Effects of Home Internet Access on Minnesota Comprehensive Assessment (MCA) Scores of Students in Hennepin County, Minnesota

Elorm Agbolosoo
Department of Resource Analysis, Saint Mary's University of Minnesota, Minneapolis, MN 55404

Keywords: Internet Access, Minnesota Comprehensive Assessment, Broadband, Geographic Information Systems (GIS), Exploratory Regression, Ordinary Least Squares (OLS)

Abstract

The internet has become an indispensable resource in our everyday lives. As the driving force behind information flow, it has impacts on our ability to access basic services such as healthcare, commerce, entertainment, education and even our ability to stay in touch with our social network. This study sought to examine the impact of home broadband internet access on the performance of 5th grade and 8th grade students in Hennepin County, Minnesota. It utilized demographic data from the 5-year ACS data released by the Census Bureau, broadband connectivity data from the FCC, and MCA performance for 5th and 8th grade students released by the Minnesota Department of Education from 2012 to 2016. An exploratory regression analysis was conducted on 15 risk factors in addition to home broadband access to determine their overall significance and relationship to the dependent variable. Ordinary Least Squares (OLS) regression was then used to determine the impact of selected variables on the overall performance of students in the 5th and 8th grades. GIS was used for data processing, analysis, and visualization of data in the sample area. The model explained 86% and 81% of the variability of students not meeting the MCA standards in the 5th and 8th grade, respectively, at the 95% confidence level. Home broadband access was significant in the 5th grade but not in the 8th grade. At the subject level, broadband access was only significant at the 95% confidence level for explaining the variability of the percentage of students not meeting the MCA standards in reading in the 5th grade.

Introduction

The internet has become a very important resource in our daily lives today; it is an indispensable asset in education and job training. Getting connected to the internet is considered the first step to delivery of socioeconomic benefits of information technology, as it plays a role in economic growth and development and also enhances communication (Hisham, 2016).

In education the internet helps teachers and students broaden their knowledge, helps modernize teaching and learning, and builds students confidence to do better in school (Thigpen, 2015). Bair and Stafford (2016) consider mobile internet as an information rich environment that could broaden learning opportunities. This is because it breaks down barriers associated with traditional teaching and learning through enabling constant and personalized access to media (Bair and Stafford, 2016).

The benefits to be derived from being connected to the internet still eludes

Agbolosoo, E. 2019. Effects of Home Internet Access on Minnesota Comprehensive Assessment (MCA) Scores of Students in Hennepin County, Minnesota. Volume 22, Papers in Resource Analysis. 19 pp. Saint Mary's University of Minnesota. University Central Services Press. Winona, MN. Retrieved (Date) http://www.gis.smumn.edu

some people; the National Information and Technology Authority (NITA, 2008 as cited by Greenhow, Walker, and Kim, 2010) states one third of the population of the United States is without internet access at home. Statistics from the International Telecommunications Union (ITU; 2015), also cited by Hisham (2016), placed the population of the world without internet access at 47.3%. Correa, Pavez, and Contrera (2017) identified sociodemographic factors and personal perceptions as a driving force behind digital exclusion.

Determinants of Academic Performance Among Students

Determinants of academic performance of students have been grouped into two broad groups as home factors and school factors. Okilwa (2016) investigated which of the above factors have a more significant influence on the academic performance of students from low income backgrounds and found out that school-based factors had a more significant impact on the performance of students.

Stewart (2008) also studied factors that impact academic performance of students in schools. Identified impacts include the school as a setting and the student. Stewart (2008) identified school level factors such as teacher student relationships and even the structure of the school as some of the factors that affect the performance of students in standardized tests. Individual level factors identified include student effort, parent–child discussion, and associations with positive peers. Stewart (2008) determined individual level factors contributed significantly to students' academic success. While the study by Stewart (2008) placed the burden of academic success on the shoulders of the student, Uline and Tschannen-Moran (2008) determined physical school structures have impacts on the academic achievements of students. The study, however, did not look at other factors that impact academic achievements. Gale and Bishop (2014) also determined there is a strong correlation between school leadership and academic performance.

Out of school determinants have also been studied. Lacour and Tissington (2011) studied poverty and its relationship to academic achievements. They determined poverty significantly affects the resources available to students. Lacour and Tissington (2011) concluded due to the lack of resources, many students struggle to reach the same academic achievement levels of students not living in poverty and also elaborated on other factors including the educational level of the mother of the child and Federal and State policies as some of the out of school factors that influence the academic achievements of students. Lacour and Tissington (2011) cite Bergerson; 2006 stating almost half of students in a study did not meet requirements necessary for a pass in any of the subjects they were examined in due to out of school factors.

Determinants of Internet Access

Access to internet has been studied in various socio-economic settings. Hisham (2016) studied the factors that influence the demand and supply of internet service in developing countries with Saudi Arabia as the case study. The study found factors responsible for internet use include level of education, mobile phone subscription, income, and employment levels. Hisham (2016) referenced Hoffman *et al*.; 1996 stating socio economic factors also play a huge role in internet access in developed countries. Le Guel; 2005 was also cited by

Hisham (2016) as pointing to the fact that other determinants of internet access included, household size, lifestyle, and social network. Bauer, Berne and Maitland (2002) analyzed qualitative and quantitative data and reported that policies in addition to economic factors have been the reason why developed countries in Europe and the United States have seen an increase in internet usage.

Despite the acknowledgment of the fact there is widespread internet access in developed countries, research has shown that there still exists a digital divide. Mossberger, Tolbert, Bowen and Jimenez (2012), after examining census tract level data in Chicago, pointed to concentrated poverty in urban areas and individual level factors as contributors to the lack of internet access in homes. Grubesic and Murray (2002) also investigated how the location of communities can affect internet access and revealed that internet is more readily available in urban areas. They attributed this to the presence of business and infrastructure as opposed to rural areas. A survey by the Center for Rural Policy and Development (2012) also reports that rural communities in the State of Minnesota stand to be disadvantaged by the digital divide due to the lack of infrastructure. The survey also highlights household incomes as a major determinant for internet adoption in homes.

Internet Access and Academic Achievement

While Erdogdu and Erdogdu (2015) posited there have not been sufficient studies to examine the relationship between internet access and academic performance, their study showed that students with the absence of internet at home scored low marks in standardized tests. Their study analyzed the other factors such as home and school factors using regression analysis to reach this conclusion. Jing and Jingye (2012) studied 1,576 middle school students in China and analyzed data using descriptive statistics, independent-samples T-test, and regression analysis; their study found that students with home internet access reported higher scores than those without home internet access.

In the United States, Fairlie and Robinson (2013) referenced the National Telecommunication and Information Authority; 2011 as placing the number of children in the range of 10-17 without access to computers at 9 million or 27%. Fairlie and Robinson (2013), however, suggest absence of computers at home did not necessarily affect the grades of middle school students that were studied. In a randomized study by Fairlie and Robinson (2013), home computers were provided to students without computers and their performance in the standardized test was compared to a control group, but they found no significant difference in the scores to conclude that the provision of computers was necessary to improve scores in standardized tests.

Purpose of Study

Policies such as “No Child Left Behind” were fashioned to bridge gaps that exist between students coming from different backgrounds. It is policies like this that make it mandatory for every school to have internet access for teaching and learning purposes. However, students spend a larger proportion of time at home during the school term and should have access to resources necessary for studying at home. Identifying areas with gaps in internet access and how these gaps affect the academic performance of students will be a first step to putting measures in place

to ensure resources are available for students or alternative measures put in place to mitigate the effects of its absence. This study seeks to explore how access to broadband internet service at home impacts the MCA scores of 5th grade and 8th grade students in public schools in Hennepin County, Minnesota.

Study Area

Hennepin county is one of the mostly urbanized counties in the state of Minnesota. Apart from being at the center of the seven-county metro area, it is home to the University of Minnesota, the US Bank Stadium and other corporate headquarters. The US Census Bureau (2017) estimated the population of Hennepin County to be 1,252,024 with 22% of this number being under the age 18 and a total land area of 553.59 square miles. Figure 1 illustrates the study area and its location in the State of Minnesota.

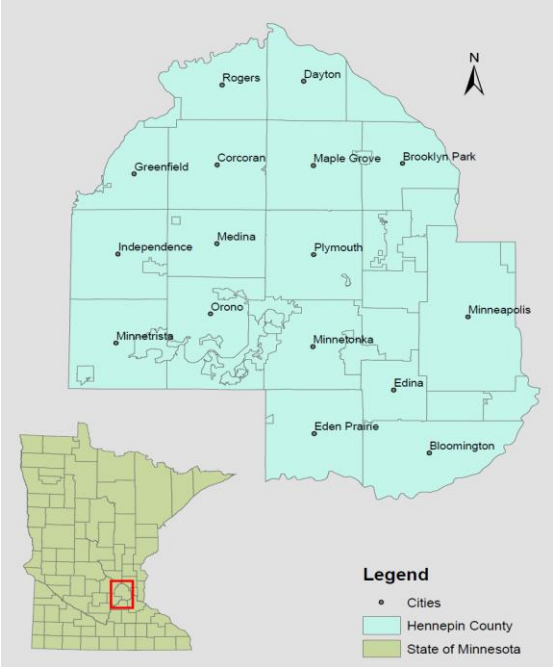

Figure 1. A map of Hennepin County, the study area.

Hennepin County is also one of the counties that have up to date data from the Census Bureau, the Minnesota Department of Education, and the Federal Communication Commission (FCC).

Methods

This study involved the use of demographic data from the Census Bureau, broadband access data from the Federal Communications Commission (FCC), data on MCA test scores, school district shapefiles from the Minnesota Department of Education, as well as census tract TIGER lines downloaded from the Census Bureau's website. Tabular school district data were linked to shapefiles using school district numbers as unique identifiers ahead of performing the regression analysis.

Variables

Demographic Data

Kominski, Elliot, and Clever; 2009 were cited by Dunst and Hamby (2016) as enumerating a total of 22 cumulative risk factors that affect children in the United States. The risks factors were grouped into four broad categories as individual risk factors, family and household risk factors, family economic risk factors, and physical environment risk factors. These risk factors were studied for their cumulative impact on the academic performance of American students in the 4th and 8th grade over a five-year period by Dunst and Hamby (2016).

Fifteen of these risk factors were located in the 5-year American Community Survey (ACS) estimates from 2012-2016 and used in this research. They were available as comma separated values (.csv) files and were downloaded at the school district level.

Minnesota Comprehensive Assessment (MCA)

State level comprehensive tests have been utilized in the past to determine students' academic performance. Vigdor, Ladd, and Martinez (2014) used the North Carolina State standardized test scores when they examined the effect of home computers and internet access on academic performance.

The MCA is a state level standardized test administered by the Minnesota Department of Education. Students are tested in math and reading from the third grade up to the eleventh grade and tested in science from the fifth grade. The results of the MCA test are classified as, not met standard, partially met standard, met standard, and exceeded standard. MCA scores were obtained for 5th and 8th grade students covering 5 academic years between 2012 to 2016.

This study focused on students who were classified as not meeting the MCA standards for the three subjects. Data was available at the school district level and downloaded from the Minnesota Department of Education website.

Once downloaded, the results were aggregated by subject and averages were determined for the percentage of students not meeting the MCA standards for both grades under study. These averages were joined to school district shapefiles downloaded from the US Census Bureau website.

Figures 2 and 3 illustrate the overall distribution of the percentage of students not meeting the MCA standards by grade and Table 1 below shows descriptive statistics of 5th and 8th grade students not meeting MCA standards by subject and grade over the 5-year period in the sample area.

Table 1. A descriptive statistic representing the minimum, maximum, average and standard deviation from the mean of the percentage of students not meeting MCA standards in Math, Reading and Science by grade in the sample area.

Subject	Min	Max	Mean	St Dev
Math (5)	4.43	36.7	14.19	8.22
Math (8)	3.30	53.70	15.30	10.44
Reading (5)	1.76	29.76	10.54	6.36
Reading (8)	6.84	48.10	19.35	9.32
Science (5)	5.72	46.30	16.64	9.77
Science (8)	6.56	62.94	21.96	12.70

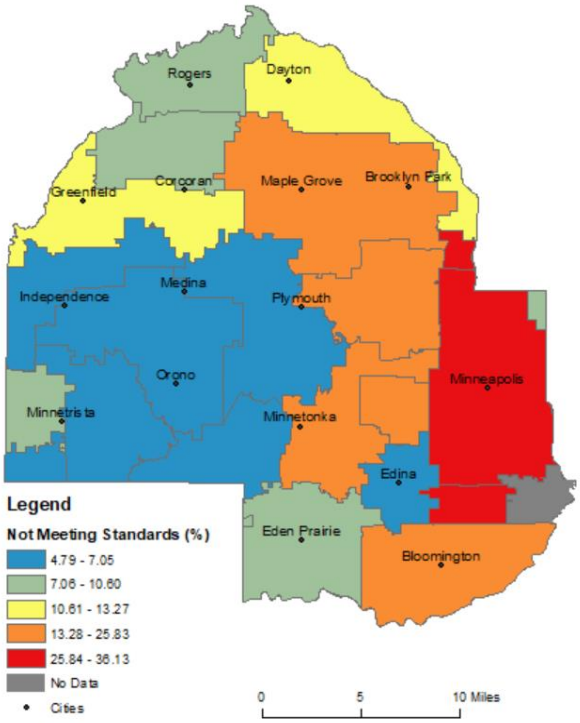

Figure 2. A map of overall distribution of students not meeting MCA standards in the 5th grade in Hennepin County. The blue areas represent the areas with the least percentage of students not meeting the MCA standards in the 5th grade, and the red areas represent the areas with the highest percentage of students not meeting the MCA scores in the 5th grade during the 5-year period.

Broadband Data

Broadband data was downloaded from the FCC website and data used spanned a five-year period from 2012 to 2016.

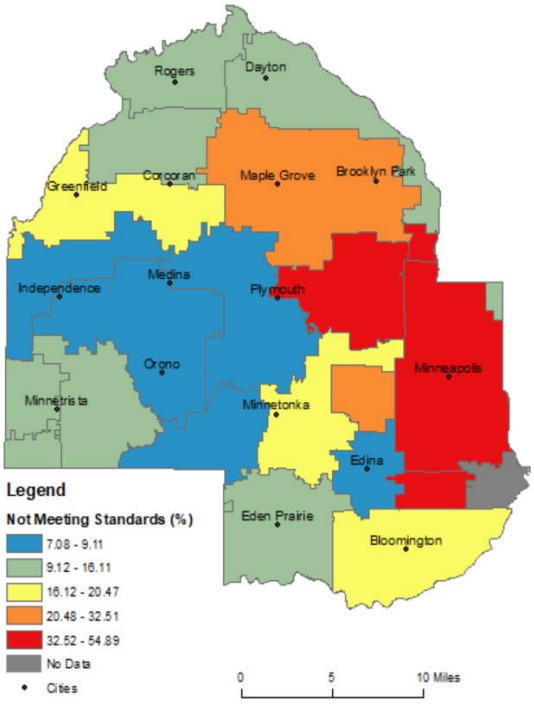

Figure 3. A map of overall distribution of students not meeting MCA standards in the 8th grade in Hennepin County. The blue areas represent the areas with the least percentage of students not meeting the MCA standards at the 8th grade, and the red areas represent the areas with the highest percentage of students not meeting the MCA scores in the 8th grade during the 5-year period.

Data downloaded was available on a census tract basis and had codes representing the estimated number of people per a thousand households accessing broadband internet in a given census tract. The data also had the number of service providers per census tract, however this was not present in data up to the year 2013. Vigdor *et al.* (2014) used the number of service providers to estimate the population accessing the internet when they studied the impact of home computers and the internet connection on academic performance of students in South Carolina because the FCC did not provide the number of subscribers in the dataset they analyzed.

The data downloaded from the census tracts were joined to the latest version of census tract TIGER lines downloaded from the Census Bureau's website. Figure 4 indicates the distribution of the average number per 1000 households accessing broadband internet service at 200kbs in Hennepin County.

In order to match the tract data to the school districts, a feature layer was created with a ratio policy on the average broadband access by population field. The overlay tool was then used to calculate the values of broadband access by the proportion of census tract that intersects the school district. The dissolve tool was then ran to aggregate the broadband data into the school district shapefile

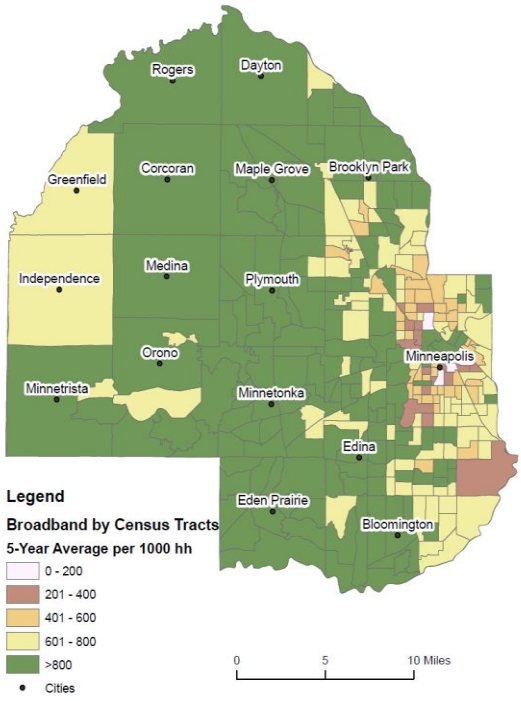

Figure 4. A map illustrating the distribution of average home broadband access at 200kbs in Hennepin County by census tract between 2012 and 2016. The green areas represent census tracts with more than 800 households in every 1000 households connected to the internet.

Data Aggregation

Data from all the various sources were aggregated into two datasets consisting of

grade 5 and grade 8 using unique identifiers in readiness for analysis.

The target study area was comprised of 17 school districts in Hennepin County in the State of Minnesota. However, due to optimum sample size required by the tools used for data analysis, 37 surrounding school districts were included in the study. Analysis was conducted on this sample area made up of 54 school districts and Hennepin County was clipped out using the clip geoprocessing tool to show the results for the county.

None of the data used contained any student identifying information or personally identifying information.

MCA data was not available for the Minneapolis St. Paul (MSP) school district and was therefore not included in the analysis.

Preliminary Analysis

A preliminary analysis was carried out by means of scatter plots and trendlines in MS Excel to get a snapshot of broadband access' relationship to MCA scores without the other potential variables.

The preliminary analysis also looked at the relationship between the percentage of households under the poverty line and broadband access.

Regression Analysis

This study relied on multiple regressions to be able to determine the relationship and impact of broadband internet access on school test results. Erdogdu and Erdogdu (2015); Jing and Jingye (2012); and Vigdor *et al*. (2014) utilized analytical methods similar to the regression used herein. A multiple regression is illustrated mathematically as:

$$Y=a+b_1X_1+b_2X_2+b_3X_3+b_4X_4$$

Where Y is the dependent variable, and a is the intercept, b is the coefficient and Xi are the independent variables.

Exploratory Regression

Rosenshein, Scott, and Pratt (2011) recommend the use of exploratory regression analysis to aid the identification of a suitable model especially in the case where many variables are being looked at. This is to reduce the amount of time that will be spent on running an ordinary least square repetitively until a passing model is found. An exploratory regression analysis was run on grade level data with an overall percentage of students who did not meet MCA expectations as the dependent variable with identified risk factors from demographic data, and broadband internet access as the explanatory variables. This process enabled the study to determine not only a good model but also to determine the significance of the variables. Appendix A and B illustrates the significance of the variables for grade 5 and grade 8 students respectively.

The significance shows the strength of variables in the exploratory regression or how much a particular variable contributes to the dependent variable. A negative or positive correlation shows how the variable affects the phenomenon being studied. A positive relationship means the dependent variable, that is the percentage of students not meeting MCA standards, increases with an increase in the independent variable while it is an inverse relationship where there is a negative relationship between the dependent and independent variables.

While the exploratory regression analysis produced different passing models, one which found high adjusted R

squared at lower Akaike's coefficient (AICC) and some significance at the 90% confidence level for the broadband access variable was selected to be used in an OLS regression at grade level and at subject level. Other model performance indicators are the Jaque-Bera (JB) Statistic which measures model bias, Variable Inflation Factor (VIF) which measures variable redundancy, Koenker (BP) Statistic which indicates the consistency of relationships being modeled, and Spatial Autocorrelation (SA).

The passing model found had the following characteristics in Table 2 below. The variables in the model are: children living with their grandparents, children who speak less English, percentage of parents in the labor force, percentage of population benefitting from cash public assistance, and number of people accessing broadband internet.

Table 2. A table of recommended values of a good model, Rosenshein *et al*. (2011) and recorded values for the selected model.

Parameter	Recommended Values	Recorded Values
Adjusted r square	0-1	0.863
Akaike's Information Criterion(AIC)	Model with smaller value	281.300
Jacque-Bera (JB) Statistic	>0.05	0.621
Koenker (BP) Statistic	>0.05	0.313
Variable Inflation Factor (VIF)	<7.5	2.642
Spatial Autocorrelation	>0.05	0.830

Appendix C illustrates the other models found during the exploratory regression sorted by their respective adjusted R square values with their corresponding statistics. The selected passing model has been shaded grey in Appendix C for easy reference.

Ordinary Least Squares

The OLS regression was informed by results from the exploratory regression. OLS was conducted on the overall percentage of students not meeting MCA standards in the 5^{th} grade and 8^{th} grade. Figures 8 and 9 illustrate how the variables interacted with the dependent variable in the various school districts.

While the exploratory regression carried out did not show a high significance for broadband access, the model selected was still used because its impact on the performance of students was the reason for commencing this study. Rosenshein *et al.* (2011) recommend the use of such variables in models if their impacts on a candidate variable is being studied even when they are not very significant in the exploratory regression.

This regression method was used to assess the impact of the explanatory variables on science, math, and reading MCA scores at the two grades as well. The results are tabulated in Appendix D and E.

Results

Results of Correlation

Figures 5 – 7 illustrate results of the preliminary analysis carried out in MS Excel. Figures 5 and 6 illustrate the relationship between broadband access and MCA scores and Figure 7 illustrates the relationship between poverty and broadband access.

Model Performance at Grade Level

The model explained 86% of the

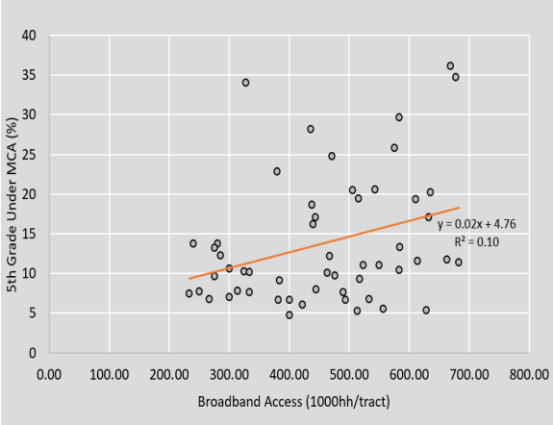

Figure 5. A scatter plot and line of fit (in red) showing the relationship between broadband internet access at 1000 households per census tract and percentage of students not meeting MCA standards in the 5th grade.

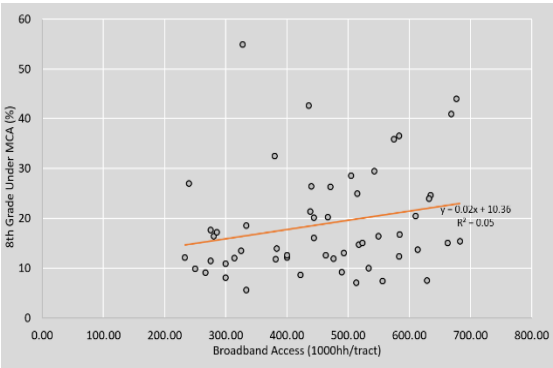

Figure 6. A scatter plot and line of fit (in red) showing the relationship between broadband internet access at 1000 households per census tract and percentage of students not meeting MCA standards in the 8th grade.

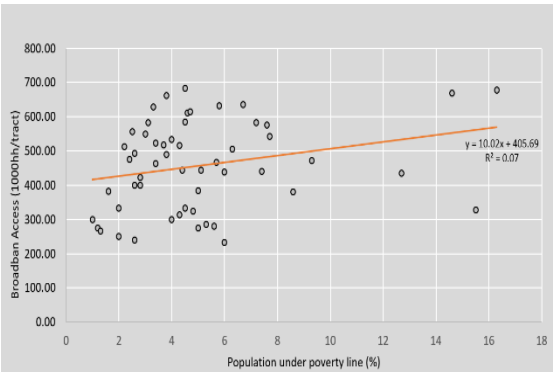

Figure 7. A scatter plot and line of fit (in red) showing the relationship between broadband internet access at 1000 households per census tract and percentage of the population under poverty line.

variability of the percentage of students not meeting MCA standards, with an adjusted R square of 0.863 in the 5th grade at the 95% confidence level. From Table 3, all the variables correlated positively to the dependent variable.

At the 8th grade level, the model explained approximately 82 percent of the variability students not meeting the MCA standards with an adjusted R square value of 0.818.

From Table 4, the study found that all the explanatory variables except broadband were significant at the 95% confidence level. However broadband access showed a negative correlation to the dependent variable which implies overall performance at MCA improved with increased broadband access while all the other variables showed positive correlations to the dependent variable.

Figures 8 and 9 are maps of residuals which illustrate areas where the model accurately predicted students not meeting MCA scores and areas where failure rates were under and over predicted.

Table 3. A table of the coefficients and variable inflation factor of each independent variable and, the coefficient of intercept, Jarque-Bera statistic and adjusted R square for the model at 5th grade.

Variable	**Coefficient**	**VIF**
Intercept	-23.004*	
Living with grandparents	0.098*	1.287
Speak less English	1.507*	2.642
Parents employed	0.307*	1.265
Cash public assistance	1.536*	1.984
Broadband access	0.0128*	1.483
Adjusted R-Squared 0.863 **Jarque-Bera** 0.951		

Significant at 95% *

Table 4. A table of the coefficients and variable inflation factor of each independent variable and, the coefficient of intercept, Jarque-Bera statistic and adjusted R square for the model at 8th grade.

Variable	Coefficient	VIF
Intercept	-26.267*	
Living with grandparents	0.237*	1.287
Speak less English	2.168*	2.642
Parents employed	0.345*	1.265
Cash public assistance	2.087*	1.984
Broadband access	-0.001	1.483
Adjusted R-Squared 0.818 **Jarque-Bera** 2.106		

Significant at 95% *

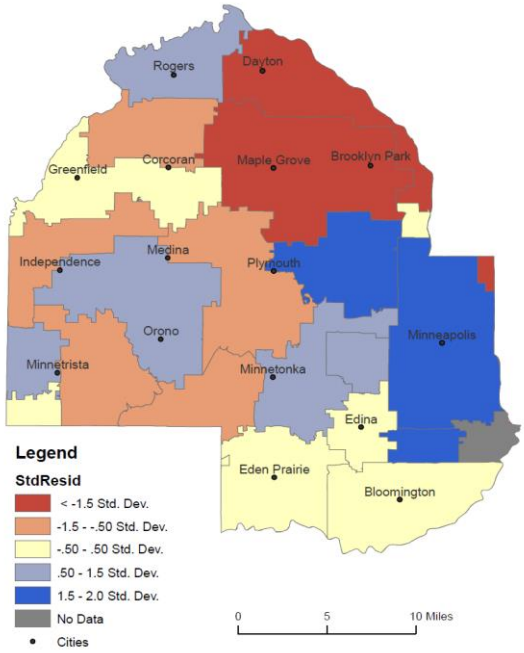

Figure 8. A map of regression residuals from the model for 5th graders showing where the model under predicted, predicted, and over predicted the percentage of students not meeting MCA standards in red, yellow, and blue respectively.

Model Performance at Subject Level

Using the same model to analyze the performance at subject levels in the 5th grade, broadband access consistently had a positive correlation to the dependent variable, which is the percentage of students not meeting the MCA standards for the various subjects. It was only significant in the model for

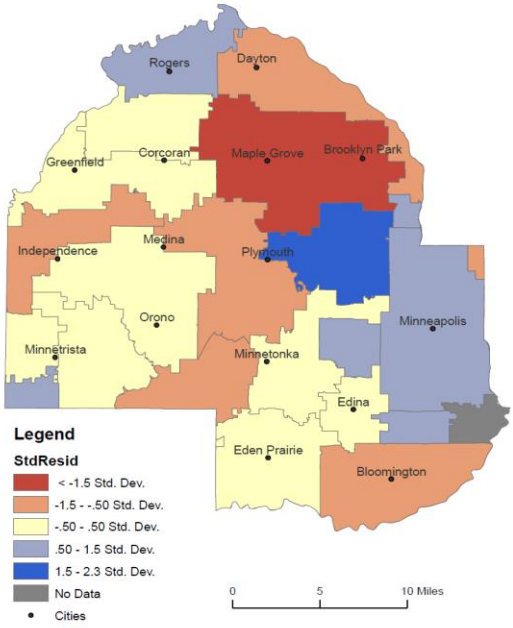

Figure 9. A map of regression residuals from the model for 8th graders showing where the model under predicted, predicted, and over predicted the percentage of students not meeting MCA standards in red, yellow, and blue respectively.

predicting students not meeting the MCA standards in reading tests. From the R squared values in Appendix D, the model explained 89%, 81%, and 77% of the variability of students not meeting MCA standards in science, reading, and mathematics respectively.

At the 8th grade, broadband access was not significant for any of the dependent variables in the model. The model did however show a negative correlation to the dependent variable in science and reading; in other words, broadband access possibly helped students in those subjects but not mathematics. From the R squared values recorded in Appendix E, the model explained 82%, 77%, and 76% of the variability of 8th grade students not meeting the standards in science, reading, and mathematics respectively.

Sources of Error

The main source of error could be from the Minneapolis St. Paul Airport school district, as it has people living there but has no school district data due to the fact that there are no elementary schools in that area. Residents of that location may be attending school in other school districts – especially the neighboring ones and contributed to their test score numbers.

Discussion

From the preliminary relationships established between MCA scores and broadband, it can be concluded the percentage of students not meeting MCA standards increased with an increase in the number of households accessing broadband per tract. However, the associated R squared values of 0.10 and 0.05 from the linear model suggest broadband access alone explained only 10% and 5% of the variability of students falling behind in the MCA test in the 5^{th} and 8^{th} grade respectively.

The linear model to determine the variability of broadband access due to the percentage of families living under poverty line explained only 7% of such variability with an R squared value of 0.07. Broadband access also correlated positively to the percentage of population under the poverty line contrary to the findings of Mossberger *et al.*2012) which determined the number of people accessing broadband reduced with an increase in poverty and most importantly in areas where poverty is concentrated in urban areas. This could be attributed to the fact that being under the poverty line is a culmination of other factors such as household incomes, household size, and employment status among others. It could also be due to the fact that being under poverty line was not significantly concentrated in Hennepin County. However, since the main purpose of this study is to determine the effects of internet access on student performance, the determinants of internet access in Hennepin County were not investigated.

From the results of the OLS, the model's Jarque-Bera values of 0.951 and 2.106 at grade 5 and 8 respectively were above the recommended value of 0.05 from literature at the 95% confidence level, an indication that the residuals were normally distributed and not biased. This conclusion is valid for the subject level analysis at both grades. Also, the Variable Inflation Factor (VIF) of all the variables were consistently lower than the recommended 7.5 at both grade and subject levels. The VIFs recorded during the OLS were all lower than the VIF returned during the exploratory regression.

From the results in Table 3, broadband access's positive correlation to the candidate variable means the percentage of students not meeting standards increased with an increase in broadband access in the various school districts in direct contrast with findings by Erdogdu and Erdogdu (2015) where access to internet at home improved the test scores of students. Findings were however consistent with the findings of Erdogdu and Erdogdu (2015) in the 8^{th} grade even though broadband access was not a significant variable at the 8^{th} grade from the results in Table 4.

In all, analysis revealed that the percentage of students not meeting MCA standards at both grades increased with an increase in the independent variable where the broadband access variable was significant.

Conclusion and Recommendations

From the outputs of the exploratory regression it can be recommended that broadband access should not be used as a variable when determining the performance of pre-high school students given that there were other variables that showed stronger significance to the candidate variable.

Studies into the impact of broadband access on academic performance in urban areas should be conducted at a granular level to include a measure of how much time students actually spend online for academic purposes. Other factors that should be considered include the level of parents and/or guardians' involvement in academic related activities at home. Also, future studies should include how school factors, such as those evaluated by Stewart (2008); Uline and Tschannen-Moran (2008), interact with home factors to impact students' scores in standardized tests.

Within the limits of data and error it can be concluded that the model found cannot be relied upon to provide an overall prediction of students not meeting MCA standards in the Hennepin County using broadband access at home as a variable on pre-high school grade students due to the fact that broadband access was found to be only significant at the 5^{th} grade and not at the 8^{th} grade. However, this model can still be used when there is the need to evaluate the impact of broadband access on students' performance at the elementary level as prescribed by Rosenshein *et al.* (2011).

References

Bair, R., and Stafford, T. 2016. Connected and Ubiquitous: A Discussion of Two Theories That Impact Future Learning Applications. *Tech Trends: Linking Research & Practice to Improve Learning*, *60*(2), 129-135.

Bauer, J.M., Berne, M., and Maitland, C. F. 2002. Internet Access in the European Union and in the United States. *Telematics and Informatics*, *19*(2), 117-137.

Center for Rural Policy and Development. 2012. Minnesota Internet Survey. *Digital Divide and Beyond.*

Correa, T., Pavez, I., and Contreras, J. 2017. Beyond access: A Relational and Resource-Based Model of Household Internet Adoption in Isolated Communities. *Telecommunications Policy*.

Dunst, C.J., and Hamby, D.W. 2016. Effects of Cumulative Family Risk Factors on American Students' Academic Performance. *4*(2), 150-154.

Erdogdu, F., and Erdogdu, E. 2015. The Impact of Access to ICT, Student Background and School/Home Environment on Academic Success of Students in Turkey: An International Comparative Analysis. *Computers & Education*, *82*, 26-49.

Fairlie, R.W., and Robinson, J. 2013. Experimental Evidence on the Effects of Home Computers on Academic Achievement among Schoolchildren. National Poverty Center Working Paper Series 13-02.

Gale, J.J., and Bishop, P.A. 2014. The Work of Effective Middle Grades Principals: Responsiveness and Relationship. *Research in Middle Level Education Online*, *37*(9), 1-23.

Greenhow, C., Walker, J.D., and Kim, S. 2010. Millennial Learners and Net-Savvy Teens? Examining Internet Use among Low-Income Students. *Journal of Computing in Teacher Education*, *26*(2), 63-68.

Grubesic, T.H., and Murray, A.T. 2002. Constructing the divide: Spatial Disparities in Broadband Access. *Papers in Regional Science*, *81*(2), 197.
Hisham, J.B. 2016. Factors affecting demand for Internet Access in Saudi Arabia. *Eurasian Journal of Business and Management, 4*(3), 29-38.
Jing, L., and Jingye, Z. 2012. Digital Divide: How Do Home Internet Access and Parental Support Affect Student Outcomes? *Education Sciences, 2*(1), 45-53.
Lacour M., and Tissington, L.D. 2011. The Effects of Poverty on Academic Achievement. *Educational Research and Reviews*, *6*(7), 522-527.
Mossberger, K., Tolbert, C.J., Bowen, D., and Jimenez, B. 2012. Unraveling Different Barriers to Internet Use: Urban Residents and Neighborhood Effects. *Urban Affairs Review, 48*(6), 771-810.
Okilwa, N.A. 2016. Exploring School- and Home-Related Protective Factors for Economically Disadvantaged Middle School Students. *Journal of At-Risk Issues*, *19*(1), 34-46.
Rosenshein, L., Scott, L., and Pratt, M. 2011. Finding a Meaningful Model This Checklist Will Help You Evaluate Regression Models. *ArcUser*. ESRI, Redlands, CA. 40-45.
Stewart, E.B. 2008. School Structural Characteristics, Student Effort, Peer Associations, and Parental Involvement: The Influence of School- and Individual-Level Factors on Academic Achievement. *Education & Urban Society*, *40*(2), 179-204.
Thigpen, T. S. 2015. Bridging the Connectivity Gap in our Nation's Schools. *Kennedy School Review*, 95.
United States Census Bureau. 2017. https://www.census.gov/quickfacts/fact/table/hennepincountyminnesota,mn/PST045217.
Uline, C., and Tschannen-Moran, M. 2008. The walls speak: The Interplay of Quality Facilities, School climate, and Student Achievement. *Journal of Educational Administration*, *46*(1), 55-73.
Vigdor, J.L., Ladd, H.F., and Martinez, E. 2014. Scaling the Digital Divide: Home Computer Technology and Student Achievement. Economic Inquiry, *52*(3), 1103-1119.

Appendix A. A summary of significance of independent variables at 5th grade. The % negative and %positive indicates the possible relationship the variables have with the candidate variable; percentage of students not meeting MCA standards in the 5th grade.

Variable	% Significant	% Negative	% Positive
Speaks less English	98.79	0	100
Families below poverty line	96.98	0	100
No High School Education	94.62	0	100
Rented Home	85.59	0	100
Cash Public Assistance	79.65	0	100
Food Stamps	74.67	3.61	96.39
Grade 1 to 8 Enrollment	62.35	99.16	0.84
Parents Employment	46.76	13.04	86.96
Multi-Family Units	44.03	0.16	99.84
Female Head of Household	36.87	14.31	85.69
Broadband Access	26.73	18.61	81.39
Male Head of Household	15.93	67.92	32.08
Family Size	13.6	68.51	31.49
Foreign Born	9.8	46.36	53.64
Lacking Kitchen	9.65	20.78	79.22
Lacking Plumbing	3.67	64.16	35.84
Children under Care of Grandparents	0.53	67.7	32.3

Appendix B. A summary of significance of independent variables at 8th grade. The % negative and %positive indicates the possible relationship the variables have with the candidate variable; percentage of students not meeting MCA standards in the 8th grade.

Variable	% Significant	% Negative	% Positive
Families below poverty line	99.5	0	100
Speaks less English	96.33	0	100
No High School Education	95.52	0	100
Rented Home	79.4	0.28	99.72
Food Stamps	74.64	1.9	98.1
Cash Public Assistance	63.94	0	100
Grade 1 to 8 Enrollment	46.98	96.02	3.98
Female Head of Household	37.83	11.92	88.08
Lacking Kitchen	25.33	0	100
Family Size	19.7	78.1	21.9
Foreign Born	14.53	76.57	23.43
Children under Care of Grandparents	13.66	4.32	95.68
Parents Employment	11.76	26.63	73.37
Multi-Family Units	10.86	43.84	56.16
Broadband Access	9.65	59.74	40.26
Male Head of Household	5.79	33.17	66.83
Lacking Plumbing	5.32	66.09	33.91

Appendix C. Table of models found after exploratory regression with corresponding values of adjusted R squares, Aikake's coefficient (AICc), Jarque-Bera statistic (JB), Koenker statistic (BP), variable inflation factor (VIF) and spatial autocorrelation (VIF) with the selected model shaded in grey.

AdjR2	AICc	JB	K(BP)	VIF	SA	Model
0.90	264.43	0.59	0.61	5.00	0.13	-FEMALW_HHH** +LESS_ENG*** +PARENTS_IN*** +CASH_PUBLI*** +FAMILIES_B***
0.90	264.81	0.63	0.15	4.95	0.32	-FAMSIZE** +LESS_ENG*** +PARENTS_IN*** +CASH_PUBLI** +FAMILIES_B***
0.90	265.24	0.59	0.39	5.14	0.55	+LESS_ENG*** +PARENTS_IN*** +CASH_PUBLI** +FAMILIES_B*** +RENTED_HOM**
0.89	269.31	0.36	0.76	4.90	0.56	+LT_9THGRAD*** +LESS_ENG*** +PARENTS_IN*** +CASH_PUBLI*** +RENTED_HOM***
0.89	269.44	0.52	0.10	3.72	0.22	-FAMSIZE*** +LT_9THGRAD*** +LESS_ENG*** +PARENTS_IN*** +CASH_PUBLI***
0.88	272.08	0.26	0.59	3.96	0.29	+LT_9THGRAD*** +LESS_ENG*** +PARENTS_IN*** +CASH_PUBLI*** +MULTI_UNIT**
0.88	273.74	0.63	0.95	2.55	0.12	-MALE_HHH** +LT_9THGRAD*** +PARENTS_IN** +CASH_PUBLI*** +RENTED_HOM***
0.88	274.29	0.59	0.14	3.41	0.31	-FAMSIZE** +LT_9THGRAD*** +LESS_ENG*** +CASH_PUBLI*** +MULTI_UNIT**
0.88	275.71	0.68	0.13	2.99	0.36	+GRANDPAREN** +LESS_ENG*** +PARENTS_IN*** +FOOD_STAMP*** +MULTI_UNIT**
0.88	275.72	0.64	0.11	2.77	0.36	-FAMSIZE** +LESS_ENG*** +PARENTS_IN*** +FOOD_STAMP*** +MULTI_UNIT**
0.87	277.82	0.63	0.43	2.65	0.77	+GRANDPAREN** +LESS_ENG*** +PARENTS_IN*** +CASH_PUBLI*** +MULTI_UNIT***
0.86	281.30	0.62	0.31	2.64	0.83	+GRANDPAREN** +LESS_ENG*** +PARENTS_IN*** +CASH_PUBLI*** +SUM_BB_AVE**
0.85	285.66	0.83	0.16	3.57	0.71	+FEMALW_HHH** -FAMSIZE** +LT_9THGRAD*** +LESS_ENG*** +MULTI_UNIT**
0.85	287.27	0.51	0.17	3.73	0.78	-FAMSIZE** +LT_9THGRAD*** +LESS_ENG*** +PARENTS_IN** +MULTI_UNIT**
0.81	297.77	0.43	1.00	1.79	0.52	+GRANDPAREN** +LESS_ENG*** +PARENTS_IN*** +LACKING_KI** +MULTI_UNIT***
0.81	298.62	0.85	0.69	2.46	0.96	+FEMALW_HHH** +GRANDPAREN** +LESS_ENG*** +PARENTS_IN*** +MULTI_UNIT***
0.80	300.67	0.69	0.77	1.78	0.66	+MALE_HHH** +GRANDPAREN** +LESS_ENG*** +PARENTS_IN*** +MULTI_UNIT***
0.80	300.81	0.48	0.90	1.78	0.79	+GRANDPAREN** +LESS_ENG*** +PARENTS_IN*** +LACKING_KI**

AdjR2	AICc	JB	K(BP)	VIF	SA	Model
						+SUM_BB_AVE**
0.80	302.29	0.82	0.36	2.41	0.61	+FEMALW_HHH** +GRANDPAREN** +LESS_ENG*** +PARENTS_IN*** +SUM_BB_AVE**
0.73	317.83	0.25	0.02	2.38	0.23	+FEMALW_HHH** -FOREIGN_BO*** +PARENTS_IN** +RENTED_HOM*** +MULTI_UNIT***
0.73	318.47	0.43	0.01	2.84	0.62	+FEMALW_HHH** +FAMSIZE** -GRADE_18_E** +PARENTS_IN** +RENTED_HOM***
0.73	318.84	0.34	0.04	2.21	0.25	+FEMALW_HHH** -FOREIGN_BO*** +PARENTS_IN** +RENTED_HOM*** +SUM_BB_AVE**
0.69	324.66	0.90	0.19	1.75	0.41	+MALE_HHH** -FOREIGN_BO*** +PARENTS_IN** +RENTED_HOM*** +SUM_BB_AVE***
0.69	325.17	0.93	0.10	1.83	0.58	+MALE_HHH** -FOREIGN_BO*** +PARENTS_IN*** +RENTED_HOM*** +MULTI_UNIT***

FEMALW_HHH = Female Head of Household, LESS_ENG = Speaks less English, PARENTS_IN = Parents, Employment, CASH_PUBLI = Cash Public Assistance, FAMILIES_B = Families below poverty line, FAMSIZE = Family Size, RENTED_HOM = Rented Home, LT_9THGRAD = No High School Education, MULTI_UNIT= Multi-Family Units, FOOD_STAMP= Food Stamps, GRANDPAREN = Children under Care of Grandparents, SUM_BB_AVE = Broadband Access, LACKING_KI = Lacking Kitchen, FOREIGN_BO = Foreign Born, MALE_HHH = Male Head of Household

Appendix D. A table of the coefficients of each independent variable and, the coefficient of intercept, Jarque-Bera statistic and adjusted R square for the model for subjects at 5th grade.

Variable	Math	Reading	Science
Intercept	-24.861*	-21.438*	-22.714*
Living with grandparents	0.085	0.090*	0.118
Speak less English	1.623*	1.128*	1.771*
Parents employed	0.341*	0.279*	0.300*
Cash public assistance	1.277*	1.207*	2.126*
Broadband access	0.012	0.014*	0.012
Adj R-Squared	0.777	0.815	0.892
Jarque-Bera	1.535	2.267	0.748

Significant at 95% *

Appendix E. A table of the coefficients of each independent variable and, the coefficient of intercept, Jarque-Bera statistic and adjusted R square for the model for subjects at 8th grade.

Variable	Math	Reading	Science
Intercept	-17.509	-30.756*	-30.537*
Living with grandparents	0.175*	0.258*	0.277*
Speak less English	1.852*	2.021*	2.632*
Parents employed	0.208	0.430*	0.395*
Cash public assistance	2.116*	1.649*	2.496*
Broadband access	0.005	-0.002	-0.005
Adj R-Squared	0.769	0.774	0.821
Jarque-Bera	0.234	1.610	2.541

Significant at 95% *