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# Enhancing Online Access for K-12 Education: Policy Implementation Strategies for US States

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## Abstract

The COVID-19 pandemic forced K-12 education to pivot to virtual platforms that required students to connect to the Internet to access school. This abrupt transition primarily impacted students living in underserved areas, particularly in rural and impoverished communities already suffering from the digital divide. To combat the digital divide a variety of private and public organizations implemented programs to provide the necessary devices and reliable Internet connections to students nationwide. Our research assessed 69 programs providing Internet access to students using three criteria: Connectivity, Implementation Speed, and Cost. Our study found a negative relationship between Connectivity and Implementation Speed, indicating that the most effective solutions require considerable time and resources. This highlights the importance of implementing both short-term and long-term solutions to ensure students can connect to online resources. Short-term solutions, such as hotspots, will help students gain Internet access quickly, while long-term solutions, such as construction of broadband infrastructure, will create lasting change for communities in need.

Since the primary obstacle to realizing these goals is funding, our research identified four alternatives for obtaining funding for increased Internet access: BroadbandUSA Program, state-level funding, the Federal Communications Commission's Lifeline Program, and tax incentives for individuals working from home. Sustained funding policies align best with implementation of more costly and long-term solutions, namely infrastructure construction. Economic policies aimed at mitigating the affordability aspects of the digital divide, such as the Lifeline Program and tax incentives, are best aligned with short-term solutions, as they are not designed to provide extended support to citizens. Using the data and analysis of these 69 programs, we demonstrate a plurality of policies aimed at local governments to address the digital divide and connect students to the Internet.

## Introduction

The digital divide is often defined as "inequalities in access to computers and the Internet between groups of people based on one or more dimensions of social or cultural identity" (Gorski, 2005). The key dimensions of social or cultural identity that affect digital access most often include socioeconomic status and geography (Cullen, 2001). This problem of connectivity and affordability disproportionately impacts rural areas. The socioeconomic factors impacting the digital divide have been studied in depth and the key drivers are understood to be age, education level, labor markets and minority status (Serrano-Cinca, Munoz-Soro and Brusca, 2018). Socioeconomic status in both rural and urban communities contributes to affordability challenges. Rural students also struggle due to the lack of infrastructure and the increased costs of installing internet infrastructure in low density areas, which is the basis for most accessibility challenges. In order to have sufficient Internet access, a person needs to be in a geographic location that has access to broadband through proper infrastructure and must be able to afford that access. As described by John Lai and Nicole Widmar (2020) a "negative correlation between rurality and Internet speed was found at the county level, highlighting the struggle for rural areas." Thus, rural areas, defined by the Census Bureau's land-use definition, often struggle with the digital divide because of accessibility challenges (Cromartie & Bucholtz, 2008).

This research focuses on the digital divide in educational contexts and the approaches taken to address this inequality during the onset of the COVID-19 pandemic in rural settings. In 2018, prior to the COVID-19 pandemic, the Federal Communications Commission (FCC) reported that only 51.6% of U.S. students residing in rural communities had access to sufficient Internet, which the FCC defines as approximately 250/25 megabits per second, compared to 94% of urban residents (Lai & Widmar 2020). Losses in reading proficiency during the COVID-19 pandemic averaged 0.33 grade equivalents for rural school districts were higher than urban and suburban districts (Fahle et al., 2022). Rural areas with little or no Internet access also scored lower on standardized tests and were less likely to plan for post-secondary school education compared to those in urban areas (Hampton et. al., 2020; Koricich).

In early 2020, the pandemic shifted K-12 education to online platforms across the United States and that shift required Internet access and digital literacy skills. The move to online learning compounded the impact on students living in rural areas that were already experiencing the digital divide due to accessibility reasons. Scholars have since demonstrated that the COVID-19 pandemic has exacerbated this disadvantage for rural students. As of March 2020, 37% of students in rural areas could not attend school and approximately 400,000 teachers could not teach due to lack of Internet access (Chandra et. al. 2020). Furthermore, the lack of digital literacy in rural areas added to this issue (Mamedova et al., 2018, 3). Even as schools return to in-person learning, they continue to utilize online platforms as a critical component of their curriculum. Centers for Disease Control and Prevention (CDC) policy dictates that students and school faculty stay quarantined at home if they are exposed and/or test positive (CDC, 2022). When students got sent home, parents had to stay home from work with little notice and time away from school to avoid further negative impacts on a student's learning (Meckler, 2021). Across the nation, state and local governments implemented different programs to expand Internet access to students in an attempt to make virtual education more attainable. These programs included hotspot programs, mobile Wi-Fi units, extended school or library hours, laptop and/or tablet rentals, and free or reduced-price home internet, see Appendix C for a full list of the programs evaluated. This paper conducts an initial assessment of the implementation of those programs across the United States to better understand the ways different localities addressed the digital divide amidst the COVID-19 pandemic.

Existing research fails to identify feasible solutions to mitigate inequities in education as it pertains to Internet connection, further demonstrating a need to identify effective strategies. This research evaluates the effectiveness of various programs connecting students to the Internet, with a secondary emphasis on assessing policy options to funding these programs. These policy solutions range from short-term solutions that bring immediate aid to students, such as hotspot programs, to long-term solutions, such as implementing a franchise tax for infrastructure build outs that would bring lasting connectivity to rural communities. Hotspot and device loaning programs are cheaper and, as the data suggests, a popular method of getting internet access to students as quickly as possible, but they are only temporary solutions. While construction of fiber optic cables can bring lasting benefits to rural communities, the costs are far higher, and the implementation is slower. Therefore, in addition to assessing programs across the nation, this paper evaluates the potential policy solutions for rural communities to fund alternative solutions, both in real dollars and in time, effectiveness, and feasibility for state and local governments. Through this evaluation process, we recommend immediate action through short term programs while keeping the long-term solutions in mind.

## Research Methods

This research project involved an initial survey of private and public sector programs designed to support educational needs in the wake of the COVID-19 pandemic. Data was collected for 69 programs that shared the common goal of providing Internet access to students for educational purposes across 33 states and Washington, DC. Data was collected via an internet search. Three categories of data were collected: program area information, program specifics, and funding information.

The speed of Connectivity was a measure of data transmission by an Internet connection. This metric was selected to determine effectiveness of each program; Internet access is not effective if it does not provide quick connectivity. Four binary criteria were used to evaluate each program with the presence (1) and absence (0) assigned for the following variables: private provider, individualized plans, non-mobile connection, in-home connection. Private providers are assumed to provide better connectivity compared to public providers because of their expertise in providing Internet services. Individual, permanent plans within the home provide faster connection compared to grouped, mobile, out-of-home plans (GeeksForGeeks, 2022). Aggregated, these variables have a maximum score of 4, which indicates a quality program with high speed of Connectivity and a minimum score of 0 indicating the program provides a poor connection.

The Implementation Speed metric quantifies the rate with which a program can be fully developed and provide Internet resources to students, which was very important in 2020 as schools operated online. Three binary criteria were employed for the Implementation Speed metric: private sponsorship, use of existing technology or equipment, and use of existing infrastructure. Due to red tape in government initiatives, private initiatives receive a more favorable score for implementation speed (Hackbarth, 2022). Many programs utilize existing technology or infrastructure to further expand access, reducing the time requirements to connect students.

Program size was also factored into the Implementation Speed metric. To measure program size as a factor for Implementation Speed, four tiers were defined: small (≤ 957 students), medium (957 < students ≤ 7350), large (7350 < students ≤ 57,500), and extra-large (> 57,500 students). Hierarchical clusters revealed the highest quartile, lowest quartile, and the middle quartiles, which were clustered together for this analysis. This strategy was selected because it groups similar data together, ensuring consistency in the scoring system. In regard to point allocation, a small program was awarded 3 points, a medium program was awarded 2 points, a large program awarded 1 point, and an extra-large program awarded 0 points. Smaller programs were determined to have a quicker Implementation Speed due to their size, so larger point totals were assigned to smaller programs.

Aggregated, these variables have a maximum score of 6, which indicates a quality program with high Implementation Speed and a minimum score of 0 indicating the program provides a poor Implementation Speed. Although larger programs may combat long implementation timelines by employing more people, this data was not available and thus was not included. Missing data was observed for 3 of 69 programs initially identified, with 66 programs having data available for each assessment category. In the case of missing data, programs were removed from analysis of Implementation Speed.

The Affordability metric assessed the economic feasibility of each program. Two binary criteria were evaluated for the Affordability metric: partial private funding and complete private funding. Per pupil cost was also factored into the affordability metric. To measure per pupil cost as a factor for Affordability, hierarchical clustering revealed four quartiles that were used to define the following categories:

3 - inexpensive (per pupil cost ≤ \$162),

2 - somewhat inexpensive (\$162 < per pupil cost ≤ \$243),

1 - somewhat expensive (\$243 < per pupil cost ≤ \$500), and

0 - expensive (per pupil cost > \$500).

In regard to point allocation, an inexpensive program was awarded 3 points, a somewhat inexpensive program was awarded 2 points, a somewhat expensive program awarded 1 point, and an expensive program awarded 0 points. The lowest cost program per pupil was rated as the highest outcome. Aggregated these variables have a maximum score of 5, which indicates a quality program with high Affordability; a minimum score of 0 indicates the program has poor Affordability. Missing financial data was observed for 31 of 69 programs; 38 of 69 programs had complete data.

To measure the overall success of each program across the three categories an Overall Score was created. The equation, shown in Figure 1, calculates the Overall Score where "C" denotes Connectivity, "I" denotes Implementation Speed, and "A" denotes Affordability. Out of convenience, the three metrics have different ranges to accommodate the criterion used. To account for this in calculation of the overall score, each metric is divided by its maximum score. Possible values for this score metric range from 0, indicating a program with poor success in the three categories analyzed, to 1, indicating a program with strong success in the three categories analyzed. The criteria used to evaluate the programs are listed in Table 1, below.

$$\frac{1}{3}\frac{C}{C_{max}} + \frac{1}{3}\frac{I}{I_{max}} + \frac{1}{3}\frac{A}{A_{max}}$$

FIGURE 1. Overall Score Formula.

Each metric was weighted equally to show the connectedness of the three metrics: a high-quality program must ensure high connectivity, quick implementation, and reasonable affordability to reach students effectively.

| Variable | Metric | Range |
| --- | --- | --- |
| Connectivity | Private Provider (Binary)<br>Individualized Plan (Binary)<br>Non-Mobile Connection (Binary)<br>In-Home Connection (Binary) | 0 to 4 |
| Implementation Speed | Private Sponsorship (Binary)<br>Use of Existing Technology or Equipment (Binary)<br>Use of Existing Infrastructure (Binary)<br>Program Size (Tiered) | 0 to 6 |
| Affordability | Partial Private Funding (Binary)<br>Complete Private Funding (Binary)<br>Per Pupil Cost (Tiered) | 0 to 5 |
| Overall Score | Connectivity<br>Implementation Speed<br>Affordability | 0 to 1 |

TABLE 1. Breakdown of variables used to calculate each metric score for Connectivity, Implementation Speed, Affordability, and Overall Score.

## Results

### *Assessment of Programs*

The selected programs that provided Internet to students across the nation were assessed on the basis of three metrics: Connectivity, Implementation Speed, and Affordability. The top 5 performing programs and their respective Overall Scores are listed in Table 2. Mobile Beacon, the highest overall scoring program, is a small scale, low cost, private hotspot program. CMS Foundation's initiative is a low cost, private hotspot. Both Cox Communications and Project 10Million are private initiatives offering both in-home connections and hotspots. Chicago Connected uses both private and public sponsorship to fund in-home Internet packages for low-income families. Table 3 lists the most successful programs across each of the three defined metrics.

| Program | Overall Score | Connectivity Score | Implementation Speed Score | Affordability Score |
|---|---|---|---|---|
| Mobile Beacon | 0.92 | 3 | 5 | 5 |
| CMS Foundation | 0.78 | 3 | 3 | 5 |
| Cox Communications | 0.73 | 4 | 4 | 2 |
| Project 10Million | 0.67 | 4 | 2 | 3 |
| Chicago Connected | 0.67 | 4 | 3 | 2 |

TABLE 2. Top 5 programs in Overall Score.

| Connectivity (= 4) | Implementation Speed (≧ 4) | Affordability (≧ 3) |
|---|---|---|
| 1Million Project (T-Mobile) | Briggs Lawrence County Public Library | Charleston, SC |
| Burlington Telecom - Vermont | Bristol, VA | CMS Foundation |
| Chicago Connected | C Spire - Mississippi | Colorado/T-Mobile |
| Cox Communications | Charleston, SC | Covington Connect |
| Mecklenburg Electric Cooperative | Concord, IN | DC Public Schools |
| PHLConnectED | Cox Communications | Goochland, VA |
| Project 10Million | BCRE | Mobile Beacon |
| Spring for ConnectED Program | Hinsdale, IL | Ottawa, MI |
| | Massillon City Schools | Project 10Million |
| | Mobile Beacon | San Antonio, TX |
| | Ottawa, MI | South Bend, IN |
| | Phoenix, AZ | State of North Carolina |
| | State of West Virginia | State of Washington |

TABLE 3. Highest scoring programs in each area: Connectivity, Implementation Speed, and Affordability.

A program launched in Charleston, South Carolina scored high in regard to both Affordability and Implementation Speed. Vehicle Networks equipped unused school buses with Wi-Fi and Expanded Public Networks during the initial stages of the COVID-19 pandemic. The Vehicle Networks and Expanded Public Networks were always intended to be a short-term fix to the pressing issue of short-term virtual education.

Therefore, it is not surprising that this initiative scored well in regard to Implementation Speed and Affordability but scored extremely poorly in regard to Connectivity (Schiferl, 2020). Similarly, a program launched in Ottawa, Michigan scored well in regard to Implementation Speed and Affordability. Through this program, libraries in Ottawa loaned out hotspot devices for families without broadband access. While broadband coverage has expanded in the area in recent years, the hotspot program was designed to connect students until the entire area can be connected via broadband (Ottawa County, 2019). A program in Goochland, Virginia shared similar success in regard to Affordability and Implementation Speed, although it is not listed in Table 3. This program partnered with Kajeet, a private firm, to distribute Hotspots to students without access to broadband. The goal of this program was to provide underserved students with the ability to connect to the Internet until infrastructure can be further developed with additional funding and implementation of long-term solutions for underserved populations in Goochland Virginia (Goochland County, 2019). These three programs all succeeded in delivering a quick and affordable avenue for students to connect to the Internet, but were strictly intended for short term implementation, until a more effective solution can be implemented or until the need dissipated.

Burlington Telecom, an internet service provider in Vermont, scored high in Connectivity. This initiative provided data via a Wi-Fi device and offered installation to families without Internet access. This program proved sufficient for virtual learning throughout school closures due to the COVID-19 pandemic, eliminating the challenge of affordability for families (Burlington Telecom, 2020). PHLConnectED provided Philadelphia students with in-home Wi-Fi and offered digital skills training. Similar to Burlington Telecom's initiative, families receiving Internet service through the PHLConnectED program were not responsible for payment, allowing communities where affordability is a key determinant of access to become connected (City of Philadelphia, 2021). Mecklenburg Electric Cooperative was awarded $3.8 million from the United States Department of Agriculture for infrastructure expansion in southern Virginia. This broadband investment provided Internet to approximately 1,250 households in the area, boosting connectivity and eliminating the accessibility challenge for this rural area (Brunswick Times-Gazette, 2019). Between these three programs, Connectivity was enhanced through diverse solutions that targeted specific communities struggling with accessibility or affordability. An in-depth analysis of each program strategy and its impact on Affordability, Implementation Speed, and Connectivity is located in Table 4.

The ten top scoring programs shared several characteristics. Amongst these high scoring programs were the inclusion of Hotspots, private ownership, individual Wi-Fi plans, and Home Networks. These ten programs were very different in size. The majority of these programs aimed to maximize Connectivity and Implementation Speed but prioritized these metrics over Affordability. Thus, many of these top ten programs scored a 2 in regard to Affordability, but nevertheless received a high Overall Score.

The ten lowest scoring programs also shared several characteristics. All the poor performing programs were public initiatives with large per pupil costs. These programs each attempted to reach a large number of students with infrastructure investments. All of these programs recorded extremely low scores for Connectivity, Implementation Speed, and Affordability. Missing data for some of the low performing public initiatives may have led to lower Affordability scores than anticipated. Of these ten lowest performing programs, none of these programs recorded a Connectivity score higher than 2 or an Affordability score higher than 1, which suggests that they were slow, expensive and did little to alleviate connectivity issues.

| **Overall Score (0 to 1)** | Hotspots | Vehicle Network | Expand Public Network | Home Network | Laptops | Tablets | Training | Infrastructure | Funding |
|---|---|---|---|---|---|---|---|---|---|
| Median | 0.508 | 0.45 | 0.45 | 0.592 | 0.475 | 0.3667 | 0.5167 | 0.4 | 0.5667 |
| Mean | 0.515 | 0.444 | 0.438 | 0.55 | 0.4608 | 0.4019 | 0.47 | 0.4048 | 0.505 |

| **Connnectivity (0 to 4)** | Hotspots | Vehicle Network | Expand Public Network | Home Network | Laptops | Tablets | Training | Infrastructure | Funding |
|---|---|---|---|---|---|---|---|---|---|
| Median | 3 | 1 | 2 | 3.5 | 2 | 2 | 3 | 3 | 3 |
| Mean | 2.676 | 1.33 | 2 | 3.4 | 2.45 | 2.33 | 2.6 | 3.143 | 2.7 |

| **Implementation Speed (0 to 6)** | Hotspots | Vehicle Network | Expand Public Network | Home Network | Laptops | Tablets | Training | Infrastructure | Funding |
|---|---|---|---|---|---|---|---|---|---|
| Median | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 2.5 |
| Mean | 2.471 | 3.167 | 2.462 | 2.1 | 2.1 | 1.889 | 2 | 1.286 | 2.5 |

| **Affordability (0 to 4)** | Hotspots | Vehicle Network | Expand Public Network | Home Network | Laptops | Tablets | Training | Infrastructure | Funding |
|---|---|---|---|---|---|---|---|---|---|
| Median | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 2 |
| Mean | 1.912 | 1.833 | 1.615 | 1.9 | 1.75 | 1.22 | 1.8 | 0.8571 | 1.7 |

TABLE 4. Performance ratings across nine program strategies. Color is used to indicate program success in each metric. *Note*: Dark green represents most successful programs, orange represents average programs success, and red tones represents least successful programs.

### *Assessment of Program Strategies*

Programs that support the expansion of Home Networks earned a median Overall Score of 0.592, the highest among the 9 program strategy categories, indicating these types of programs are well equipped to perform successfully across all three areas analyzed. The programs that implemented Home Networks scored high across all three criteria due to above average scores in Connectivity, with a median score of 3.5, and Affordability, with a median score of 2, and average scores in regard to Implementation Speed, with a median score of 2. Programs that utilized Vehicle Networks or provided Funding to students received the highest Implementation Speed scores, with median scores of 3 and 2.5, respectively, because they were short-term solutions intended to temporarily provide internet access. Because these programs served as short-term solutions to the digital divide, despite reaching students quickly, they did not provide lasting assistance with Internet connectivity. Hotspots were successful, specifically in terms of Affordability, with a median score of 2, due to widespread private assistance in funding, and were better than average for Connectivity and Implementation Speed, with median scores of 3 and 2, respectively. The affordability of Hotspots is appealing to funding bodies, but ultimately does little to address the magnitude of the digital divide and its long-term impacts on the public education system. Infrastructure investments scored lowest in Affordability and had the slowest Implementation Speed, but assured better than average Connectivity, once built out.

The nature of the digital divide ensures no one solution will completely dissolve the gap between those with access to modern technology and the Internet and those who do not. Thus, it is important to assess a variety of solution strategies, including those with both short-term and long-term structures. Of the highest scoring program strategies in the Implementation Score metric, programs providing Funding or Hotspots score the highest in the remaining categories. This indicates that the best short-term approach is to either address the issue of affordability and provide funding so families can invest in their own Internet resources or provide students with Hotspots. The unique circumstances of each target area must be considered when determining whether Funding or Hotspots is the best option. Programs developing Infrastructure score the lowest in the Implementation Speed metric but score highest in Connectivity. This indicates that the best long-term approach to the digital divide is to invest in the development of broadband infrastructure. The primary trade-off of implementing a program that is quick to reach students is the lifespan of such an initiative: solutions that only provide short term relief, such as Hotspots, will never make progress towards eliminating the digital divide, but rather postpone the problem until a long-term solution, such as Infrastructure, is developed.

We discovered a negative correlation coefficient between the Connectivity score and Implementation Speed score, indicating a low probability of a single solution providing both strong Internet connection and fast reach to students. This relationship can be seen in Table 4 as stark contrasts observed for each program strategy category between the Connectivity and Implementation Speed metrics. This negative correlation emphasizes the tradeoffs when determining the most effective solution for an individual school or area. For example, rural areas' temporary use of Hotspots to mitigate the impact of the digital divide on education is effective due to the extremely lengthy process of laying fiber optic cable across sparsely populated areas (Goochland County, 2019). A program in Goochland, Virginia, a rural and low population density area, is currently providing Hotspots to students while various areas within Goochland County are currently installing broadband Infrastructure (Goochland County, 2021). Neither of these solutions can meet a high standard of both Connectivity and Implementation Speed, but the Hotspots are providing short term relief while plans for long term relief in the form of Infrastructure are being executed. Holistically, this negative correlation between Connectivity and Implementation Speed shows that permanent solutions are the most difficult to implement but are the most effective in minimizing the digital divide over the long term.

## Policy Alternatives

The initial findings focused on assessing the implementation of different programs to address the digital divide. This raises a secondary question: How can these programs be supported by federal, state, and local funding mechanisms? For many in rural areas, the digital divide is directly caused by the lack of infrastructure that provides reliable Internet connectivity. Hundreds of rural counties need to buy and install fiber optic cables to provide high quality, and reliable Internet for the long-term. To do so is costly, with some estimates at $7.3 to $8.9 million for construction and installation with an average cost of $44,000 to $55,000 per square mile, although this cost varies by Internet service provider, installation method, and geographic location (OTELCO, 2020). While low in Affordability, aid from private institutions, federal and state funding, and tax incentives can make this process more feasible for local and state governments.

The Affordability of different service providers will vary by company and location. There are two primary methods for fiber optic cable installation: underground and aerial. The base cost for burial installation is higher, but there are more fees associated with aerial build. For instance, if the Internet provider does not own the poles, which are most often owned by electricity providers, the Internet Service Provider needs permission to build along the poles (Kim, 2022). Furthermore, more isolated rural counties "cost substantially more to connect" depending on the distance between homes and businesses and any infrastructure already there (OTELCO, 2020). Thus, long-term implementation is low in Affordability and low in Speed of Implementation

Not only is broadband costly to implement, it is also costly to access. While the cost of broadband has decreased over the past few years nationwide, about 13.4% of the US lives below the poverty line, equating to roughly 42.5 million Americans (DePietro, 2021). Consequently, many households could not afford monthly payments for broadband. Although it is unlikely that Internet providers will decrease their rates for an extended period, the following solutions are actions that local governments can take to minimize the cost for citizens. For the purposes of this paper, policy solutions are focused on financing the construction and installation of sustainable broadband infrastructure. To fund the expansion of infrastructure of the Internet or support other programs targeting the digital divide, the following policy options exist.

## Option 1: BroadbandUSA Program

Under the National Telecommunications and Information Administration, part of the Department of Commerce, the BroadbandUSA program's goal is to give funding to rural areas across the country for broadband infrastructure. For the 2020 fiscal year, the program offered $45 million to state and local governments that qualified for grants (BroadbandUSA, 2018). Funds awarded by BroadbandUSA in February 2022 are developing infrastructure in 12 states and one territory, worth $277 million (U.S. Department of Commerce, 2022). This program would not take much time nor funds to apply in terms of Implementation Speed and Affordability. The application varies by program, but the potential benefits from this grant program is worth the cost of spending time on the application. It can also be very effective. If given the funds, it will directly pay for the installation of broadband. If a county is not approved, the time spent on the application is insignificant. Further, the program is feasible for most rural counties in the country. For instance, in the Eastern Shore region of Virginia, two rural counties, Accomack and Northampton counties, were able to install 320 miles of fiber optic cables over 10 years. Both counties were fully refunded for their efforts by Broadband USA. This specific program took 5 years to pay for and install the cables and helped hundreds of households gain stronger, more efficient broadband access (Broadband USA, 2018). The annual application cycle makes this a clear option for rural areas that are planning ahead for future infrastructure build outs. Of the nine previously identified program strategies, this policy option is best suited to fund Infrastructure developments. Obtaining funding through BroadbandUSA minimizes the effects of Infrastructure's low scores in the Affordability metric and allows high Connectivity to reach currently underserved areas. Although BroadbandUSA's funding is only eligible for rural areas, acquiring this funding will allow state funding to go toward maintaining or creating broadband infrastructure in suburban or urban areas.

## Option 2: State Funding

There are various options for state funding in the US, including money given through CARES Act funding. In Virginia, for example, state funds to build broadband infrastructure were allocated from the CARES Act funding. In September 2020, $50 million was approved by then-Governor Northam to build fiber optic infrastructure in rural areas through the Tobacco Region Revitalization Commission (Arnold, 2020). Any rural county in Virginia could request funds, $7.3 to 8.9 million, for the 2023 fiscal year (OTELCO, 2020). Similarly the BroadbandUSA program, applying for state funding is low in terms of the time spent by local governments to apply. Even if the grant does not cover the entire cost of infrastructure expansion, it is worth applying and acquiring resources to defray the full cost. Moreover, if given the funds, it would cover the high-cost activities associated with installation of fiber optic cables. Even if the approved amount is lower than requested, any funds from the state would proportionally lower the overall cost for the taxpayers. Since the COVID-19 pandemic began, state and local governments have focused on policies to protect public health. However, this has, in some states included funds available for broadband expansion. For instance, with federal CARES Act funding, the federal government gave states money for economic growth. The CARES Act is just one example of the aid available through the state government. Of the program strategies identified, long term solutions, such as Infrastructure, are the most effective use of state funding. If state governments fund various short-term solutions, the long run aggregate costs of maintaining and replacing the short-term plans will exceed the upfront costs of implementing Infrastructure. However, state funding through the CARES Act presented a unique circumstance in that this type of emergency funding should be used to implement emergency solutions, such as Hotspots or distributing funding to underserved families.

### Option 3: Federal Communications Commission

The Federal Communications Commission has a program to help consumers below the poverty line pay for Broadband. The Lifeline Program gives each household a monthly allowance ranging from $7.25 to $9.25 to assist with monthly payments (Lifeline Program, 2020). To help people with the application process, local governments could advertise this program and help forward any questions they cannot answer to a program representative. The Lifeline program is low in fiscal cost, but high in time spent by citizens applying for individual payment assistance. Although the allowance is only a fraction of the broadband costs, many households would qualify for some form of payment from the federal government. Although, it can take significant time to complete the application. This program could defray some costs for citizens and lower their monthly broadband expenses. The application is available through the federal government and would be guaranteed as long as the citizens/household renews their application every year. Of the nine identified program strategies, this funding structure aligns best with an initiative that addresses the issue of Affordability by providing funding to families. This type of funding structure is best suited for areas where the digital divide is caused primarily by affordability rather than lack of accessibility and thus may better serve urban regions. Non-profits working in urban regions have developed application assistance programs to help residents apply for these funds, especially supporting families that already receive other services, such as SNAP benefits or housing assistance.

## Option 4: Tax Incentives

Federal law allows any citizen to deduct part of their broadband costs on their 1040 form when they need to use the Internet to work (Ireland, 2020). On the tax form, they need to prove that their employer requires that they work from home and provide an itemization of how long they work, which can be as simple as a work schedule signed by their employer. While it can make some of the Internet costs tax deductible, it cannot exceed 2% of their gross income (Ireland). These programs cost nothing but can take a significant amount of time and are achieved by individual actions. It does not cost anything to fill out the tax form. However, getting the paperwork needed to verify the work status may take more time than if they did not complete this part of the tax form. If approved, it can lower the annual cost for citizens to purchase broadband. Like the FCC program, it will only cover some of the broadband costs for residents. The paperwork required to be approved is relatively straightforward but can be complicated if it is not done exactly the way the IRS dictates. Of the identified program strategies, this funding structure aligns with a program that installs in-home networks. Offering tax incentives for people using in-home networks for work can incentivize families to invest in such networks, expanding Internet access for the whole family including students that need Internet for schoolwork.

## Discussion

Education now has an enhanced reliance upon online platforms for students since the beginning of the COVID-19 pandemic. Therefore, a balance between implementing an effective Connectivity program quickly while still maintaining vision for the long-term implications of the digital divide will be critical to the continued pursuit of Internet access for all. Nine broad categories of program strategy were defined within this analysis, suggesting the importance of individualization of programs when addressing the digital divide. Because there are multiple causes of the digital divide, it is important to develop an understanding of different solutions and which solutions are best suited to address each cause. A program in Chicago, Illinois provided funding to low-income families to purchase in-home broadband packages. This solution was successful because the root cause of the digital divide in urban areas, such as Chicago, is lack of affordability (Digital Bridge K-12, 2020). While a Funding program was successful in urban Chicago, a Hotspot and

Infrastructure program was successful in rural Goochland because the root cause of the rural digital divide is accessibility to infrastructure. These two example solutions are vastly different, but each bridges the discrepancies present in their respective communities, showing the significance of tailoring solutions to each individual area. Therefore, it is clear from this analysis that there needs to be a multi-pronged solution to the digital divide regardless of geography. However, when evaluating different policy solutions, it is important not only to recognize the balance between Connectivity and Implementation Speed, but also the distinct needs of urban and rural communities.

The data collection portion of our research has several limitations. First, data availability was restricted to programs whose information was readily available online between September 2020 and May 2021. Of these programs, very few published self-evaluations of the effectiveness of their programs. Thus, our evaluation could not be compared to determine the effectiveness of our metrics. Additionally, many of the initiatives analyzed in this study contained missing data, disrupting the continuity among the three metrics during holistic analysis. Although this study is limited in the data collected, the policy recommendations are based upon general trends identified, which were relatively unimpacted by these limitations.

This research suggests that there needs to be a plurality of policies to best close the digital divide. In the short-term, students need Internet access for their education. Therefore, Hotspot programs receiving assistance from private companies in terms of funding and device distribution serve as an example for other states to provide immediate access for students. Therefore, local and state governments should seek out private aid to help fund Hotspot programs and begin tracking and supporting existing programs. Aid offered by private companies would reduce the State’s cost, while still providing immediate access to those who need it. Moreover, the best indicator of success is a further expansion of the program, so it is crucial that states incorporate plans for future funding for existing Hotspot programs.

In the long-term, state and local governments should focus on the financing for implementation and construction of broadband Infrastructure. States should aim to provide grants and subsidies to bring the cost of broadband down to $10 per month for those below this threshold. Therefore, there should be a program for citizens, based on their income, to apply for state aid in paying for broadband. While it does not solve the issue of accessibility, it will make broadband more affordable for Americans, a problem that is ever-growing in the COVID-era. To reach the threshold for $10 per month for broadband for low-income families, the government will need to provide a minimum of $23,512,750 (see supplemental material). An increase in taxes, franchise tax, and the use of federal aid would help fund this effort. These different solutions are explained below.

We believe an increase in taxes on goods and services is a simple and efficient solution to grant more money towards broadband development, although its political feasibility varies by state. For instance, in July 2020, Virginia increased the cigarette tax making it 60 cents per pack. With cigarette sales continuing to rise over the past 12 months, the state can expect an estimated $100 million per year. While former Governor Northam pledged to use some of the money to decrease the cost of healthcare, a portion of this should be distributed to the program to help low-income families afford broadband. State governments also can propose a franchise tax, similar to that in North Carolina (NCDOR, 2021). In summary, the tax would be $200 for the first $1 million then $1.50 per $1,000 after the first million. While the estimated gains from this plan are unknown, it would certainly generate more money that could be used to make broadband more affordable. Finally, because the COVID-19 pandemic has amplified the need for affordable broadband, many federal programs have given money to different states and localities. It is up to the state to decide which programs would best fit their counties in need of broadband.

## Conclusion

The COVID-19 pandemic caused a global shift of work and school online, which increased the pressure on families with school-age children that had no reliable or affordable access to the Internet. The two primary obstacles preserving the digital divide are access to infrastructure in rural areas and lack of affordability in urban areas. As evidenced by our analysis, an array of unique solutions were effective in connecting students in 2020, but such programs need to be implemented to reach a much larger number of students to effectively close the digital divide. Therefore, it is the duty of policymakers to implement strategies that mitigate challenges of accessibility for rural students and challenges of affordability for urban students. To accomplish this goal, broadband provision and device distribution programs across the United States must be implemented, making Internet access available to all students regardless of geographical location. Additionally, policymakers need to evaluate the aforementioned funding options to decrease the cost of broadband, in an effort to connect urban students. Because each community has unique needs pertaining to the digital divide, we propose the creation of local committees for each county so the impact of programs can be best suited for its intended population. Without the support of lawmakers, students will continue to face challenges related to accessing their educational materials due to lack of Internet resources.

| Tax Rate | Adjusted Gross Income | Single | Married Filing Jointly | Married Filing Separately | Total | Broadband Cost/mo | Money Given by the State/mo** | Money needed from the State |
|---|---|---|---|---|---|---|---|---|
| 2% | $0-3,000 | 184,846 | 61,785 | 16,020 | 128,151 | $10 | $50 | $6,407,550 |
| $60 + 3% of excess over $3,000 | $3001-5,000 | 99,997 | 11,214 | 13,689 | 114,900 | $16 | $44 | $5,055,600 |
| $120+ 5% of excess over $5,000 | $5001-17,000 | 508,920 | 80,665 | 21,800 | 654,185 | $26 | $34 | $22,242,290 |
| $720 + 5.75% of excess over $17,000 | $17000 and Up | 1,443,776 | 1,328,654 | 113,594 | 2,886,023 | Market Price* | $0 | 0 |
| | | | | | | | | $33,705,440 |

APPENDIX A. Price for Broadband Based on Income.

| Tax Rate | Adjusted Gross Income | Single | Married Filing Jointly | Married Filing Separately | Total | Broadband Price to Citizen/mo | Money Given from the State/mo | Money needed from the state |
|---|---|---|---|---|---|---|---|---|
| 2% | $0-3,000 | 184,846 | 61,785 | 16,020 | 128,151 | $10 | $50 | $6,407,550 |
| $60 + 3% of excess over $3,000 | $3001-5,000 | 99,997 | 11,214 | 13,689 | 114,900 | $25 | $35 | $4,021,500 |
| $120+ 5% of excess over $5,000 | $5001-17,000 | 508,920 | 80,665 | 21,800 | 654,185 | $40 | $20 | $13,083,700 |
| $720 + 5.75% of excess over $17,000 | $17000 and Up | 1,443,776 | 1,328,654 | 113,594 | 2,886,023 | Market Price* | $0 | 0 |
| | | | | | | | | $23,512,750 |

*Each tax bracket increases by $15 which provides an alternative to the flat rate of 8.5 and ends up costing less to the Commonwealth.

APPENDIX B. Alternative* Price for Broadband Based on Income.

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