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**Equity in Access to Math Education and Technology in a Rural School:  
A Literature Review**

By

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## **Abstract**

This literature review examines the effects that the lack of equity in access to technology and advanced math courses by rural students has on their college and career readiness when compared to that of non-rural students. The literature concerning equity in accessibility to technology by rural students suggests that the homework gap persists in rural communities even though substantial efforts have been made to close the gap. These efforts include an increase in dual-credit course offerings, increased broadband availability and technology lending at school. In many rural areas, the equity in access to a device may not necessarily be the main concern. Rather, accessing broadband due to its expense or the inability to have reliable access due to the geographic impediments creates a distinct equity concern for rural students. Once the problems were identified for this literature review, suggestions for providing rural school districts with potential solutions was created.

*To my loving and supportive family, thank you*

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Chapter 1: Introduction

Background and Rationale

I began my career in education teaching math to 8th-grade students at an inner-city school in Texas nearly 22 years ago. At that time, technology, in the form of computers and software programs, was beginning to take root. Fortunately, this became an efficient means of learning and reinforcing many concepts in mathematics. Over the course of many years, the necessity for having access and the ability to use technology in all aspects of education has increased significantly (Van De Walle, Karp & Williams, 2013). In just over two decades, education has evolved to the point where many of our secondary and post-secondary courses require access to high-speed internet. More often than not, these courses also require a device, equipped with a dedicated keyboard, to access online course content. This level of accessibility is necessary in order to ensure that students have the opportunity to receive an equitable education (Lehmann, Chase, & eBooks Corporation, 2015).

Twenty-two years later, I find myself teaching high school mathematics to students who live in a poor, agrarian and very diverse rural community. Many of my students live on ranches and farms that are so remote that access to broadband internet is nearly impossible due to numerous rolling hills and an overall lack of high-speed internet infrastructure. While geographic hurdles to broadband access are a problem in the area, it's also the case that a family's financial means may also limit their

access to a device or to the internet. Hurdles such as these present very real equity concerns in education when comparing students that attend rural schools to those that attend non-rural schools in areas where broadband internet and devices are more accessible (Resta & Laferrière, 2015).

Many rural schools across the United States have limited access to the internet and this can affect available coursework (Cha, 2015) The variety of advanced mathematics course offerings are limited, if available at all, in my rural community, as well. As a result, many of my students are forced to take courses online. Understandably, having access to these courses would better prepare my students for education beyond high school and make them better able to compete with non-rural students who are afforded the luxury of a variety of mathematics course offerings and access to high-speed internet at school as well as away from school (Gagnon & Mattingly, 2016). Rural students who do not have internet access at home and have to take online mathematics coursework because of limited available in-school coursework, are forced to complete all of their work at school since they will not have access once they arrive home in the evening. As well, some students simply cannot take online courses because the meeting time for the course is in the evening and requires the use of a, web-based, videoconferencing program such as Skype or Zoom. If students do not have access to a functioning device or high-speed internet while at home, then attending these meetings are impossible (Rehn, Mao, & McConney, 2017).

Additionally, many of my students spend hours riding a school bus to and from school. Given the distance and unpredictable weather in Wyoming, many parents view

riding a school bus as a much more practical, safe, and efficient means of transportation when compared to using a personal vehicle. A large majority of these students participate in extracurricular activities and as a result they do not leave the school until well after 6:00 pm. For many of these students, their bus rides require an additional thirty to ninety minutes each direction. Unfortunately, these circumstances leave little time for students to complete school-work before and after school.

There are numerous works of research that speak to these equity concerns. Diann Shaffhauser suggests that without high-speed internet access, it is impossible for rural students to succeed academically (Shaffhauser, 2019). In 2011, Sandra Glover's research contends that rural students must use technology in order to be successful (Glover, 2011). Researchers have labeled these inequities as the "homework gap" or the "digital divide" (Huang & Russell, 2006; Noguerón-Liu, 2017). While I have experienced these first-hand with the students that I teach, these concerns are not isolated to rural Central Wyoming. Most states within the United States and most countries have rural communities that are affected by these inequities.

### Purpose and Research Question

This is a small and focused piece of a much larger problem when considering equity in education. This review will focus on the relationship between equity, mathematics education and access to technology in rural schools and homes. The purpose of this literature review is an attempt to ascertain the answer to two very important questions. Question 1) What is being done to bridge the "homework gap" and the "digital divide" in rural communities? Question 2) What are the effects of inequities

such as this on rural students and their ability to be college or career ready? I am interested in this to help my district consider ideas that we could implement to help our students.

### Methodology

In order to pursue an answer to these research questions, this literature review will consist of a review of both qualitative and quantitative research that has been conducted. This work will contain the summarization of research that has been conducted and a summary of data gathered by other researchers.

To accomplish this pursuit, an exhaustive search of pertinent literature was conducted using several databases. Initially, I searched these databases using several keywords and phrases. Some of the keywords and phrases used are as follows: technology, digital equity, access, device, broadband, affects, college and career readiness, rural students, online courses, technology use in education, technology impact on education, advanced courses in rural schools, digital divide, homework gap, broadband video conferencing, dual credit, digital learning. Once the list of resources was narrowed based on several keyword searches, I read any attached abstract or read the entire article. By doing so, I was able to eliminate any resource that did not relate to this review.

Following a review of the literature, I decided to limit the age of the research to be included in this review to nothing more than ten years old. However, I did include some research that was older than this limit because of its foundational benefit. I also used relevant resources from the reference section contained in the literature that I

initially located using my keyword searches. Once I located sufficient enough literature that addressed my research questions adequately, I summarized and placed it into logic subcategories within my literature review.

## **Chapter 2: Literature Review**

### **Introduction**

In April of 2014, the National Council of Teachers of Mathematics (NCTM) published a position paper concerning equity in education. In the article, the NCTM addressed the necessity for creating an opportunity for which all students have access to and receive mathematics instruction that is both rigorous and engaging. Furthermore, they suggest that stakeholders need to be considerate of a student's personal circumstances and focus on those in order to truly make mathematics education more equitable and individualized. In order to achieve equity in mathematics education, NCTM states that teachers need to work in collaboration with their colleagues and other educational specialists. These are to include special education and educational technology specialists in order to provide the best service to their students by implementing best practices in teaching mathematics. Lastly, NCTM advises that mathematics educators receive professional development and training in order to facilitate growth in the area of mathematics education and equity (NCTM, 2014).

According to the State Educational Technology Directors Association (SEDTA), students and teachers need to have equitable access to high speed internet in order to ensure academic success in teaching and learning (Fox, 2019). Unfortunately, there continues to exist inequities in mathematics education and technology for students of rural schools. As a result, there is a gap in academic achievement created between

urban students and rural students or what appears to be “the haves and have nots” (Rowell, Morrell, & Alvermann, 2017).

The lack of equity in access to technology for rural students at school and at home has been described as the “digital divide” (Huang & Russell, 2006). This divide is due in large part to the affordability for schools as well as students, connection to high speed internet, and the lack of proper teacher training for developing knowledge and best practices. Additionally, this divide creates what is described as the “homework gap” (Noguerón-Liu, 2017). The gap is the result of not having access to technology at home in order to successfully complete homework assignments. Not only does the homework gap exist, but our rural students aren’t being prepared for education beyond high school as a result of not having access to equitable mathematics education and technology (CPE, 2018).

### **Necessity for Technology In mathematics and Teacher Preparation**

In the early 1980’s, an effort to reform mathematics began. Amongst many reform ideas was the intention of making mathematics education more equitable for all students in the United States. Along with NCTM’s stance on equity, it is suggested that the use of technology in education enhances what a student learns and is vital to their understanding of mathematics (Van De Walle, Karp & Williams, 2013).

In 2018, Robinson, Wiborg and Shulz, published research results on the effects of the amount of time spent using technology and a student's GPA. Their research showed that there is a positive correlation when technology is used for an academic purpose and a student's GPA. They also found that there was a negative correlation

between the amount of time spent using technology for non-academic purposes and a student's GPA. While conducting their research, they developed a term called "digital bind". This refers to the lack of access to technology at a student's school even though their teachers are requiring the access and the utilization of certain devices, programs and connectivity. Additionally, Robinson, Wiborg and Shulz draw the connection between having access to necessary technology and academic success and suggest that without access, then students will not be sufficiently equipped to be successful in their academic pursuit.

In 2011, Sandra Glover published her dissertation pertaining to the access of technology by rural school students. Glover's research indicated that while integrating technology into rural education was only one of many changes to improve the academic success of students, it would be a step in the right direction. Additionally, Glover's study was about the perceptions of stakeholders concerning the effects of integrating technology in education. Glover indicated that at the research site she chose, the perception of the staff was that technology did improve the academic success of the students. While conducting the research, the students were engaged while using technology in the educational setting. Those teachers that integrated technology in their instruction observed more academic success with their students than teachers that chose not to include a regular technology component (Glover, 2011). Glover attributed the success and growth that the students displayed was, by and large, due to the inclusion of technology in the teaching practices of the teachers. Glover found that it is imperative that, in light of the success brought to students that attended technology

integrated classrooms, teachers accept this change. However, this change will require that teachers change their current practices and receive quality professional development on technology integration for best practices in education.

“It is essential that teachers and students have regular access to technologies that support and advance mathematics sense making, reasoning, problem solving, and communication” (NCTM, 2015). The NCTM recognized not only the necessity of integrating technology to ensure that students are engaging in properly, they also recognized that in order to facilitate this need, the teachers require training so that they can meet these needs. Pre-service teachers as well as current teachers require training on efficient and effective use of technology in mathematics education. The focus should be on developing pedagogical strategies that address the needs of all students (NCTM, 2015).

In the 2017 National Education Technology Plan Update, there is a recognition that teachers need to be trained in how to best incorporate the use of technology in education. It is no longer a debate of whether or not it should be used, rather an issue of how best to integrate technology to engage all students in education (Phelps, 2018). A focus on training educators to be able to “select, evaluate, and use appropriate technologies and resources to create experiences that advance student engagement and learning” (NETPU, 2017).

Although stakeholders committed to providing quality education recognize the need for students to be actively engaged and learning by using technology, there is a lack of teacher preparation in doing so (Blanchard, LePrevost & Tolin, 2016). Schools

in rural environments are likely to have provided teachers with professional development opportunities in using technology to enhance how they are currently teaching. However, they fail to provide training on using technology in conjunction with newer methods of teaching and learning (Blanchard, LePrevost & Tolin, 2016). Additionally, it is suggested that teachers receive school wide training in the best practice of using technology through universities rather than school prepared professional development (Blanchard, LePrevost & Tolin, 2016).

Max (2017) contends that pre-service mathematics teachers should be provided with training to best meet the needs of rural students and especially those teaching in extremely diverse areas. Max also suggests that pre-service mathematics teachers should receive training with various types of technology so that they gain a certain level of comfort in integrating its use in their classrooms (2017).

### **Equity in Access to Advanced Courses: Rural Students**

Since the advent of standards-based education reform, stakeholders have been concerned with balancing the playing field for all students. Valburn (2018), suggests that there is a misconception that all students should perform equally despite their living conditions, race, socioeconomic status, gender or family composition. Instead, she suggests that equality does not necessarily translate to equal opportunities or equity. She further asserts that in order to create an environment where there is equality, then equity in education is the solution to removing those obstacles that prevent all students from being successful.

Rural schools, especially those that serve low-income students, struggle to retain, not just teachers, but high-quality teachers that are equipped to teach more rigorous mathematics courses. An unfortunate side effect of low-income rural schools is the difficulty in retaining quality educators for consecutive years. This education environment yields a less than equitable access to quality teaching for students of poor rural schools (Blanchard, LePrevost & Tolin, 2016). The lack of teacher retention in rural schools has been attributed to many things. A few of which are: “poverty, geographic isolation, low teacher salaries, and a lack of community amenities” (Azano & Stewart, 2016).

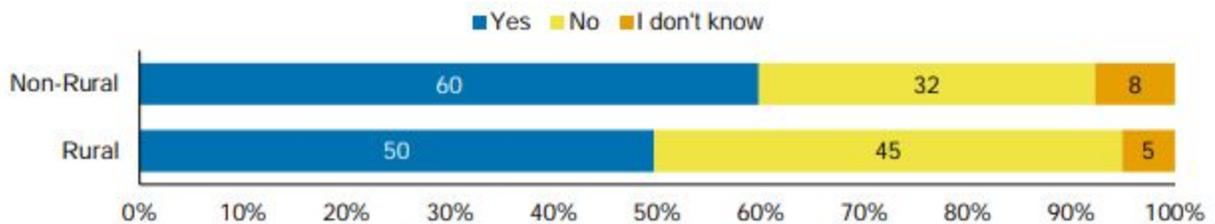
The digital divide for rural secondary students will have negative implications as they pursue post-secondary education. Because rural students have not had similar access to technology, they have not developed the technology use knowledge that their urban counterparts have. Colleges and universities will need to consider these things when determining how to educate students that are arriving from a rural environment (Alexander, 2017). Additionally, it has been found that a tool for predicting further academic success for rural students is whether or not they have participated in advanced mathematics courses (Irvin, Byun, Smiley, & Hutchins, 2017).

Similar to advanced courses, dual enrollment provides students the opportunity to earn college credit while taking classes as a high school student. Research has shown that students taking dual enrollment courses were more likely to be successful and prepared for post-secondary education (An & Taylor, 2015). In 2019, the American College Testing (ACT) released data collected from students illustrating a comparison

between the percentage of rural students and non-rural students participating in “credit-bearing” courses. Table 1 illustrates this comparison:

Figure 1

Enrollment in a Credit-bearing College Course in the Past Academic Year, by Geographic Area



Note: Croft, M., & Moore, R. (2019). Rural students: Technology, coursework, and extracurricular activities. *Iowa City: IA: ACT Center for Equity in Learning*

There is a connection to the ability to afford technology and the level of education that a person is able to attain (Alexander, 2017). In order to participate in higher education, students often require the use of high-speed internet (Reavy, Hereford & Kelley, 2011). The majority of people living in a rural environment are unable to connect through an internet service provider at the same speed that someone living in an urban area (Townsend, Sathiaseelan, Fairhurst, & Wallace, 2013). While cell phones have provided rural students some connection, the speed at which it connects is still dependent on the device as well as the ability to access the cell phone towers. Additionally, there is concern that even though most cell phones are very capable, they

lack the ability to use certain programs and lack a dedicated keyboard. As a result, the “homework gap” continues to grow. The homework gap refers to a student's inability to complete assigned work while at home due to a lack of technology accessibility (Alexander, 2017).

Research has found that the likelihood that rural schools would offer advanced courses was less than that of non-rural schools even though the benefits of such course offerings are substantial (Gagnon & Mattingly, 2016). In 2016, Gagnon and Mattingly collected data pertaining to the number of rural school districts that offer advanced placement courses. Gagnon and Mattingly (2016) found:

Only 51.4% of rural school districts enroll at least one student in an AP course, compared with 78.3%, 93.8%, and 97.3% of town, suburban, and urban districts. (p. 272)

Rural graduates that attend post-secondary education institutions are taking different courses than students of non-rural schools (Anderson, & Chang, 2011). Anderson and Chang used data collected in a National Assessment of Educational Progress (NAEP) survey and contend that rural students are less likely to have access to advanced placement or dual credit courses. The Wyoming Department of Education describes dual enrollment courses as college courses that are taken while students are still in high school where there is a possibility that they will earn college credit (WDE, 2020).

Anderson and Chang also found that rural students enter high school at a much lower level in mathematics compared to non-rural students. As well, they found that

rural students finish high school at a lower level of mathematics than students that attend non-rural schools (2011). In all, Anderson and Chang (2011), suggest that students of rural schools were taking fewer mathematics courses than those that did not attend rural schools.

**Equity in Access to Broadband and Devices: At school and at home.**

In 1996, the Federal Communication Commission sought to “encourage” the availability of “advanced telecommunications capability” for all citizens in the United States (U.S. Federal Communication Commission, 2019). The mission of the FCC is to close the digital divide by providing for each American a minimum broadband access speed of 25mbps download and 3mbps upload (U.S. Federal Communication Commission, 2019). Table 2 shows the progress that the commission has made from 2013 to 2017 for various speeds.

Figure 2

## Deployment (Millions) of Fixed Terrestrial Services at Different Speed Tiers

Area	2013		2014		2015		2016		2017	
	Pop.	%								
<b>10 Mbps/1 Mbps</b>										
United States	294.244	93.2%	297.873	93.7%	302.138	94.3%	309.129	95.8%	315.620	96.9%
Rural Areas	42.573	69.7%	46.263	75.1%	48.361	77.7%	52.456	83.4%	56.166	88.1%
Urban Areas	251.671	98.9%	251.609	98.2%	253.777	98.4%	256.673	98.9%	259.454	99.1%
Tribal Lands	2.622	67.1%	2.701	68.7%	2.886	72.8%	3.201	80.2%	3.353	83.5%
<b>25 Mbps/3 Mbps</b>										
United States	263.971	83.6%	284.246	89.4%	287.853	89.9%	296.373	91.9%	304.405	93.5%
Rural Areas	29.077	47.6%	37.174	60.3%	38.271	61.5%	42.677	67.8%	46.960	73.6%
Urban Areas	234.893	92.3%	247.072	96.4%	249.582	96.7%	253.695	97.7%	257.446	98.3%
Tribal Lands	1.449	37.1%	2.245	57.1%	2.290	57.8%	2.520	63.1%	2.727	67.9%
<b>50 Mbps/5 Mbps</b>										
United States	187.416	59.4%	270.740	85.2%	283.329	88.5%	291.380	90.3%	298.219	91.6%
Rural Areas	15.571	25.5%	32.100	52.1%	35.316	56.7%	39.260	62.4%	42.428	66.5%
Urban Areas	171.844	67.5%	238.640	93.1%	248.013	96.1%	252.119	97.1%	255.792	97.7%
Tribal Lands	1.161	29.7%	1.913	48.6%	2.116	53.4%	2.269	56.9%	2.462	61.3%
<b>100 Mbps/10 Mbps</b>										
United States	165.184	52.3%	201.894	63.5%	215.582	67.3%	244.297	75.7%	288.378	88.5%
Rural Areas	12.568	20.6%	16.472	26.7%	20.481	32.9%	25.925	41.2%	37.395	58.6%
Urban Areas	152.616	60.0%	185.423	72.3%	195.101	75.6%	218.372	84.1%	250.983	95.8%
Tribal Lands	1.058	27.1%	1.315	33.4%	1.669	42.1%	1.875	47.0%	2.198	54.7%
<b>250 Mbps/25 Mbps</b>										
United States	0.000	0.0%	15.692	4.9%	67.912	21.2%	140.795	43.7%	191.505	58.8%
Rural Areas	0.000	0.0%	2.031	3.3%	5.460	8.8%	10.029	15.9%	18.564	29.1%

Note: Adapted from U.S. Federal Communication Commission, 2019

BROADBAND DEPLOYMENT REPORT (2019).

The report identifies that while steady progress in rural areas, there is still a discrepancy between the percent of connected Americans in urban and rural areas.

“Wealth and education often positively correlate with higher broadband use” suggested Alexander (2017, p. 24). Alexander (2017) recognizes that while there has been tremendous growth in the area of equity in access to technology, there still remains accessibility concerns for a large portion of people in the United States.

Shaffhauser (2019) echoes many of the same concerns that others have with regard to the digital divide. Shaffhauser stated that many rural students lack sufficient access to high-speed internet. Therefore, preventing them from academic success. She further advises that rural students suffer academically because of the lack of qualified teachers that would be able to teach more rigorous and advanced level courses. Shaffhauser also suggests that fulfilling this need is imperative in bridging the equity in opportunity gap that exists between rural and non-rural students (Shaffhauser, 2019).

### **The Digital Divide and Homework Gap**

Twenty percent of students in the United States live in and attend schools in rural areas. Nearly 27% of those students do not have access to minimally required broadband in order to access educational material while at home (Croft & Moore, 2019). Croft and Moore (2019) report that although progress has been made to connect schools to high-speed internet, 6% of schools fail to meet minimum broadband speeds. In a survey conducted by American College Testing (ACT), fewer rural students report

having ideal connectivity and a device equipped with a dedicated keyboard while at home than those students that attend non-rural schools (Croft & Moore, 2019).

Students with limited access to a device and have poor internet quality are more likely to attend rural schools (Moore, Vitale, & Stawinoga, 2018). Studies show that students from poor families are more likely to have access to a single device while at home than those from more affluent families (Moore, Vitale, & Stawinoga, 2018). Moore, Vitale, & Stawinoga (2018) report that data collected from a survey showed that seven out of ten teachers are assigning homework that requires broadband access. Additionally, they suggest that this exacerbates the problem of the homework gap given that rural students do not have access to broadband internet at home.

One of the most evident hurdles to surpass in ensuring equity in access to technology is the reduction in the cost of high-speed internet. While the cost of broadband internet has steadily decreased, it remains one of the largest contributing factors to decreasing the amount of time poor students can spend on the internet for academic purposes. In order to provide equity in access to technology, efforts need to be made to reduce the cost of hardware as well as finding by which to provide rural students with high-speed internet access at a less expensive cost (Resta & Laferrière, 2015).

### **Equity Effects on Rural Students: College and Career Readiness**

Research conducted by the Center for Public Education (CPE) found that about 20% of the students in the United States attend rural schools. The study also found that almost 75% of the students living in rural areas come from homes of poverty. Of those

homes, 20% of them have dealt with poverty for several generations. The CPE also found that students that attend rural schools do not have access to the amount of course offerings that students of urban schools do. Specifically, students that attend rural schools are offered half as many advanced mathematics courses as urban students. With the lack of financial resources and lack of rigorous course offerings, rural students are not as well prepared for post-secondary education when compared to their urban counterparts (CPE, 2018).

In an effort to remedy the problem that many rural students face with poverty and being able to afford college credits, earning college credits through dual enrollment while in high school becomes a viable option (Roberts, 2019). In 2019, Kelley and Woods reported on how multiple states provided funding for dual enrollment programs. They also identify varying degrees in which states provide dual enrollment for both College and Career Technology (CTE) as well as more traditional academic two- and four- year academic tracks.

As an attempt to improve post-secondary attendance and success, many rural school districts have adopted the use of dual enrollment courses to better provide for their students (Zinth, 2014). However, there are many concerns that students and school districts face in rural areas. Zinth (2014), identified that a student's lack of broadband access is one of the key concerns.

High school students that participated in dual-enrollment courses and earned college credit were significantly more likely to complete high school and attend a four-year college or community college (Lichtenberger, Witt, Blankenberger, & Franklin,

2014). Lichtenberger, Witt, Blankenberger, & Franklin (2014) also suggest that administrators and policy makers be made aware of this in order to promote taking dual enrollment courses while in high school.

Research has shown that high school students that participated in dual-credit courses and transitioned to post-secondary education as full-time students were more likely to have a higher grade point average than students that did not dual-enroll (Jones, 2014). Jones (2014), reported that those students that engaged in dual-enrollment courses were also more likely to persist in their education at four-year institutions.

### **Summary of Review**

The review of literature surrounding this topic demonstrated the necessity for having equitable access of technology by all students. This literature review has supported the equity in access to technology concerns that I share about my rural students. Their ability to access technology while at home as well as school has been shown to be beneficial in the learning process. Given that nearly 41% of high school teachers assign homework that requires broadband access and a device (Klein, 2019), exploring this research is worthwhile. Additionally, this literature review explored the research as it pertained to a rural student's ability to be college or career ready (CCR) (Roberts, 2019). The research suggests that when students lack the access or ability to access advanced coursework while in high school, those students are much less prepared to be successful in post-secondary education. As well, the literature provided us with potential solutions to solving these problems and these will be discussed further in Chapter 3 of this review.

## **Chapter 3: Discussion, Implications and Recommendations**

### **Discussion**

Based on the literature contained in this review, we can conclude that the digital divide adversely affects many rural students' ability to be college and career ready. In this chapter, I will be discussing how the literature answers my research questions and demonstrates how they are related.

### **Bridging the Gap**

Billions of dollars have been spent on connecting households through wired connections, yet nearly three million households with children from 3 to 18 have no internet connection at all in the United States (Reisdorf, Yankelevich, Shapiro, & Dutton, (2019); McFarland, Hussar, Zhang, Wang, Wang, Hein, Diliberti, Cataldi, Mann, & Barmer, (2019). Many of these households are situated in rural environments and are affected by the homework gap or lack of internet access at home (Reisdorf, Yankelevich, Shapiro, & Dutton, (2019).

Fortunately, there are proposed solutions for the unfortunate circumstances that many of our rural students face. In an effort to address the lack of broadband internet access at home, the Federal Communication Commission (FCC) allowed for the use of a band of radio waves to be used exclusively for Educational Broadband Service (EBS). The spectrum allows for the wireless use of this band for educational purposes using typical network and mobile devices (Reisdorf, Yankelevich, Shapiro, & Dutton, (2019).

In an effort to address the digital divide and the homework gap associated with the lack of affordable and high-speed internet access, students are taking advantage of

access points that are providing broadband internet access through television white space (Rebmann, Means, Riedesel, & McDowell, 2019). In 2008, the FCC released access to lower frequency bands for access to the public. These bands created newer technologies to allow for high-speed internet connection where other connection types are not feasible. Because these bands are similar to VH and UH frequencies, their signal is not impeded by trees or buildings and the signal is easier to extend to rural areas (Rebmann, Means, Riedesel, & McDowell, 2019).

For schools that have less than desirable internet and Wi-Fi networks, E-Rate funds are provided to schools to subsidize money dedicated to providing high speed internet, technology infrastructure as well as devices that students use while in school (Johnston, 2018). With schools lacking sufficient bandwidth to support the ever-evolving demands of our technology-based curriculums, E-Rate funds are provided. E-Rate funds are subsidies that schools receive for improving technology and internet access speeds. FCC commissioner, Jessica Rosenworcel offered several solutions in a meeting with educational leaders date, year. Rosenworcel (2017) suggested that the FCC was encouraging school districts to sell the 2.5GHz spectrum that they purchased nearly 60 years ago to the FCC. She also suggests that this spectrum can be resold and that the funds could be used to advance the possibility of closing the “homework gap”. Lastly, Rosenworcel emphasized the success of other programs, such as mobile hotspots, “Wi-Fi on wheels” (Johnston, 2018).

Research showed that many rural students also come from families that simply cannot afford the cost of high-speed internet. Thankfully, there are programs that

provide assistance that offsets the cost of internet access for qualifying families. For instance, the FCC offers financial assistance through its Lifeline program in order to make high-speed internet access more affordable (Lifeline Support for Affordable Communications, 2020).

Many of the students in my rural community spend hours on traveling to and from school via buses. Many of those students lack sufficient internet access at home in order to complete homework. Google initiated a program called Rolling Study Halls (Rolling Study Halls | Google for Education). This program provides school districts with the equipment necessary to allow students to connect to the internet while traveling on a school bus so that they can complete schoolwork. My school district has participated in the program. Not only did we provide students with access to the technology, we also asked teachers to ride the school buses and provide students with assistance when needed.

I have contacted several school districts similar to my own within the State of Wyoming. I asked several questions relative to what each district was doing to address equity in access to technology and broadband internet at school and at home. In a phone interview with Charles Auzqui, Superintendent of Arvada/Clearmont Schools, SCSD #3, he identified with similar concerns and suggested a plan that his school district was using to address them. Auzqui advised that his district allowed students to remain at the school, after normal hours, to work on high school homework as well as dual credit homework. He further advised that many of those students then rode the school bus home that was used as an after-school activities bus.

I work in a school district that consists of approximately 30% Native American students. Those students generally live in poverty and lack access to the technology necessary to participate in advanced coursework let alone complete homework. The majority of these students live on the Wind River Indian Reservation and travel great distances to attend Wind River High School. EBS has not been made available to all rural areas in the United States. In February of 2020, the FCC allowed Tribes in rural areas to apply for access to three channels within the 2.5 GHZ spectrum (U.S. Federal Communication Commission, 2020). By doing so, Tribal Leaders can begin the process of providing broadband internet access to Tribal areas that fall into the rural category of having a population of less than 50,000.

### **College and Career Readiness**

In order for students to be best prepared and receive a high-quality education, it is necessary for educators to begin to implement technology into their lesson plans and instructional practices (Deaton, 2017). Teacher perceptions and training about technology and its use in mathematics education have profound implications on the academic success of students. Schools in which every student is afforded a device for learning purposes as opposed to those that use more of a traditional type of instruction could potentially demonstrate more academic success with its students (Deaton, 2017).

Unfortunately, for many of my rural students, access to classes that are not offered by my school often require them to be taken online. While at school, students have access to the requisite level of resources to be successful in taking college level classes online. However, this scenario presents many difficulties for my students once

they leave the school. Some students are limited with their access to a device and internet. For some students, access to the internet is limited to the use of their cell phone at best. Completing schoolwork on a cell phone without a dedicated keyboard is time consuming and lacks the functionality that a laptop or desktop would (Napoli & Obar, 2014).

Research and data have also shown that many rural students come from families that might not be able to afford a device or the cost of internet access (Tsetsi & Rains, 2017). Indeed, there are programs that offer financial assistance with these issues, but for some they are still unable to provide adequate levels of broadband access to complete advanced or college coursework.

Research shows that high school students that participate in advanced classes or college level courses are more likely to be successful once they transition to post-secondary education. The research and data also show that rural schools are half as likely to offer advanced mathematics courses to students. When these statements are combined and consider that rural students lack equity in accessing the technology necessary for taking online courses at home, the only logical conclusion is that rural students are less likely to be successful once they graduate from high school and seek post-secondary education and training. This is not to say that all rural students will pursue education beyond their high school careers, but that rural students should have equity in access to these courses in order to become as college and career ready as those that attended non-rural schools.

Table 3 illustrates the break-down of each question as a problem to be solved. By doing so, the table will conveniently allow us to analyze potential advantages as well as and disadvantages for each proposed solution in an attempt to ascertain an answer to each of the following two research questions: Question 1) What is being done to bridge the “homework gap” and the “digital divide” in rural communities? Question 2) What are the effects of inequities such as this on rural students and their ability to be college or career ready?

Table 1:

A comparison of advantages and disadvantages for proposed solutions to each question as a problem to be solved.

Question or Problem	Proposed Solution	Advantages	Disadvantage
What is being done to bridge the “homework gap” and the “digital divide” in rural communities?	Wi-Fi on School Busses	<ul style="list-style-type: none"> <li>● Students with long rides home.</li> </ul>	<ul style="list-style-type: none"> <li>● Cost to install and maintain.</li> </ul>
	Hot-Spot Lending	<ul style="list-style-type: none"> <li>● No student cost</li> </ul>	<ul style="list-style-type: none"> <li>● School district expense.</li> <li>● Must have cell service.</li> </ul>
	Mobile hotspot.	<ul style="list-style-type: none"> <li>● Central location of accessibility</li> </ul>	<ul style="list-style-type: none"> <li>● School district expense</li> </ul>
	Activities Bus	<ul style="list-style-type: none"> <li>● Provide students access at school.</li> </ul>	<ul style="list-style-type: none"> <li>● Requires work to be done at school.</li> </ul>
	Device Lending	<ul style="list-style-type: none"> <li>● Provides students with a device equipped with dedicated keyboard</li> </ul>	<ul style="list-style-type: none"> <li>● Filtering</li> <li>● damage</li> </ul>
	Fiber Infrastructure Installation	<ul style="list-style-type: none"> <li>● High-speed</li> </ul>	<ul style="list-style-type: none"> <li>● \$20-180k per mile for installation</li> </ul>
	TVWS-EBS	<ul style="list-style-type: none"> <li>● Broadband access</li> <li>● Access for students living on the WRIR</li> </ul>	<ul style="list-style-type: none"> <li>● New technology</li> <li>● Application process</li> </ul>

<p>What are the effects of inequities such as this on rural students and their ability to be college or career ready?</p>	<p>Increase the number advance course offerings</p>	<ul style="list-style-type: none"> <li>● Post-secondary success</li> </ul>	<ul style="list-style-type: none"> <li>● Cost</li> <li>● Qualified teachers</li> </ul>
	<p>Increase dual enrollment.</p>	<ul style="list-style-type: none"> <li>● Post-secondary success</li> <li>● Earn college credit</li> </ul>	<ul style="list-style-type: none"> <li>● Technology requirement</li> <li>● Broadband requirement</li> </ul>
	<p>On-line synchronous or asynchronous college courses.</p>	<ul style="list-style-type: none"> <li>● Post-secondary success</li> <li>● Earn college credit</li> </ul>	<ul style="list-style-type: none"> <li>● Technology requirement.</li> <li>● Broadband requirement</li> </ul>

## **Implications**

Much has changed in mathematics education since I started teaching. When I started my classroom was equipped with blackboards, piles of chalk, more than enough students in every class, and two computers at the back of the room. I am fairly certain that only one of them worked but was never used because even though it had the potential of being a great learning tool, I lacked the training in order to use it effectively.

Several years and a career change later, I found myself back in the classroom, but faced with an entirely different approach to teaching mathematics. I was employed by a school district that provided all necessary technology and the connection to the internet was high-speed and stable. I also found that mathematics education had evolved and that best practices would require the integration of technology in instruction for providing the best service for my students. My students were engaged at school and at home as well because I could expect them to have access to technology once they left to go home for the day.

It never really occurred to me that it was possible for there to be a lack of equitable access to technology, high-speed internet, and mathematics education until I moved and sought employment at a rural school near where I had grown up. I had completely taken for granted that at this point in the evolution of mathematics education and the advances that we have made with technology that all students would have equity in access at their fingertips. However, I was devastated to learn that this was not the case for my school, specifically, but to learn that this was fairly common throughout the world after having done this research.

I have had to adapt my teaching style to fit the needs of the students given the lack of access to technology once they leave school. Instead of expecting them to be able to do practice problems online, I have to print questions for them to answer on paper. Ordinarily I would share online resources to assist with mathematics understanding and remediation to students and parents, but without a stable internet connection, they cannot access these resources.

As a mathematics teacher in a rural environment, I have observed that there is a distinct lack of equity in the access to upper level math classes when compared to the access that students would in a school just 20 miles from my own. Because we are a small school and have limited resources, we offer a limited choice of mathematics courses. My teaching partner and I are hopeful that we will be able to convince our administration to adjust the schedule in order to accommodate for additional course offerings. Until then, students will need to pursue advanced courses online provided they have a device and adequate access to broadband at home.

### **Recommendations**

I recommend that further research be conducted with respect to the impact that these equity concerns have on the overall culture of a rural community, school and the individual rural student. While researching the literature associated with this literature review it occurred to me that these equity issues might influence a schools' culture as well as a rural student's self-efficacy with respect to success in high school as well as college or career training. We are, after all, talking about ensuring that every student, regardless of where you live, be provided with equitable access to education.

I have been working and living in this community for the past couple of years and have had several conversations about the aspirations of our students and the general expectations that our community has for its youth beyond high school. I would venture to guess that in many rural communities, these conversations would be similar. It is very common to learn that the expectation for the majority of these students is to join the workforce and not pursue post-secondary education or training for a trade. It would be interesting to know what creates this culture and mindset that appears to be generational.

These conversations remind me of what I was told when I was growing up. I can distinctly remember hearing those that supported, mentored and guided me through high school and into post-secondary education. They told me that I could do anything that I wanted to and that I simply had to work hard to achieve it. I find myself supporting, mentoring and guiding my students on a regular basis. I too tell them, "You can do anything!".

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