the number of years and the quality of students' schooling and increased professional support and development for educators.[14] With ubiquitous deployment of broadband infrastructure, the largest hurdle to realizing these benefits for Alabama would be eliminated, along with additional benefits in other areas of public life such as health and public safety.

AREN and the E-rate Program

Across the United States, the federal E-rate program for K–12 schools and postsecondary educational institutions financially supports access to the internet. The Universal Service Administrative Company, under the direction of the FCC, administers the E-rate program. The E-rate program provides discounts to eligible schools and libraries for telecommunications and internet services, including internal connections, maintenance, and managed broadband networks. The discounts range from 20 percent to 90 percent of the costs of eligible services, depending on the share of students in a district who live in poverty. In 2020, Alabama received $811 million in E-rate subsidies.

The Alabama Research and Education Network (AREN) manages the backbone of the network, which connects more than 600 libraries and schools and the Alabama supercomputer to the internet. Managed by the Alabama Supercomputer Authority, AREN provides services to 94 percent of school systems in the state. In particular, AREN, through its service providers, installs, maintains, and monitors school systems' internet. Examples of education-related AREN-led initiatives include a synchronous distance education program in 2005, a one-to-one learning device program in 2018, and a 2019 program that provided internet to libraries.

Broadband access is a necessity in order to provide online education. K–12 online learning was already increasing across the United States prior to the pandemic. In the 2017–18 school year, 21 percent of public schools and 13 percent of private schools offered at least one online course. Of the schools that offered at least one online course, 81.9 percent were primary schools.[15]

Leader Perspectives on Broadband for Education

Having physical facilities to support broadband-based education in Alabama is only half the equation: having educators ready to take advantage of the resource is also required. To better understand the frontline story, we conducted interviews with school superintendents (or their designated representatives) from twenty-seven Alabama districts. The state superintendent of education supported the effort with a personal endorsement and encouraged district leaders to participate. Superintendents graciously spent time explaining the status of their schools in accessing and using broadband to support the work of their educators.

The interviews covered six topics:

- Students' and teachers' access to broadband and technical devices
- The districts' experience with AREN and E-rate
- Teachers' use of digital resources in teaching and administration
- Professional development and IT supports to develop teachers' digital skills
- Online instruction offered by the district
- The districts' use of digital resources to help low-income or low-performing students

Their responses offered a deep and rich view of the many facets of provision, use, and support of broadband and the digital offerings it can support across the districts. A full presentation of the findings are presented in Appendix A along with tables of responses to the interview questions.

The picture for broadband deployment and use that we gained from our interviews with superintendents was encouraging. Their districts have made broadband internet and technical devices widely accessible by students and teachers at school. It is clear that significant functions of educators are already supported with broadband technology and digital programs and applications. At the same time, there is still notable room for expansion in the use of digital resources in teachers' instruction, the offering of online courses, and help for disadvantaged students. Based on these findings, the focus in the future should be student-centered, including but not limited to improving access to technology by rural and small districts, expanding online instruction for both core and noncore courses, and providing tailored help and support for disadvantaged students.

A Proposal: Make Alabama the Broadband for Education State

Alabama is poised for change. With a few marginal adjustments in an already strong start, the state can realize dramatic growth in its human capital and economic health. This proposal describes the overall approach and provides details on how the Alabama Innovation Commission, the governor and the state legislature can accelerate the rate of growth.

Improving the K–12 public education system in Alabama has been a desire for years, for good reason. The future benefits of improved learning for individuals are well known and well documented: greater employability, greater chances of completing higher education, higher wages, longer and more productive work lives. What has been missing is an approach that can achieve the improvement at scale.

The quality of schools arises from a host of factors. Of these, the largest available lever of change is the efficacy of instruction. Any plan to raise the caliber of student learning must support current and future educators in delivering high-quality instruction to every student every day. The pandemic prompted us to see that "classroom" might take on different dimensions even if not required by public health concerns. The plan must also recognize that much of learning occurs when students are *not* in classrooms; club activities, sports, outings, homework, and community-based experiences are examples. An approach to student-centered learning from instruction provided by teachers, backed by high-quality course materials and lessons, can only occur at scale if we can ensure that teachers have the proper access to instructional resources and the support to guarantee that they deliver high-quality instruction.

As part of its final recommendations, the Alabama Innovation Commission has a chance to move aggressively on these ideas. It can do so by strengthening the focus on K–12 education as a driver of its Broadband Alabama initiative. Ensuring physical facilities and services are available also needs to accompany targeted support to make certain that all students have equitable opportunity to access and use it. These commitments open horizons of possibility in K–12 schools to enrich existing practices with a wider range of digital instructional resources and new high-quality teaching methods that match materials and instruction to student needs. This shift requires that educators and leaders complete new paths of professional development to increase the educator labor force's capacity and expertise.[16]

This proposal builds on many important advances already in place in Alabama—in schools and in communities. Still, it will require a multiyear initiative to build the necessary political coalition, secure the required funds, and organize the waves of needed construction. As the policy leaders and educators in the state have already demonstrated, this proposal can benefit from the strong capacity for action that has been on display over the pandemic period.

Policy Design

Ensuring equitable opportunities for learning in K–12 schools and full preparation for postsecondary options will require a three-part solution:

Access to Broadband The Alabama Innovation Commission could advance educational excellence in Alabama schools by leveraging broadband technology and its use in the public K–12 arena. Two related strands of effort are needed. First, the small number of schools that are not connected to broadband networks in all instructional classrooms should be heavily or fully subsidized to achieve **universal connectivity in the K–12 public education system.** The value of a ubiquitous broadband network that links every school building and instructional classroom justifies extended subsidies to telecom providers to complete the necessary construction. Universal classroom access opens new horizons for co-teaching, professional

development, and support and deployment of student learning supports in more efficient ways. With ensured broadband access, barriers to using best-of-breed instructional resources in Alabama K–12 classrooms would be removed.

Help the Unserved Alabama can realize substantial returns on future broadband investment if it makes coverage of households with K–12 students a priority. Alabama can leverage approved state and federal funds it already plans to spend just by adding consideration of the number of K–12 students in unserved census tracks when making subsidy decisions for new broadband facilities. The state can **close the "homework gap."** Students would then have access to digital resources to support their learning, regardless of location.

Implementation Considerations:

- E-rate program funding and ASA support are available for connecting the last handful of schools and classrooms. (School district budgets already fund the residual construction costs and ongoing subscription charges.)

- The Alabama Broadband Fund, managed through ADECA, is the logical lead for managing a statewide broadband deployment plan.

- Even before the COVID pandemic, the state legislature approved a bump in General Fund commitments starting in 2020, which are expected to grow further.

- Alabama received $1.8 billion in aid from the Coronavirus Aid, Relief, and Economic Security (CARES) Act of 2021.[17]

- Alabama received $2.1 billion from the Coronavirus State and Local Fiscal Recovery Fund as part of the American Rescue Plan. These funds are authorized for use in several areas, including broadband construction.

- The pending bipartisan Infrastructure Bill in Congress includes $65 billion for broadband deployment and subscription support for the nation. If Alabama gets 1 percent of that, it will amount to $650 million in support.

Affordable Internet Service Subscriptions The state's recent COVID experience with internet subsidies for students illuminated the need for a policy and program to ensure affordable service across the state. Many state leaders will look at statewide broadband deployment as "déjà vu all over again," replicating the experience with the Universal Service Fund for ubiquitous telephone service. And they would be right: the same income barriers will persist when broadband is everywhere. The upside is that the earlier experience

can serve as a foundation to ensure that all broadband service providers offer adequate and affordable service to every household.

Implementation Considerations:

- During the COVID pandemic, the Alabama state legislature initially approved $100 million in CARES funds for internet subscription vouchers for low-income families with public school students; half the amount was later reallocated to other uses because there were fewer applications than expected. ADECA quickly devised a process to disburse the funds that worked until the end of the 2020–21 school year. Thus, a dedicated mechanism for delivery of subsidies already exists to support low-income families with school-aged children.

- Consistent with current policy directions, the governor and the state legislature have the discretion to establish broadband internet as an essential utility. It would then be possible to make adjustments to public assistance and universal services programs in order to provide needs-based support on a sliding scale. Families with K–12 elementary and secondary students could receive their support bundled with other forms of public assistance instead of through the ADECA internet voucher program.

Expansion of Use of High-Quality Instructional Materials in Classrooms For this plan to succeed, the Alabama State Department of Education has a critical role to play. If Alabama is to become the Broadband for Education state, ALSDE will need to maximize its expertise and available resources to support ubiquitous personalized learning, high-quality instruction in school, extended support learning by students, and learning support by teachers and administrators.

Implementation Considerations:

- The American Rescue Plan includes funds to support the capacity building that this proposal will require. The Elementary and Secondary School Emergency Relief Fund in 2021 provided $2 billion for education aid to the state of Alabama.[18] That can be leveraged for much of the organizational design and professional development needed to realize this proposal.

- Budget allocations must be redirected for ALSDE professional development to rapidly expand the competence of curriculum leaders and teacher leaders to integrate digital education resources into programs for Alabama K–12 students. The professional development of education leaders and district heads of curriculum must be rapidly accelerated to champion greater access to high-quality instructional materials inside and outside of Alabama and to support optimal classroom instruction.

- One option to upskill the teacher force is to develop a career path to certify and reward educators who complete intensive training in online personalized learning that includes competence in continuous-improvement practices.[19]

- It will be especially important to harness best-of-breed online offerings in subject areas that are currently lacking qualified high-impact teachers. ALSDE already has experience with curricula review in most subject areas and which could seek deeper evaluations of online resources, especially those that support personalized instruction and pacing.

- Experience in other communities showed that adoption of high-touch high-bandwidth education was more successful when there was readily available tech and instructional support of teachers and school leaders (perhaps through use of coaches).

- It will be important to recognize the ongoing need for professional development as the supply of high-quality instructional resources grows and evolves.

Economic Impact Analysis

Decisions to create statewide broadband access must reflect consideration of the costs in relation to expected benefits. Once in place, the network will be available for multiple uses; commerce, health care, public services administration, civic participation, skills training/upskilling, and entertainment will all gain from the larger number of connected households.

This proposal has framed the investment in a statewide broadband network only in terms of its value to Alabama public K–12 education. We have developed a simple economic impact analysis to estimate the required investment from state resources, a narrow scenario of benefits, and the returns on the initial investment over time. A full explanation of the investigation and methods appears in Appendix B. Here, we provide a brief summary of approach and results.

We expect that access to broadband everywhere in the state will improve education in Alabama and that the gains will be widespread. Many of them, however, will be hard to isolate. One place where we can segment the impact is for students whose overall academic attainment improves enough that they shift from only having a high school diploma to pursuing a college degree. That is admittedly a small portion of all those whose welfare will be improved due to broadband, and we do not wish to imply that this group alone should bear the full cost of the investment. Nonetheless, they provide a concrete way to illustrate the benefit side of the proposition.

Using statistics shared in earlier portions of the briefing paper, and explained fully in Appendix B, we calculate that by ensuring access for all, each future graduating cohort

will add 2,483 students to the set of college educated. Using published analyses from labor economics, we predict that the premium in lifetime earnings for having a college degree over a high school diploma is $765,000. The cumulative gains in personal income over the twenty-year useful life of the fiber equipment is around $5.5 billion. We consider this the marginal gain in social welfare for the state. After deducting the state's investment, the estimated social welfare return on investment is 214 percent.

We examine a pure financial return on investment by looking at personal income taxes. We use a 9 percent tax burden to quantify the share of that new income that would return to the state. In the twentieth year, the state will see a cumulative increase in state income tax revenue of $495 million. This produces a financial return of 28 percent of the initial state investment at the end of twenty years.

NOTES

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3 PowerSchool, "ALSDE's Road to Recovery with Performance Matters," video presentation, April 2021, https://powerschool.wistia.com/medias/xazi9qbat9.

4 Trisha Powell Crain, "Alabama Schools Are Seeing Teachers Retiring at the Highest Level in Nearly a Decade," *Advance Local*, June 30, 2021, https://www.al.com/news/2021/06/alabama-schools-are-seeing-teachers-retiring-at-the-highest-level-in-nearly-a-decade.html.

5 Trisha Powell Crain, "As Teacher Morale Hit Bottom, These Alabama Districts Looked for Ways to Ease Workload," *Hechinger Report*, March 17, 2021, https://hechingerreport.org/as-teacher-morale-hit-bottom-these-alabama-districts-looked-for-ways-to-ease-workload.

6 Alabama ESSA state plan, p. 17, October 12, 2017, https://www2.ed.gov/admins/lead/account/stateplan17/alconsolidatedstateplanfinal.pdf.

7 State of Alabama Executive Order No. 704, (April 26, 2017); Alabama Broadband Accessibility Act (March 28, 2018) and Act 2019-327 (May 30, 2019).

8 While the FCC defines broadband as 100/3, the standard is insufficient to support multiple users of a single connection. This is the likely scenario for families with students using the internet for schoolwork while others simultaneously access other resources.

9 Ramsey Archibald, "Many Students in Alabama Contend with Internet Access Issues," *Government Technology*, July 24, 2020, https://www.govtech.com/network/many-students-in-alabama-contend-with-internet-access-issues.html.

10 Tyler Cooper and Julia Tanberk, *The State of Broadband in America, Q2 2021*, BroadbandNow Research, August 18, 2021, https://broadbandnow.com/research/q2-broadband-report-2021.

11 Caroline Beck, "Broadband Expansion to Underserved Areas Could Cost $4B-$6B," *Alabama Daily News*, February 1, 2021, https://www.aldailynews.com/broadband-expansion-to-underserved-areas-could-cost-4b-6b.

12 ADECA reports that the new grants awarded since the publication of the 2021 Annual Report raise the average cost per new service to $806. Telephone conversation with ADECA representative, August 3, 2021; Alabama Broadband Accessibility Fund 2021 Annual Report, Alabama Department of Economic and Community Affairs, January 28, 2021, https://adeca.alabama.gov/maps-plans-and-reports.

13 "FCC Launches Country's Largest Effort to Close Homework Gap," Federal Communications Commission, June 29, 2021, https://www.fcc.gov/document/fcc-launches-emergency-connectivity-fund.

14 "Connecting Learners: Narrowing the Educational Divide," The Economist Intelligence Unit, 2021, https://connectinglearners.economist.com/data/EIU_Ericsson_Connecting.pdf.

15 eLearning Statistics, ThinkImpact, 2021, https://www.thinkimpact.com/elearning-statistics/#2-K–12-elearning-statistics.

16 The policy ideas and recommendation in this proposal complement work in two other Hoover briefing papers. This initiative lends itself well to the activities of research and evaluation proposed by Eric Hanushek in his EdLabs recommendation. Additionally, the instruments that are proposed for financing this plan are consistent with the work of Joshua Rauh in his paper on state and local tax policy.

17 "How Much Each State Will Receive from the Coronavirus Relief Fund in the CARES Act," Center on Budget and Policy Priorities, March 26, 2020, https://www.cbpp.org/research/how-much-each-state-will-receive-from-the-coronavirus-relief-fund-in-the-cares-act.

18 Caroline Beck, "K–12 Schools Look to 'Fill the Gap' with Incoming $2 Billion COVID Relief Funds," *Alabama Daily News*, July 13, 2021, https://www.aldailynews.com/K–12-schools-look-to-fill-the-gap-with-incoming-2-billion-covid-relief-funds.

19 "School Culture of Innovation," Future Ready Schools, Alliance for Excellent Education, accessed July 12, 2021, https://futureready.org/implementation-guide/school-culture-of-innovation/.

APPENDIX A: LEADER PERSPECTIVES ON BROADBAND FOR EDUCATION

Having physical facilities to support broadband-based education in Alabama is only half the equation: having educators ready to take advantage of the resource is also needed. To better understand the frontline story, we conducted interviews with superintendents (or their designated representatives) from twenty-seven Alabama school districts. The superintendents graciously spent time explaining the status of their schools in access to and use of broadband to support the work of their educators.

The interviews covered six topics:

- Students' and teachers' access to broadband and technical devices
- The district's experience with the Alabama Research and Education Network (AREN) and the federal telecommunications support program E-rate
- Teachers' use of digital resources in teaching and administration
- Professional development and IT supports to develop teachers' digital skills
- Online instruction offered by the district
- The district's use of digital resources to help low-income or low-performing students

Access to Technology

Overall, the respondents reported that students and teachers in Alabama have solid access to broadband internet and technical devices for learning and instruction at school. In all interviewed districts, 100 percent of instructional classrooms have access to broadband internet (table 1). In a large majority of districts, all students have individual devices, such as computers, laptops, or pads, for their classroom learning (table 2). In addition, all respondents say that 100 percent of their teachers have individual devices for their instruction (table 3).

Broadband Internet access at home for students and teachers varies. In half of interviewed districts, more than 70 percent of students have access to broadband internet at home, including 17 percent of districts with above 90 percent of students with broadband internet at home (table 4). In roughly half of the Alabama districts, more than 90 percent of teachers have broadband at home (table 5).[1]

Interaction with AREN and E-rate Program

More than two-thirds of the surveyed districts participate in AREN (table 6). This contrasts with 94 percent of all districts across the state. For the majority of respondents, AREN

provides value by setting a process for securing internet service, negotiating a rate discount with the internet provider, or providing the means to build a local network hooked up to fiber internet (table 7). The majority of surveyed districts that participate in AREN connect to the internet through a local provider (table 8). Nearly 90 percent of respondents said participation in AREN was a net benefit, with reduced internet cost being the most commonly reported reason (tables 9 and 10).

The field is not consistent when it comes to estimating the value of joining the AREN consortium. Nearly one-quarter of respondents believed participation was mandatory (tables 11 and 12). Regardless, all respondents saw the reduced cost of internet services as being beneficial. At the same time, more than half the district leaders mentioned drawbacks to the program: excessive paperwork was most frequently reported (table 13). All of those mentioning administrative burden were in rural or small districts. Two-thirds or more of interviewed districts owned inside wiring, pedestal at point of presence, wired ethernet, and wireless hotspots in their district (table 14). The responses show that 100 percent of instructional classrooms in almost every district are wired to ethernet (table 15). In more than 90 percent of districts, 100 percent of instructional classrooms had Wi-Fi connection (table 16). These responses identify the chief benefit for districts—the service subsidies—and suggest the possibility of streamlining the process for districts with limited staff.

Teachers' Use of Digital Resources and Districts' Offer of Professional Development and IT Support

In spite of extensive connectivity, the interviewed districts have yet to fully utilize the technology in instruction and learning. Teachers' use of digital resources is most prevalent in administrative functions such as recording attendance or grades or corresponding with school and district colleagues. Nearly all the respondents indicated that 100 percent of their teachers regularly used digital resources for administrative functions (table 17).

Use of fast internet to support lesson planning was less prevalent across all the grades, according to our respondents. Roughly half the superintendents reported that all their teachers used these resources, though most said that 50 percent or more of teachers were using digital sources for planning and instruction (tables 18 and 20–22). Fewer teachers use digital resources to share lesson plans or resources (table 19).

Professional Development

All represented districts provide professional development opportunities for teachers to develop competence in the use of digital resources in teaching and administration, primarily through training, paying for training by external providers, and sharing useful information and resources with teachers (table 23). All represented districts also provide IT support to help teachers use digital resources in teaching and administration

(table 24). The most common means were deploying IT staff for on-site instruction and troubleshooting as well as offering training classes. Further research needs to probe whether the training and IT support solely addresses electronic administration or drives instruction as well.

Online Instruction

While twenty-five among twenty-seven represented districts offer at least one course that primarily relies on broadband for instruction (table 25), around half do not offer any such courses for elementary or middle schools and half the districts provide less than 30 percent of primarily online courses for high schools (tables 26 and 27). Fewer districts have courses exclusively offered online (table 28). Exclusive online instruction, when offered, tends to spread across core and noncore courses for elementary and middle schools and concentrate on elective and advancement courses for high schools.

The majority of districts reported that their reliance on online instruction to fulfill instruction plans for elementary and middle schools was somewhat small or very small; around half of districts responded that way in regard to high schools (table 29). The most prevalent reasons for districts to offer online courses were to make courses available to more students and to make high-quality courses available to students (table 30). It is also notable that half of the districts adopt online courses to fill in a shortage of educators. This is not surprising given that nearly 60 percent of districts had 1 percent to 10 percent of teacher positions vacant (table 31) and that one-third of districts had teacher turnover rates of 11 percent to 20 percent (table 32).

A substantial proportion of district leaders said they expect a greater share of online education in instruction in the next five years, particularly for high schools (table 33). However, a large majority did not plan to provide synchronized instruction for any grade span in post-pandemic time, especially for elementary schools (table 34).[2]

Use of Digital Resources to Help Low-Income or Low-Performing Students

The interviewed district leaders said they try to use digital resources to help education for low-income and low-performing students. They employ a variety of ways to help underserved students access the internet during out-of-school time, primarily by providing Wi-Fi hotspots in various venues (e.g., school buses and parking lots), extending time for students to stay in school, and working with local libraries (table 35). More than 70 percent of districts also subsidize broadband internet at home for students from low-income families (table 36). In addition to technology access, districts help develop underserved students' skills at using digital resources for learning, mainly through the support of teachers, classes, and resource sharing (table 37). The majority of districts also provide web-based support for low-performing schools through remedial classes, tutoring, and information sharing (table 38).

Summary

The picture for broadband deployment and use that we gained from our interviews with superintendents was encouraging. Their districts have made broadband internet and technical devices widely accessible by students and teachers at school. At the same time, there is still notable room for expansion in the use of digital resources in teachers' instruction, the offering of online courses, and help for disadvantaged students. Based on these findings, the focus in the future should be student-centered, including but not limited to improving access to technology by rural and small districts, expanding online instruction for both core and noncore courses, and providing tailored help and support for disadvantaged students.

NOTES

1 The Alabama State Department of Education shared its most recent technology audit of the prevalence of internet in schools and in students' homes. Due to the pandemic, some districts did not complete the audit, but those that did showed student rates of available internet that were on par with the reports from our superintendent respondents.

2 Synchronized instruction refers to classes that some students attend in person while other attend online.

Table 1. Variation among districts in percentage of instructional classrooms having access to broadband internet

Response	*Frequency*	*Percent*
0%	0	0
1–10%	0	0
11–20%	0	0
21–30%	0	0
31–40%	0	0
41–50%	0	0
51–60%	0	0
61–70%	0	0
71–80%	0	0
81–90%	0	0
91–99%	0	0
100%	27	100

Frequency and percentage of respondents indicating percentage of classrooms within their district having access to broadband internet.

Summary: In every interviewed Alabama district, 100 percent of instructional classrooms have access to broadband internet.

Table 2. Variation among districts in percentage of elementary, middle, and high school students having access to individual devices for classroom learning

Response	*Elementary*		*Middle*		*High*	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
0%	0	0	0	0	0	0
1–10%	0	0	0	0	0	0
11–20%	0	0	0	0	0	0
21–30%	0	0	0	0	0	0
31–40%	1	4	1	4	1	4
41–50%	1	4	0	0	0	0
51–60%	0	0	0	0	0	0
61–70%	0	0	0	0	0	0
71–80%	1	4	0	0	1	4
81–90%	0	0	1	4	0	0
91–99%	1	4	0	0	0	0
100%	23	85	24	92	24	92

Frequency and percentage of respondents indicating percentage of students within each category in their district having access to individual devices, such as computers, laptops, and pads, for their classroom learning.

Summary: An overwhelming majority of interviewed districts report that 100 percent of students in elementary, middle, or high schools in their district have individual devices, such as computers, laptops, and pads, for their classroom learning.

Table 3. Variation among districts in percentage of elementary, middle, and high school teachers having access to individual devices for instruction

Response	*Elementary*		*Middle*		*High*	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
0%	0	0	0	0	0	0
1–10%	0	0	0	0	0	0
11–20%	0	0	0	0	0	0
21–30%	0	0	0	0	0	0
31–40%	0	0	0	0	0	0
41–50%	0	0	0	0	0	0
51–60%	0	0	0	0	0	0
61–70%	0	0	0	0	0	0
71–80%	0	0	0	0	0	0
81–90%	0	0	0	0	0	0
91–99%	0	0	0	0	0	0
100%	27	100	26	100	26	100

Frequency and percentage of respondents indicating percentage of teachers within each category in their district having access to individual devices, such as computers, laptops, and pads, for their classroom instruction.

Summary: Every surveyed Alabama district indicates that 100 percent of teachers have individual devices for their instruction.

Table 4. Variation among districts in percentage of students having access to broadband internet at home

Response	*Frequency*	*Percent*
0%	0	0
1–10%	0	0
11–20%	0	0
21–30%	1	4
31–40%	0	0
41–50%	3	13
51–60%	2	8
61–70%	4	17
71–80%	7	29
81–90%	3	13
91–99%	3	13
100%	1	4

Frequency and percentage of respondents indicating percentage of students in their district having access to broadband internet at home.

Summary: In half of the Alabama districts, 71 to 80 percent or more of students have access to broadband internet at home. Seventeen percent of districts have a share of students with broadband internet at home above 90 percent. The lowest reported share of students with access to broadband at home in a district is in the 21 to 30 percent range.

Table 5. Variation among districts in percentage of teachers having access to broadband internet at home

Response	*Frequency*	*Percent*
0%	0	0
1–10%	0	0
11–20%	0	0
21–30%	0	0
31–40%	0	0
41–50%	2	8
51–60%	1	4
61–70%	0	0
71–80%	4	16
81–90%	6	24
91–99%	7	28
100%	5	20

Frequency and percentage of respondents indicating percentage of teachers in their district having access to broadband internet at home.

Summary: In roughly half of the Alabama districts, more than 90 percent of teachers have broadband at home. The lowest reported share of teachers with access to broadband at home in a district is in the 41 to 50 percent range.

Table 6. Number and percentage of districts participating in the Alabama Research and Education Network (AREN)

Response	*Frequency*	*Percent*
Yes	19	70
No	8	30

Frequency and percentage of respondents indicating participation in AREN.

Summary: More than two-thirds of surveyed Alabama districts participate in the Alabama Research and Education Network (AREN).

Table 7. Variation among districts in arrangements with the Alabama Research and Education Network (AREN)

Response	*Frequency*	*Percent*
AREN serves as an administrative hub to process the application for the internet service for the district.	12	63
AREN serves as an administrative hub to negotiate a rate discount for whatever the internet provider serves each school's geography.	11	58
AREN provides a network hub hooking up the schools in the district to the fiber internet.	12	63
Other	3	16

Frequency and percentage of respondents indicating specified arrangements with AREN. Responses are not mutually exclusive. Responses under "Other" include: "They are internet service provider based on allocation of speed," "professional development information, support via email," "A very knowledgable [member of] staff that helps when asked."

Summary: For the majority of interviewed Alabama districts, AREN serves as a hub to process the application for internet service, negotiate a rate discount with the internet provider, or provide a network hooked up to fiber internet.

Table 8. Number and percentage of districts providing connection to AREN through a local provider

Response	*Frequency*	*Percent*
Yes	12	63
No	7	37

Frequency and percentage of respondents indicating connection to AREN through a local provider. Reported local providers: AT&T, Charter Dependent, ITS, Pine Belt, Mediacom, TDS, WOW.

Summary: The majority of interviewed districts provide connection to AREN through a local provider.

Table 9. Variation among districts in opinion about their participation in the Alabama Research and Education Network (AREN)

Response	*Frequency*	*Percent*
A net benefit	16	89
A neutral arrangement	1	6
A net cost	1	6

Frequency and percentage of respondents indicating specified opinion about participation in AREN.

Summary: The overwhelming majority of districts participating in AREN think of their participation as a net benefit.

Table 10. Variation among districts in reasons for positive opinion about AREN

Response	*Frequency*	*Percent*
Provides internet at reduced cost	14	88
Provides manpower for infrastructure	3	19
Allows choice of provider	1	6
Provides convenient internet services and installation	1	6
Provides reliable internet	1	6
Offers simplified application process	1	6

Frequency and percentage of respondents indicating specified reasons why AREN participation is a net benefit.

Summary: The overwhelming majority of districts viewing their participation in AREN as a net benefit cited reduced cost for internet access as their justification.

Table 11. Number and percentage of districts participating in the E-rate program

Response	*Frequency*	*Percent*
Yes	27	100
No	0	0

Frequency and percentage of respondents indicating participation in the E-rate program.

Summary: Every Alabama district interviewed participates in the E-rate program.

Table 12. Number and percentage of districts believing their E-rate participation is mandatory

Response	*Frequency*	*Percent*
Yes	6	23
No	20	77

Frequency and percentage of respondents indicating their belief that participation in the E-rate program is mandatory.

Summary: The overwhelming majority of surveyed districts do not believe their participation in the E-rate program is mandatory.

Table 13. Variations in districts' views on advantages and disadvantages of the E-rate program

Advantages		
Response	*Frequency*	*Percent*
Reduced cost	27	100
Provision of infrastructure	7	26
Access to equipment	6	22
Provision of security	2	7
Disadvantages		
Response	*Frequency*	*Percent*
No disadvantages	10	42
Excessive paperwork	7	29
Limits usage of funds	5	21
Application takes up time	4	17

Frequency and percentage of respondents' cited advantages and disadvantages of participation in the E-rate program.

Summary: All sampled districts find the E-rate program beneficial for reducing cost. While the preponderance of interviewed superintendents explicitly report no disadvantage to the program, the most frequently cited drawback relates to excessive paperwork.

Table 14. Number and percentage of districts owning and operating certain portions of their network

Response	*Frequency*	*Percent*
Inside wiring only	18	67
Inside wiring and pedestal at point of presence	19	70
Wired Ethernet network	22	81
Wireless nodes/hotspots	20	74
None	2	7

Frequency and percentage of respondents indicating ownership and operation of certain portions of their network.

Summary: Roughly two-thirds or more of districts own the internal wiring, the pedestal of point of presence, the wired Ethernet network, or the wireless hotspots in their network.

Table 15. Variation among districts in percentage of instructional classrooms wired to Ethernet

Response	*Frequency*	*Percent*
0%	0	0
1–10%	0	0
11–20%	0	0
21–30%	1	4
31–40%	0	0
41–50%	0	0
51–60%	0	0
61–70%	0	0
71–80%	0	0
81–90%	0	0
91–99%	0	0
100%	26	96

Frequency and percentage of respondents indicating percentage of classrooms within their district that are wired to Ethernet.

Summary: In almost every district, 100 percent of instructional classrooms are wired to Ethernet.

Table 16. Variation among districts in percentage of instructional classrooms having Wi-Fi connection

Response	*Frequency*	*Percent*
0%	0	0
1–10%	0	0
11–20%	0	0
21–30%	0	0
31–40%	0	0
41–50%	0	0
51–60%	0	0
61–70%	0	0
71–80%	0	0
81–90%	0	0
91–99%	2	8
100%	24	92

Frequency and percentage of respondents indicating percentage of classrooms within their district that have a Wi-Fi connection.

Summary: In more than 90 percent of Alabama districts, 100 percent of instructional classrooms have a Wi-Fi connection.

Table 17. Variation among districts of elementary, middle, and high school teachers who regularly use digital resources to support administrative functions

Response	*Elementary*		*Middle*		*High*	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
0%	0	0	0	0	0	0
1–10%	0	0	0	0	0	0
11–20%	0	0	0	0	0	0
21–30%	0	0	0	0	0	0
31–40%	0	0	0	0	0	0
41–50%	0	0	0	0	0	0
51–60%	0	0	0	0	0	0
61–70%	1	4	0	0	0	0
71–80%	1	4	2	8	1	4
81–90%	0	0	0	0	1	4
91–99%	1	4	1	4	1	4
100%	24	89	23	88	23	88

Frequency and percentage of respondents indicating percentage of teachers within each category in their district who regularly use digital resources to support administrative functions.

Summary: Nearly 90 percent of interviewed superintendents indicated that 100 percent of their teachers, regardless of grade span, regularly use digital resources for administrative functions. The usage is also widespread in the remaining districts.

Table 18. Variation among districts of elementary, middle, and high school teachers who regularly use digital resources to develop and update lesson plans

Response	*Elementary*		*Middle*		*High*	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
0%	0	0	0	0	0	0
1–10%	0	0	0	0	0	0
11–20%	0	0	0	0	0	0
21–30%	0	0	0	0	0	0
31–40%	0	0	0	0	0	0
41–50%	0	0	0	0	0	0
51–60%	2	7	1	4	1	4
61–70%	1	4	0	0	0	0
71–80%	1	4	4	15	5	19
81–90%	8	30	7	27	7	27
91–99%	1	4	2	8	1	4
100%	14	52	12	46	12	46

Frequency and percentage of respondents indicating percentage of teachers within each category in their district who regularly use digital resources to develop and update lesson plans.

Summary: All the teachers in around half of interviewed districts regularly use digital resources to develop and update lesson plans. The majority of teachers in the other half of the districts regularly do so.

Table 19. Variation among districts of elementary, middle, and high school teachers who regularly use digital resources to share lesson plans or resources with other teachers

Response	*Elementary*		*Middle*		*High*	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
0%	0	0	0	0	0	0
1–10%	0	0	1	4	2	8
11–20%	1	4	1	4	1	4
21–30%	3	12	0	0	0	0
31–40%	2	8	4	17	4	17
41–50%	0	0	1	4	1	4
51–60%	2	8	1	4	0	0
61–70%	2	8	1	4	2	8
71–80%	3	12	4	17	4	17
81–90%	6	24	4	17	2	8
91–99%	1	4	2	8	3	13
100%	5	20	5	21	5	21

Frequency and percentage of respondents indicating percentage of teachers within each category in their district who regularly use digital resources to share lesson plans or resources with other teachers.

Summary: In 20 percent of interviewed districts, all the teachers regularly use digital resources to share lesson plans or resources with other teachers. In another 40 percent of the districts, 71 to 99 percent of teachers regularly do so.

Table 20. Variation among districts of elementary, middle, and high school teachers who regularly use digital resources in their delivery of lessons

Response	*Elementary*		*Middle*		*High*	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
0%	0	0	0	0	0	0
1–10%	0	0	0	0	0	0
11–20%	0	0	0	0	0	0
21–30%	0	0	0	0	0	0
31–40%	0	0	0	0	0	0
41–50%	1	4	2	8	3	12
51–60%	1	4	0	0	0	0
61–70%	1	4	2	8	2	8
71–80%	3	11	3	12	3	12
81–90%	6	22	4	15	4	15
91–99%	2	7	3	12	3	12
100%	13	48	12	46	11	42

Frequency and percentage of respondents indicating percentage of teachers within each category in their district who regularly use digital resources in their delivery of lessons.

Summary: All the teachers in nearly half of interviewed districts regularly use digital resources in their delivery of lessons. In another 40 percent of the districts, 71 to 99 percent of the teachers regularly do so.

Table 21. Variation among districts of elementary, middle, and high school teachers who regularly assign students to use digital resources to do coursework

Response	*Elementary*		*Middle*		*High*	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
0%	0	0	0	0	0	0
1–10%	0	0	0	0	0	0
11–20%	1	4	0	0	0	0
21–30%	1	4	0	0	0	0
31–40%	1	4	3	12	3	12
41–50%	2	7	4	15	2	8
51–60%	2	7	0	0	0	0
61–70%	2	7	1	4	1	4
71–80%	2	7	1	4	3	12
81–90%	2	7	3	12	3	12
91–99%	1	4	2	8	2	8
100%	13	48	12	46	12	46

Frequency and percentage of respondents indicating percentage of teachers within each category in their district who regularly assign students to use digital resources to do coursework.

Summary: All the teachers in nearly half of interviewed districts regularly assign students to use digital resources to do coursework. Teachers in the other half of the districts also do so, although with varying percentages.

Table 22. Variation among districts of elementary, middle, and high school teachers who regularly use digital resources to provide extra support to students

Response	*Elementary*		*Middle*		*High*	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
0%	0	0	0	0	0	0
1–10%	0	0	0	0	0	0
11–20%	0	0	0	0	0	0
21–30%	0	0	0	0	0	0
31–40%	2	8	1	4	1	4
41–50%	1	4	2	8	2	8
51–60%	0	0	1	4	3	13
61–70%	1	4	1	4	2	8
71–80%	7	28	4	17	3	13
81–90%	4	16	6	25	4	17
91–99%	1	4	1	4	1	4
100%	9	36	8	33	8	33

Frequency and percentage of respondents indicating percentage of teachers within each category in their district who regularly use digital resources to provide extra support to students.

Summary: All the teachers in one-third of interviewed districts regularly use digital resources to provide extra support to students. The majority of teachers in the other half of the districts also use digital resources for the same purpose.

Table 23. Professional development opportunities districts offer to elementary, middle, and high school teachers to develop competence in the use of digital resources in teaching and administration

	Elementary		*Middle*		*High*	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
Training offered by the district	27	100	26	96	26	96
Paying for training offered by external providers	24	89	23	85	23	85
Sharing information about relevant resources for teachers' own use	24	89	23	85	23	85
Other	11	41	10	37	10	37
None	0	0	0	0	0	0

Frequency and percentage of respondents indicating that their district provides the specified professional development opportunities to teachers within each category to develop competence in the use of digital resources in teaching and administration. "Other" responses include outsourcing out of district, sharing among schools, AL Tech in Motion, regional and service centers, Schoology, Google system, in-service centers, training a group of teachers to train in the classroom (referred as instructional coaches), teachers collaborating on technology, tech teacher at the school, state-run technology training programs that all the teachers participate in, training in Google Classroom and Zoom, a specialist with tool kit and office hours, training for Access and Acellus, Amystye, science motion, and other free resources.

Summary: Districts provide a variety of professional development opportunities for teachers to develop competence in the use of digital resources in teaching and administration. Almost all interviewed districts offer training themselves; most districts also pay for training outside the district and share relevant information for teachers' use.

Table 24. Availability of district-wide IT support to help elementary, middle, and high school teachers use digital resources in teaching and administration

	Elementary		*Middle*		*High*	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
Training classes	22	81	21	78	20	74
Specialized Q&A channels	6	22	5	19	5	19
On-site instruction and/or troubleshooting by IT staff	27	100	26	96	25	93
Other	7	26	7	26	7	26
None	0	0	0	0	0	0

Frequency and percentage of respondents indicating availability of district-wide IT support to help elementary, middle, and high school teachers use digital resources in teaching and administration. "Other" responses include training from local school tech coordinator, experts down the hall, a help-desk ticketing system to get an assigned school technician to respond, calls to a real person via help desk Zoom call with IT, Apple professional development for educators, and development through regional in-service centers.

Summary: All interviewed districts have IT staff who provide on-site instruction and troubleshooting. The majority of the districts also offered training opportunties. Some districts provide various channels to address specific issues.

Table 25. Number and percentage of districts offering any courses that rely primarily on broadband for instruction

	Frequency	*Percent*
Yes	25	93
No	2	7

Frequency and percentage of respondents indicating whether the district offers any courses that rely primarily on broadband for instruction. Further probing of the results indicates that the two districts not offering any online courses are small (with two to twelve schools).

Summary: Most districts offer at least one course that relies primarily on broadband for instruction.

Table 26. Variation among districts of percentage of courses in elementary, middle, and high schools that rely primarily on broadband for instruction

Response	*Elementary*		*Middle*		*High*	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
0%	14	58	11	46	1	4
1–10%	1	4	1	4	9	39
11–20%	2	8	2	8	1	4
21–30%	1	4	2	8	1	4
31–40%	0	0	0	0	0	0
41–50%	2	8	1	4	1	4
51–60%	0	0	1	4	0	0
61–70%	0	0	0	0	2	9
71–80%	0	0	0	0	0	0
81–90%	1	4	2	8	2	9
91–99%	1	4	0	0	0	0
100%	2	8	4	17	6	26

Frequency and percentage of respondents indicating percentage of courses within each category of their district schools that rely primarily on broadband for instruction.

Summary: The percentage of courses that rely primarily on broadband for instruction varies across districts and by grade span. The number of primarily online courses offered increases with the grade span. Close to 60 percent of districts do not provide such courses in elementary schools, whereas the other districts vary in the percentage of online courses offered in elementary schools. Nearly half of the districts do not provide online middle school courses, while 17 percent of the districts offer all middle school courses online. About 26 percent of the districts offer all high school courses online, but nearly half of the districts provide less than 30 percent of the courses online for high schools.

Table 27. Variation among districts of courses offered exclusively online for elementary and middle school students

	Elementary		*Middle*	
	Frequency	*Percent*	*Frequency*	*Percent*
Literacy	6	22	8	30
Math	6	22	8	30
Science	6	22	8	30
Other courses	5	19	7	26
None	17	63	13	48

Frequency and percentage of respondents indicating that classes within specified subject areas are offered exclusively online for elementary and middle school students. This question was asked only of the twenty-five districts that offer at least one course that relies primarily on broadband for instruction. "Other courses" for elementary schools include history, social studies, career prep, health, electives, computer course. One district responded "every class." "Other courses" for middle schools include history, social studies, remediation/credit recovery/intervention, career prep, health, electives, and computer science. One district responded "every class."

Summary: Over 60 percent of the districts do not provide any courses offered exclusively online for elementary schools. Around half of the districts do not do so for middle schools. Courses offered exclusively online for elementary and middle schools include both core and other courses.

Table 28. Variation among districts of courses offered exclusively online for high school students

	Frequency	*Percent*
Advanced placement (AP) courses	17	63
Career and technical education (CTE) courses	12	44
Foreign languages	19	70
Elective courses (e.g., economics, psychology)	18	67
Other courses	12	44
None	0	0

Frequency and percentage of respondents indicating that classes within specified subject areas are offered exclusively online for high school students. This question was asked only of the twenty-five districts that offer at least one course that relies primarily on broadband for instruction. "Other courses" for high schools include dual-enrollment courses, every class, remedial/intervention/credit recovery, science, computer science, career prep, health, electives, state-mandated courses, core courses (math, English, science, history classes that are required for graduation), access courses, higher math (cal 2).

Summary: Courses offered exclusively online for high schools are concentrated on noncore courses, although a couple of districts mentioned core courses in the "Other courses" category.

Table 29. Variation among districts' level of reliance on online instruction to fulfill instruction plans for elementary, middle, and high schools

	Elementary		*Middle*		*High*	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
Very large	1	4	1	4	3	13
Somewhat large	2	8	4	17	4	17
Neither large nor small	2	8	2	9	4	17
Somewhat small	2	8	7	30	9	39
Very small	17	71	9	39	3	13

Frequency and percentage of respondents' indication of their district's level of reliance on online instruction to fulfill instruction plans within each category.

Summary: The reliance of the majority of the districts on online instruction to fulfill instruction plans for elementary and middle schools is somewhat small or very small. Around half of the districts feel so for high schools.

Table 30. Number and percentage of districts citing particular reasons to offer online courses

	Frequency	*Percent*
To fill in a shortage of educators	14	52
To augment the work of long-term substitutes	1	4
To augment the work of employed teachers	5	19
To make the courses available to more students	19	70
To make high-quality courses available to students	18	67
Other reasons	11	41

Frequency and percentage of respondents indicating specified reasons to offer online courses. "Other reasons" include students/parents preferring flexibility and virtual options, helping students be career ready, preparing tools for lifelong learning, emphasizing soft skills, preparing students for graduation, allowing students to explore more of their interests, mandatory virtual option in all Alabama high schools, hybrid learning for certain courses, remediating or accelerating students, and scheduling purposes.

Summary: The most common reasons for districts to offer online courses are making courses available to more students and making high-quality courses available to students. Half of the districts fill in a shortage of educators by offering online courses.

Table 31. Variation among districts of percentage of vacant teacher positions

Response	*Frequency*	*Percent*
0%	9	33
1–10%	16	59
11–20%	1	4
21–30%	0	0
31–40%	0	0
41–50%	0	0
51–60%	0	0
61–70%	0	0
71–80%	0	0
81–90%	0	0
91–99%	0	0
100%	1	4

Frequency and percentage of respondents indicating percentage of vacant teacher positions within their districts.

Summary: Nearly 60 percent of districts have 1 to 10 percent of teacher positions vacant. Another two districts have higher vacancy rates.

Table 32. Variation among districts of percentage of teacher turnover

Response	*Frequency*	*Percent*
0%	0	0
1–10%	16	62
11–20%	9	35
21–30%	1	4
31–40%	0	0
41–50%	0	0
51–60%	0	0
61–70%	0	0
71–80%	0	0
81–90%	0	0
91–99%	0	0
100%	0	0

Frequency and percentage of respondents indicating percentage of teacher turnover within their districts.

Summary: Around 62 percent of districts have teacher turnover rates of 1 to 10 percent. Another one-third of districts have teacher turnover rates of 11 to 20 percent.

Table 33. Variation among districts of expectation of change in the share of online education in instruction in district elementary, middle, and high schools in the next five years

	Elementary		*Middle*		*High*	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
Greater share	11	41	13	50	17	65
Similar share	13	48	10	38	7	27
Smaller share	3	11	3	12	2	8

Frequency and percentage of respondents indicating their expectation of change in the share of online education as a part of total instruction in each category of school in their districts.

Summary: Most districts expect to include the same or a greater share of online education in instruction in the next five years. The expected share increases with the grade span.

Table 34. Variation among districts' plans to provide synchronized instruction in elementary, middle, and high schools post-pandemic

	Elementary		*Middle*		*High*	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
Yes	4	15	6	23	6	23
No	23	85	20	77	20	77

Frequency and percentage of respondents indicating whether their districts plan to provide synchronized instruction post-pandemic for each category of school. "Synchronized instruction" means the same class that some students attend in person and other students attend online.

Summary: The majority of interviewed districts do not plan to provide synchronized instruction for any grade span, particularly elementary schools, post-pandemic.

Table 35. Variation in districts' options for providing underserved students with access to the internet during out-of-school hours

	Frequency	*Percent*
Extended hours for students to stay in school	19	70
School buses with Wi-Fi hotspots	20	74
District coordination with local public libraries	14	52
Other	15	56
None	0	0

Frequency and percentage of respondents indicating specified option for providing underserved students with access to the internet during out-of-school hours. "Other" responses include Wi-Fi hotspots that can be checked out and taken home, access points in parking lots outside of school, online help, summer literacy camps, working with local internet service providers to provide free internet access to disadvantaged students, Alabama Broadband Connectivity program for students, additional days added to school calendar.

Summary: Districts employ a variety of ways to help underserved students access the internet during out-of-school time, primarily through providing Wi-Fi hotspots in different venues, extending time for students to stay in school, and working with local libraries.

Table 36. Number and percentage of districts subsidizing broadband internet at home for students from low-income families

	Frequency	*Percent*
Yes	7	26
No	20	74

Frequency and percentage of respondents indicating that they subsidize broadband internet at home for students from low-income families.

Summary: The majority of districts subsidize broadband internet at home for students from low-income families.

Table 37. Variation in methods of assistance offered by districts to underserved students in elementary, middle, and high schools to develop skills in using digital resources for their learning

	Elementary		*Middle*		*High*	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
Specialized classes/sessions for a group of students together	14	52	14	52	15	56
Extra support by the teacher of a course using digital resources in instruction	23	85	22	81	22	81
Support by individual tutors	13	48	13	48	12	44
Sharing information about relevant resources for students' individual use	15	56	16	59	15	56
Other	6	22	4	15	4	15
None	1	4	1	4	1	4

Frequency and percentage of respondents indicating specified method of assistance to underserved students by category of school for the development of skills in using digital resources for learning. "Other" responses include core classes, credit-bearing classes for high schools, troubleshooting tips on website; sessions to help parents understand, digital support to students prior to classes; a media platform, getting digital help in the Acellus lab or from the librarian.

Summary: The majority of districts help develop underserved students' skills in using digital resources for learning through classes, support by educators, and resource sharing.

Table 38. Variation in methods of web-based support offered to low-performing students in any courses in elementary, middle, and high schools

	Elementary		*Middle*		*High*	
	Frequency	*Percent*	*Frequency*	*Percent*	*Frequency*	*Percent*
Remedial classes	21	78	20	74	21	78
Individual tutoring	19	70	18	67	19	70
Sharing of relevant resources for students' individual use	17	63	17	63	18	67
Other	3	11	3	11	3	11
None	2	7	2	7	1	4

Frequency and percentage of respondents indicating specified method of web-based support to low-performing students in any courses by category of school. "Other" responses include intervention classes, content based of standardized testing for that student (curriculum-driven content), Iready, USA test prep (all students), IXL (middle school), and Acellus (middle and high school).

Summary: The majority of districts provide web-based support to help low-performing students learn through classes, tutoring, and information sharing.

APPENDIX B: ESTIMATING THE NET ECONOMIC BENEFIT OF THE ALABAMA BROADBAND FOR EDUCATION PROPOSAL

Assessing broadband infrastructure expansion as a policy instrument to improve education outcomes in Alabama requires a cost-benefit calculus from the perspective of the state. To facilitate the policy valuation, we provide an estimate of the economic benefit and the return on investment associated with access to broadband internet for all Alabama students.

Access to broadband internet is likely to have a positive impact on a wide array of value-generating activities in Alabama. Our economic benefit estimation focuses on the direct benefits linked to higher earnings of students who for the first time would have broadband internet at home during their school years.

Our cost-benefit analysis requires the following ingredients:

1. *An estimate of the number of students in a cohort with access to broadband at home.* Our survey directly asked district superintendents about students' access to broadband at home. Using the weighted midpoint average response method, we infer that 71.1 percent of students in the average Alabama school district have access to broadband internet at home. This suggests that 28.9 percent of students in the average district do not have broadband at home.

   In 2019, 57,276 students graduated from high school.[1] Our survey results suggest that 16,553 (28.9 percent × 57,276) students in a given graduating cohort may not have access to broadband at home.

2. *An estimate of the additional number of students pursuing tertiary education because of access to broadband internet at home.* Occupational projections in Alabama show that future jobs will require college or university education at a minimum.[2] Researchers at Michigan State University have found that students with broadband-quality internet at home are roughly 15 percentage points more likely to plan to complete any college or university beyond high school compared with students who do not have internet at home or have cell phone access only.[3] This finding implies that providing access to broadband at home to all Alabama students would lead to an additional 2,483 (15 percent × 16,553) students in a graduating cohort pursuing tertiary education.

3. *An estimate of the college education premium in lifetime income.* Tamborini, Kim, and Sakamoto find that college graduates have higher earnings than high school graduates in a lifetime (until age 69).[4] In particular, the authors estimate that the lifetime earnings premium of a college degree compared with high school diploma is

$765,000.[5] This suggests that the 2,483 Alabama students in a high school graduating cohort who may attend college because of broadband access at home could earn a total of $1,899,495,000 in additional income in their lifetime.

4. *An estimate of tax collected by the state of Alabama per additional dollar of income generated.* The Tax Foundation estimates tax burden for 2019 in the state of Alabama at 9 percent.[6] This means that for every dollar of value produced in Alabama, the state receives nine cents through various taxes (e.g., income, property, or sales taxes). The Alabama tax burden estimate suggests that the 2,483 Alabama students in a cohort who may pursue college education and earn a higher lifetime income due to access to broadband at home could contribute a total of $170,954,550 to their state through taxation.

5. *An estimate of the useful life of broadband infrastructure.* We use 20 years as a conservative estimate of how long a newly deployed broadband network could last before requiring substantial replacement.[7] This means that 20 cohorts of students would benefit from the new broadband infrastructure. This suggests that the state of Alabama would collect $3,419,091,000 (20 × $170,954,550) in additional tax revenue associated with broadband network expansion through increased lifetime earnings.

   In a sensitivity analysis, we consider an extended useful life for the broadband network of 30 years rather than 20 years. Considering the potentially extended use of the new infrastructure, the state's additional tax revenue rises to $5,128,636,500.

6. *An estimate of the state's contribution to the cost of broadband infrastructure.* CTC Technology and Energy has estimated the cost of developing broadband infrastructure across Alabama's underserved areas at $4 billion to $6 billion.[8] We use the midpoint of that range as an estimate of the total infrastructure cost (i.e., $5 billion).

   In our calculation, we consider that the Alabama Department of Economic and Community Affairs could subsidize 35 percent of the broadband network cost.[9] Services closer to existing networks or those associated with positive net benefits for developers may require lower subsidization than the average service connection. Higher levels of subsidization may be needed for service connections located away from existing infrastructure or those that may be financially unattractive to developers. Using 35 percent as an indicative subsidy rate, we estimate the state's contribution to broadband infrastructure cost at $1,750,000,000 (35 percent × $5,000,000,000).

Putting together the ingredients for our cost-benefit analysis, we find that the tax revenue gains associated with broadband infrastructure for education are estimated at $3,419,091,000 (point 5) under standard infrastructure useful life. At the same time, the state's contribution to the cost of broadband infrastructure development is estimated at $1,750,000,000 (point 6). Comparing the $3,419,091,000 of additional tax revenue because

of broadband network expansion with the state's contribution of $1,750,000,000 to the cost of that network development, we estimate the state of Alabama's return on investment at 95 percent and its investment multiplier at 1.95. When an extended infrastructure useful life is considered, the state's return on investment increases to 193 percent, and its investment multiplier becomes 2.93.

It is important to highlight the large amount of additional income potentially generated through broadband for education. Part of it may be collected by the state through taxation, but the remainder is likely to be spent and invested in the Alabama economy, creating cascading benefits in the society. Comparing the additional income generated due to broadband network expansion with the state's contribution to infrastructure cost, we

Table 1. Parameters used in cost-benefit analysis

Parameter	*Value*
Students affected	
High school graduating cohort size [1]	57,276
Share of students without broadband at home [2]	28.9%
Number of students in a cohort without broadband at home [3]	16,553
Rate increase in college attendance because of broadband at home [4]	15.0%
Number of additional students pursuing college because of broadband [5]	2,483
Benefit	
College degree lifetime income premium (until age 69) [6]	$765,000
Tax burden [7]	9.0%
Cost	
Total broadband infrastructure cost [8]	$5,000,000,000
Subsidy rate [9]	35.0%
State's costs of broadband infrastructure [10]	$1,750,000,000

[1] *"The Condition of College & Career Readiness 2019: Alabama Key Findings," ACT, https://www.act.org/content/dam/act/unsecured/documents/cccr-2019/Alabama-CCCR-2019.pdf.*
[2] *Source: Authors' calculation based on survey interviews of Alabama district superintendents.*
[3] *Calculation: 57,276 × 28.9%.*
[4] *Source: Keith N. Hampton, Laleah Fernandez, Craig T. Robertson, and Johannes M. Bauer, "Broadband and Student Performance Gaps," James H. and Mary B. Quello Center, Michigan State University, March 3, 2020, https://doi.org/10.25335/BZGY-3V91.*
[5] *Calculation: 16,553 × 15.0%.*
[6] *Estimation assumes equal gender representation. Source: Christopher R. Tamborini, ChangHwan Kim, and Arthur Sakamoto, "Education and Lifetime Earnings in the United States,"* Demography *52, no. 4 (August 2015): 1383–1407.*
[7] *Source: Erica York and Jared Walczak,* State and Local Tax Burdens, Calendar Year 2019*, Tax Foundation, Washington, DC, 2021, https://files.taxfoundation.org/20210322135318/State-and-Local-Tax-Burdens-Calendar-Year-20192.pdf.*
[8] *Source: Caroline Beck, "Broadband Expansion to Underserved Areas Could Cost $4B–$6B,"* Alabama Daily News*, February 1, 2021, https://www.aldailynews.com/broadband-expansion-to-underserved-areas-could-cost-4b-6b.*
[9] *Source: Alabama Broadband Accessibility Fund,* 2021 Annual Report*, Alabama Department of Economic and Community Affairs, January 28, 2021, https://adeca.alabama.gov/maps-plans-and-reports.*
[10] *Calculation: $5,000,000,000 × 35%.*

Table 2. Cost-benefit analysis of broadband infrastructure development

Time outlook after infrastructure development	*Initial state investment*	*Cumulative additional income*	*State's social return on investment*	*State's social investment multiplier*	*Cumulative additional tax revenue*	*State's return on investment*	*State's investment multiplier*
Standard infrastructure use (useful life: 20 years)							
10 Years	$1,750,000,000	$848,710,532	–52%	0.48	$76,383,948	–96%	0.04
20 Years	$1,750,000,000	$5,496,411,064	214%	3.14	$494,676,996	–72%	0.28
38 Years (break even)	$1,750,000,000	$19,803,245,745	1,032%	11.32	$1,782,292,117	2%	1.02
50 Years	$1,750,000,000	$29,502,794,681	1,586%	16.86	$2,655,251,521	52%	1.52
Full outlook	$1,750,000,000	$37,989,900,000	2,071%	21.71	$3,419,091,000	95%	1.95
Extended infrastructure use (useful life: 30 years)							
10 Years	$1,750,000,000	$848,710,532	–52%	0.48	$76,383,948	–96%	0.04
20 Years	$1,750,000,000	$5,496,411,064	214%	3.14	$494,676,996	–72%	0.28
35 Years (break even)	$1,750,000,000	$20,005,319,681	1,043%	11.43	$1,800,478,771	3%	1.03
50 Years	$1,750,000,000	$38,191,973,936	2,082%	21.82	$3,437,277,654	96%	1.96
Full outlook	$1,750,000,000	$56,984,850,000	3,156%	32.56	$5,128,636,500	193%	2.93

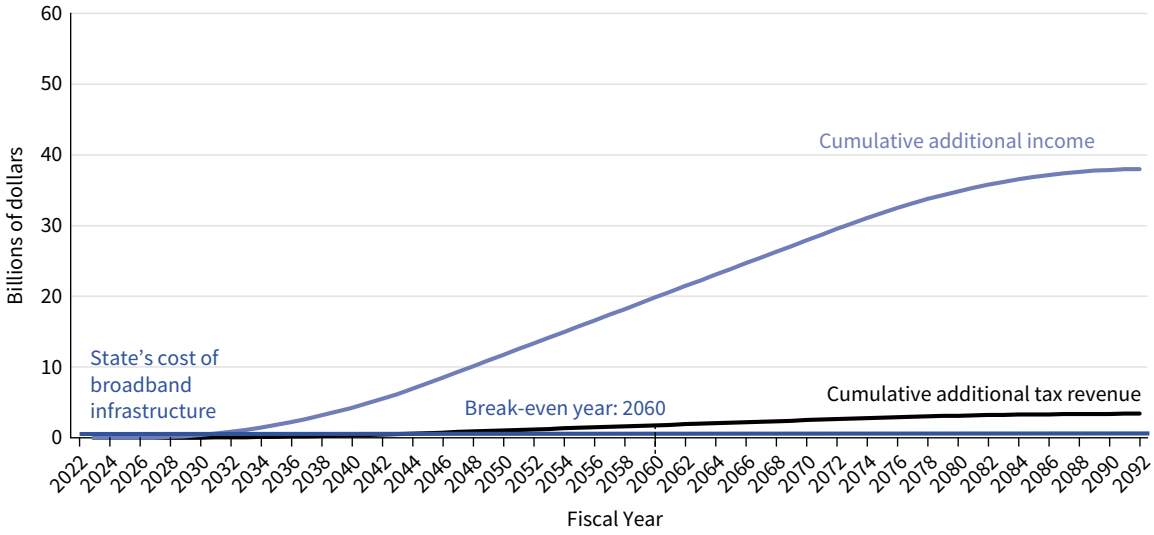
Cumulative additional income (tax revenue) represents the total flow of additional income (tax revenue) in a given time frame. For simplicity, we assume students benefit the same regardless of the number of years of access to broadband at home during school years. We also assume smooth earnings distribution across fiscal years between college graduation and age 69. Tamborini, Kim, and Sakamoto (see n4) use age 69 as an endpoint of productive life. Return on investment (social return on investment) is calculated by subtracting the initial investment value from the cumulative tax revenue (income) in a given time frame, then dividing this new number by the initial investment value. The investment multiplier (social investment multiplier) is the ratio between the cumulative tax revenue (income) in a given time frame and the initial investment value.

estimate the social return on investment at 2,071 (3,156) percent and the social investment multiplier at roughly 22 (33) under standard (extended) infrastructure longevity.

Table 1 outlines the parameters used in our estimation of net economic benefit of broadband infrastructure development. Table 2 presents a cost-benefit analysis using the smoothed distributed-benefit method. Our projections show that twenty years after infrastructure development, the total new income generated is estimated at $5,496,411,064 and the associated additional tax revenue is estimated at $494,676,996. These projections correspond to a 214 percent social return on investment and a financial return that covers 28 percent of initial state investment at the end of twenty years.

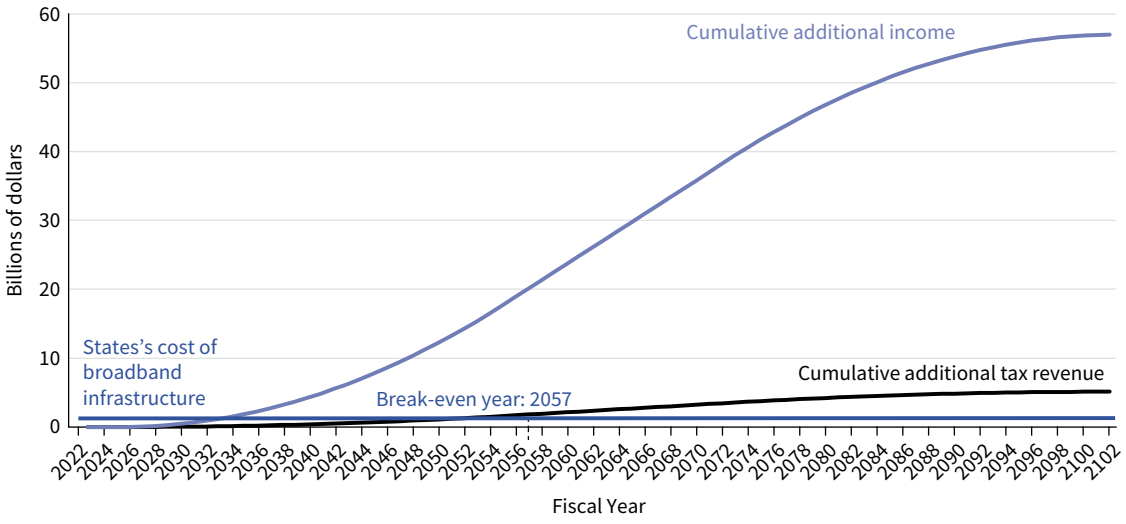
Figure 1 plots the cumulative tax revenue at different times, assuming twenty years of useful life for the broadband network. The year 2023 is used as the year of first broadband infrastructure use. Our projections suggest that the state's contribution to the infrastructure cost will be fully paid (break even) through tax revenue gains in 2060. Figure 2 plots the cumulative

Figure 1. Cumulative additional income and tax revenue from broadband for education under standard useful life



Note: 2023 is used as year of first broadband infrastructure use. Standard useful life corresponds to twenty years of infrastructure use.

Figure 2. Cumulative additional income and tax revenue from broadband for education under extended useful life



Note: 2023 is used as year of first broadband infrastructure use. Extended useful life corresponds to thirty years of infrastructure use.

tax revenue when an extended useful life of thirty years is considered for the infrastructure. The extended useful life is associated with an earlier financial break-even time of 2057.

The net economic benefit of broadband infrastructure for education is substantial for both the state and the overall economy in Alabama. In the long-term horizon, benefits channeling through education fully pay off the state's cost of broadband infrastructure development. In addition to education, broadband benefits are likely to flow in through other channels such as commerce, health care, public services administration, civic engagement, skills development, and entertainment production. Economic benefits through those channels could exceed the education-related benefits of broadband. Additional wealth and tax revenue generated from broadband expansion through sectors besides education render the investment more attractive and the state's support more justifiable.

NOTES

1 "The Condition of College & Career Readiness 2019: Alabama Key Findings," ACT, https://www.act.org/content/dam/act/unsecured/documents/cccr-2019/Alabama-CCCR-2019.pdf.

2 "State of the Workforce Report XIV: Alabama, 2020," Alabama Department of Labor, http://www2.labor.alabama.gov/WorkforceDev/WorkforceReports/Alabama.pdf.

3 Keith N. Hampton, Laleah Fernandez, Craig T. Robertson, and Johannes M. Bauer, "Broadband and Student Performance Gaps," James H. and Mary B. Quello Center, Michigan State University, March 3, 2020, https://doi.org/10.25335/BZGY-3V91.

4 Christopher R. Tamborini, ChangHwan Kim, and Arthur Sakamoto, "Education and Lifetime Earnings in the United States," *Demography* 52, no. 4 (August 2015): 1383–1407.

5 Estimation assumes equal gender representation; see Tamborini, Kim, and Sakamoto, "Education and Lifetime Earnings." Researchers at Georgetown University estimate a higher college degree premium at $964,000: Anthony P. Carnevale, Stephen J. Rose, and Ban Cheah, "The College Payoff: Education, Occupations, Lifetime Earnings," Center on Education and the Workforce, Georgetown University, https://cew.georgetown.edu/cew-reports/the-college-payoff.

6 Erica York and Jared Walczak, *State and Local Tax Burdens, Calendar Year 2019*, Tax Foundation, Washington, DC, 2021, https://files.taxfoundation.org/20210322135318/State-and-Local-Tax-Burdens-Calendar-Year-20192.pdf.

7 PPC, a major broadband network developer, estimates the likelihood of a fiber network failure after twenty to forty years of use at one in one hundred thousand. Various components of the network equipment may have shorter useful lifetimes than fiber optic. https://www.ppc-online.com/blog/4-factors-that-influence-how-long-your-fiber-network-will-last.

8 Caroline Beck, "Broadband Expansion to Underserved Areas Could Cost $4B–$6B," *Alabama Daily News*, February 1, 2021, https://www.aldailynews.com/broadband-expansion-to-underserved-areas-could-cost-4b-6b.

9 Alabama Broadband Accessibility Fund, *2021 Annual Report*, Alabama Department of Economic and Community Affairs, January 28, 2021, https://adeca.alabama.gov/maps-plans-and-reports.

About the Authors

Sofoklis Goulas is a senior researcher at the Center for Research on Education Outcomes (CREDO) at Stanford. He specializes in the economics of education and policy evaluation. He has been the lead analyst on impact evaluations of school choice and school improvement programs in the United States. He holds an MSc in finance and economics from Warwick Business School, and an MS and PhD in economics from University of North Carolina–Chapel Hill.

Chunping Han is the quantitative research manager of the Center for Research on Education Outcomes (CREDO) at Stanford University. Her research in education focuses on the impact on student learning outcomes of education policies, such as school choice, closure of low-performing schools, and equity in education. She received a PhD in sociology from Harvard University and a master's in education from Stanford.

Margaret "Macke" E. Raymond is the director of the Center for Research on Education Outcomes (CREDO) at Stanford University, which analyzes education reform efforts around the country. She is passionate about ensuring our country provides opportunities for all its youth through excellent education in all schools. CREDO is a leader in studying US charter schools, school reform policy, measurement and performance, and accountability systems and incentives. Raymond holds a BA summa cum laude from Boston University, with three master's degrees and a PhD in political science from the University of Rochester.