Design of a Prioritization Methodology for Equitable Infrastructure Planning

A Technical Report submitted to the Department of Systems Engineering

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Claire Lynn Miller

Spring, 2022

Technical Project Team Members

Rahul Dhansinghani

Ayman Ibrahim

Aditya Kannoth

Lena Nguyen

Steven Pham

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Reid Bailey, Department of Engineering Systems and Environment

Design of a Prioritization Methodology for Equitable Infrastructure Planning*

Rahul Dhansinghani, Ayman Ibrahim, Aditya Kannoth, Claire Miller, Lena Nguyen, Steven Pham, Professor Reid Bailey

Abstract— **Charlottesville City Schools, like many school districts around the country, is interested in expanding the number of children with safe routes to walk to school in response to bus driver shortages. However, there is currently not much walking infrastructure that allows elementary students to do so, and the city would like a way to prioritize infrastructure projects that meet current needs. This project aims to provide decision-makers with a methodology to assess the walkability of school districts in order to prioritize future infrastructure investments. The methodology, built with significant stakeholder involvement, is designed to be transparent to all stakeholders, easy to use, and built on sound decision theory principles while integrating equity in the decision process. The methodology consists of three phases. First, a geospatial information system (GIS) is used to identify areas with the greatest need based on the walkability of roads and socioeconomic factors within communities. Once areas in need have been identified, projects in these areas are compiled. The second step calculates a prioritization score to each project based on the calculated walkability improvement the project will have and how many people will be impacted by the project. The final step visualizes the prioritization score and cost of each project. The methodology was then evaluated against objectives that were determined in collaboration with the primary stakeholders that would be applying the method.**

I. INTRODUCTION

Due to the COVID-19 pandemic, Charlottesville City Schools experienced a serious shortage of bus drivers and buses. School districts across the country are facing similar issues and have struggled to transport all students to and from school [1] [2]. Some temporary solutions that districts have implemented included walking school buses, where a group of children can walk to and from school with one or more adults. Some districts have even had to call in members of the National Guard to assume bus driver positions [3]. Improving infrastructure for walking to school has received increased attention due to these shortages. At the same time, the movement to make communities more walkable and bikeable is gaining popularity. Many benefits for individuals that come from having multimodal options include a decrease in transportation costs, a healthier lifestyle, and a higher quality of life. *Safe Routes to School* is a program that is specifically focused on creating safer walking and biking routes for students [4]. There are many cities that have a coordinator to advance the goals of this program, including the City of Charlottesville.

*Research supported by the University of Virginia School of Engineering.

All authors are with the University of Virginia School of Engineering, Charlottesville, VA 22901 USA

To reduce busing demand, the Charlottesville City Schools and Safe Routes to School coordinator want to enhance the walking infrastructure to encourage school children to take alternative transportation modes. From a survey conducted in 2012 for Clark Elementary School, a school within the city, a majority of parents cited a lack of connectivity in existing infrastructure as a reason for not allowing their kids to walk to school [5]. Infrastructure is also the major predictor for whether a person will choose to walk or bike instead of driving [6]. Therefore, building safer and more comfortable infrastructure is an important step in encouraging students to walk or bike to school. The primary objective of this project is to use Charlottesville as a case study for developing an infrastructure prioritization process for school walkability projects.

II. LITERATURE REVIEW

There are three main focus areas to this project that require an in-depth analysis: other projects that measure and improve walkability, the approaches to equity and human rights concerns of those projects, and the use of geospatial information systems (GIS) within those projects.

A. *Measuring and Improving School Walkability*

The Charlottesville Bicycle and Pedestrian Master Plan presents the city's current approach to improving infrastructure. The city conducted an analysis of the existing conditions and engaged with users in public meetings to determine three overarching trends for improvement: safety, connectivity, and multimodal support [7]. This project used the ActiveTrans Priority Tool (APT) to identify and rank the priority bicycle projects in the city. The APT is a step-by-step prioritization method for infrastructure improvements. The spreadsheet tool allows the user to select factors that represent their values, then weight these factors as they see fit by assigning a number zero through ten. The user then selects a number of variables to represent each factor, depending on what data is available. The advantages of the APT are its flexibility, user-friendliness due to a step-by-step approach, and transparency in score calculation. However, there are also some key limitations. The methodology does not provide a framework that focuses on walkability specifically to schools, and the vast number of variables available under each factor puts the burden on the user to decide which variables are most important. In addition, the weighting process does not make it clear to the user what trade-offs they are making between factors by assigning certain weights and double-counting is not prevented.

Another method that was evaluated was the Humboldt County priority tool. This study created and tested a regional

Safe Routes to School (SR2S) prioritization tool that streamlined the decision-making process and increased the capacity for effective programs and grant applications. The study created a county-wide inventory of the SR2S programs that outlined available resources, needs, and challenges of each school district. A point system was used to evaluate schools across each of these categories. Schools were then prioritized based on the number of total points they received. One important concept that emerged from the Humboldt Study is school-readiness, which assesses whether an infrastructure project is a good fit for a school based on the availability of existing SR2S programs [8]. The Study's prioritization approach also accounts for needs by assessing a school district's demographics, socioeconomic and physical environment. While the authors provide reasoning for some of the point allocations, the points allocated to each category seem arbitrary. This approach also was designed to choose one school that would then receive funding, not to prioritize projects spread across a number of schools.

Moudon et. al. used stepwise regression to create a walkability score and a walking potential score for each school in the state using several built-environment predictors like vehicular traffic exposure and residential density. For the walking potential score, socioeconomic predictors like school lunch percentage were also included. A number of factors encouraging children to walk to school included lower traffic exposure, higher sidewalk prevalence, higher street connectivity, living within a mile of the school, and school encouragement [9]. This study was school-focused, had a sound approach to assigning weights, and incorporated equity by considering socioeconomic factors. However, it did not consider how to prioritize projects to increase a school's walkability. The most frequently used factors in the literature to measure walkability are summarized in Table I. A common theme that emerged was the separation of physical factors from social factors.

TABLE I. PHYSICAL/SOCIAL FACTORS AFFECTING WALKABILITY

Physical Factors	Social Factors
Traffic conditions [9, 4] • Speed limit [8], ped/bike collisions [9, 8] Crossing safety [4] • Type of crosswalk, crossing guard presence Sidewalk conditions [9] • Presence, width, continuity, obstructions Road connectivity [9] • Way of measuring route efficiency/directness Distance [9, 4] Pedestrian facilities [8] Bicycle facilities [8]	Time constraints [4] School readiness [8, 4] • Walking school buses, staff support, PTO interest, parent/school communication

B. *Equity in Infrastructure Planning*

The *Equity Transportation Scorecard* [10] introduces the concept of "communities of concern". The objective of the Scorecard was to identify key criteria that would assess projects based on their contribution to the transportation needs of underserved communities. The first step of this equity evaluation tool is to define and locate communities of concern (COCs) using GIS. The COCs are defined as census block groups within an area that have low scores across a range of socio-economic variables, including access to health care and job transit accessibility indices. The authors then devised a point-based system to score each project depending on its impact and the projects were ranked. In this work, we build on the communities of concern concept to identify specific areas that should be prioritized when comparing infrastructure projects.

The *Ottawa Neighborhood Equity Index Project Report* [11] produced a visualization of equity by census tract using a variety of indicators to calculate the equity index. The project chose 5 domains to represent equity – economic opportunity, social and human development, health, community and belonging, and physical infrastructure – and 17 indicators from the Canadian Census at the census tract level to represent each domain. The Ottawa project transformed the multidimensional dataset to a single composite index using a principal component analysis (PCA). PCA creates a principal component based on the relationship of the original variables to one another. This magnitude in variability is used to determine the appropriate weights for each variable's contribution to the new indicators. We build our equity work on the Ottawa Neighborhood Equity Index Project methodology, in particular on the five domains of equity and the usage of PCA to derive weights for each factor. The five domains provide a robust multidimensional view of equity as opposed to relying on just one or a few indicators while PCA provides a well-founded approach to identifying weights that connect those multiple dimensions to underlying relationships.

In *Equity in Neighborhood Walkability* [12], a study by the University of Nebraska Omaha, researchers studied the equity and walkability factors in Portland, Charlotte, and Pittsburgh with maps of each city distinguished with a variety of colors. A 3x3 matrix of different colors is used to indicate the shifts between the relationships. One axis of the matrix indicates social vulnerability and walkability on the other axis. This provided a good basis for a visualization that incorporated two important factors in the project.

III. METHODOLOGY

The development of this methodology centered around the city of Charlottesville as a case study and tailored to its unique needs. Charlottesville is a city located in central Virginia at the base of the Blue Ridge Mountains. The city is made up of about ten square miles and is home to 50,000 people, spread across 37 census block groups. According to data from 2021, fourteen percent of Charlottesville residents walk to work and three percent ride a bicycle. These activities are supported by over 30 miles of paved and unpaved trails around the city, some of which are used by families to get to and from school. The public school system has 4,000 students enrolled and is made up of six elementary schools, one upper-level elementary school, one middle school, and one high school. Because the city is home to many people who want access to infrastructure that supports walking and biking, this idea has been touched on in several planning documents - including the 2015 Bicycle and Pedestrian Master Plan, the 2016 Streets that Work Plan, and the 2021 Comprehensive Plan.

The Safe Routes to Schools coordinator and the city's Bike and Pedestrian Planner maintain a list of infrastructure projects targeting school walkability. However, the city as a whole does not take a school-focused approach when it comes to project planning. The process starts with compiling a list of projects that is based on regularly scheduled improvements as well as complaints that are brought in by residents. The projects on this list are then prioritized and rough plans are sketched in order to secure funding. Projects that are funded are then planned and constructed. The coordinator and city schools want a new method to prioritize projects that would focus specifically on increasing the number of children walking to school, unlike the method used in the city's 2015 Bicycle and Pedestrian Master Plan Update.

Four core characteristics for a robust prioritization approach were identified after significant stakeholder engagement. The tool should have an easy-to-use interface that provides adequate feedback and guides the user through the process. Provided instructions should be concise and supply appropriate troubleshooting advice. Transparency is implemented by communicating the results in simple terms to stakeholders and community residents. Focusing on equity is a critical component of the approach, as there are several traditionally underrepresented communities in the city. Lastly, the tool should yield measurable insights that inform decision makers on how specific infrastructure projects have made a meaningful difference within the community.

IV. Infrastructure Prioritization Approach

Based on the prior work, stakeholder input, and objectives, we iteratively developed a three-phase model to integrate equity into the school walkability prioritization approach.

The three steps are as follows:

1. *Identify areas of highest need* – Visually assess walkability and equity needs throughout the city to choose projects to prioritize within areas of highest need in the city of Charlottesville
2. *Rank projects within areas of highest need* – For all possible infrastructure projects within the highest need areas from Step 1, input project data, calculate prioritization scores based on their benefits (i.e., the potential impact on walkability) and their proximity to schools, and rank projects
3. *Visualize project rankings in context* – Display the top scoring projects from Step 2 to characterize their benefits in the context of cost and other factors such as school readiness

Step 1: Identify Areas of Highest Need

When considering which projects to prioritize, the city staff who would use this tool emphasized that they would like to choose projects that have an impact on places with existing poor walking infrastructure and focus on communities with the highest social need. This first step allows the user to examine the current social equity and walkability conditions throughout the city. This step is based on a visual assessment, instead of based on a computed score, in order to allow flexibility to choose projects based on the goals of the user. It also allows decision makers to more easily digest critical information.

ArcGIS was selected to create the map because of its robust geospatial processing and analytical capabilities. The map shows the location of the potential projects, location of each school, and the census block groups within each school district. The block groups are symbolized based on a 3x3 grid of colors, representing the relationship between low to high walkability on one axis and low to high areas of equity concern on the other (Fig. 1). The walkability for the block group is based on the average of all the walkability scores of each road segment within the block group.

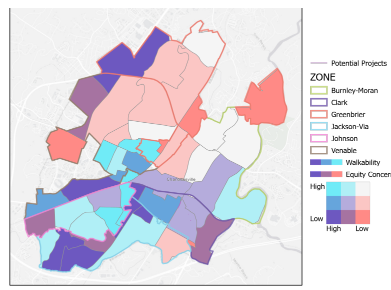

Figure 1. Visual Assessment Map

Once an area with high need has been visually identified, the user can view the walkability scores of individual road segments surrounding potential projects. The user can then select which projects they wish to prioritize in step two.

A. *Measuring Walkability*

The walkability score for each segment is derived from a demerit point system. It is designed to take into account five main factors: roadway classification, sidewalk presence, crosswalk characteristics, terrain, and traffic calming features. These factors were determined based on the literature review of other walkability studies, as well as what data would be available without requiring manual input from the user. The point system is designed to penalize segments that lack characteristics that make pedestrians feel safe while traveling. The system also rewards features that promote safety, such as pedestrian signs or flashing beacons. The flowchart (described below) was created to represent the logic used within ArcGIS to grade the walkability of each road segment. The point deductions outlined in the chart are also referenced to determine the projected change in walkability of an infrastructure project that is used in Step 2. First the road is classified as either local, collector, or arterial (Fig. 2).

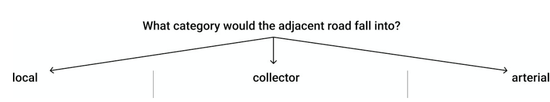

Figure 2. Road classification on walkability score flowchart

The categories are consistent across each type of road, but the point deductions double from local to collector, then again from collector to arterial. The point deductions increase in this way due to greater safety concerns on streets with more traffic and higher speed limits. Points are also deducted for segments that have a grade over five percent. There are point additions for features that increase safety along a segment (i.e., beacons, school zone signs, etc.). Points are also deducted for segments that have a grade over five percent. There are point additions for features that increase safety along a segment. Such features would include flashing beacons, school zone signs, pedestrian signs, mid-block crosswalks, etc.

Once the road is classified, sidewalk presence is determined. Fig. 3 shows the point deductions that would be applied on a collector road.

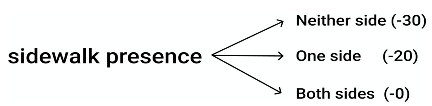

Figure 3. Sidewalk presence on walkability score flowchart

The next features assessed are signs and signals present at the ends of the segment where a pedestrian would have to cross the street. These are referred to as crossing characteristics, as shown in Fig. 4.

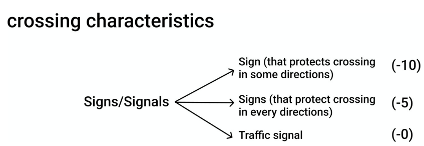

Figure 4. Crossing characteristics on walkability score flowchart

The final feature considered is what types of markings exist at the start and end of a road segment (Fig. 5).

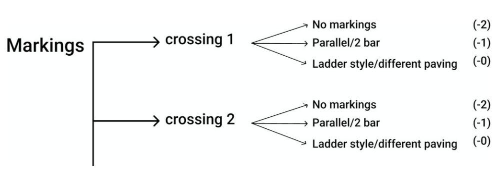

Figure 5. Markings on walkability score flowchart

There should be at least three of four possible crosswalks at each intersection to reach every possible direction. The tool considers whether or not an intersection meets this minimum as well as the type of marking.

The data for the walkability score factors come from multiple sources. The City of Charlottesville has an open data portal, which includes a "Road Centerlines" layer and a digital elevation model (DEM) that contains elevation point data. The Road Centerlines layer contains the functional classification of the roadway. In Spring 2017, a Safe Routes to School project was completed by a group of urban planning graduate students at the University of Virginia. Their dataset included sidewalks, crosswalks, and trails, and was based on 2015 data from the city and was augmented by adding additional street crossings and turning the sidewalks from polygons to polylines.

Using the scoring system described above, the walkability score for each road segment is calculated by ArcGIS. The segment scores are aggregated to calculate the average walkability score of each block group for each school district.

B. *Measuring Areas of Equity Concern*

Determining areas in need begins with the selection of appropriate equity factors, which were based on the Ottawa project. The factors are selected based on relevance in describing the aspects of equity, robustness or accuracy, and availability of data at the census tract and block group level. The domains are from the Ottawa project but different factors were used to depict the equity concern of Charlottesville. The data is from the 2015-2019 American Community Survey, a survey conducted annually by the US Census Bureau. That data is cleaned, transformed, and normalized for principal component analysis. Factors that have a positive relationship have a (+) sign whereas those with (-) sign have a negative relationship. The PCA is run in R, a statistical computing program. Three principal components accounted for 64% of the variance. The weight of each indicator is the sum of each absolute loadings multiplied by the variance, divided by the sum of all weights, shown in Table II below.

TABLE II. INDICATOR WEIGHTS AND CORRESPONDING EQUITY DOMAIN

Indicator	*Weight*	*Domain*	*Domain Weight*
% of Unemployed Population 16 Years and Over (-)	9.3%	Economic Opportunity	30.0%
% of Homeowners Who are Paying at Least 50% of Income on Mortgage (-)	10.9%		
% of Population in Poverty (-)	9.7%		
% of Population 25 Years or Over with Bachelor's Degree or Better (+)	9.6%	Social and Human Development	29.0%
% of Homeowners with 1 or More Vehicles (+)	10.0%		
% of Homes at or Above Charlottesville Median Home Value (+)	9.4%		
% of Children Under 18 Living with Single Parents (-)	10.5%	Community and Belonging	20.1%
% of Population Living in the Same Household for 8+ Years (+)	9.6%		
% of Population that Bike, Walk, or Use Public Transportation Regularly to Commute to Work (+)	9.9%	Physical Environment	20.9%
% of Population with 30 Minute and Over Commute Time (-)	11.0%		

The indicator weights are multiplied by the standardized data for each indicator to get a weighted score for each census block group. The weighted score is on a scale of 0 to 100. These scores are used to represent the intensity of inequity on a heat map in ArcGIS in which an area with darker shade would indicate an area of lower score, or high inequity concern.

Once the walkability and equity scores have been computed, they are then symbolized for each block group within each school district based on a 3x3 quantile grid of the relationship between the two scores. One axis represents walkability and the other represents equity concern. The location of each elementary school and potential infrastructure projects are also shown over the block group visualization. The user can then choose an area to focus on based on their goals. One possible goal would be to focus primarily just on low walkability areas to alleviate strain on the buses - allowing those who need bus transportation the most to have access. Once areas have been identified, the user can zoom in to view the walkability of each road segment that are near the potential projects. They can then select all or certain projects within the areas to be prioritized in Step 2.

Step 2: Rank projects within areas of highest need

Step 2 focuses on ranking the individual infrastructure projects in high-need census blocks. Projects are ranked according to their impact on walkability and their proximity to a school. Proximity to a school is the Manhattan distance that the project is from the nearest school. It was selected as a proxy for the number of people that will be positively affected by the project in their walk to school.

Improvement in walkability and proximity to a school are calculated through the ArcGIS platform. Following the selection of census blocks in Step 1, a custom Web App allows for potential projects to be inputted into ArcGIS in which the user selects the location of the project and is prompted to enter characteristics: name of the project, the type of project, and its projected total cost. The increase in walkability of each project is calculated in ArcGIS using the framework provided in the walkability flow chart. School proximity is also measured in ArcGIS. The project data is exported from ArcGIS into Microsoft Excel where the priority score for each project is calculated.

To calculate the priority score, the walkability and proximity metrics are linearly normalized and then summed. Walkability improvement is normalized from 0 to 60 (higher is better) while school proximity is normalized from 0 to 1.5 miles (closer to school is better). The upper bound of walkability improvement is determined by the maximum point increase on the walkability flow-chart, and the school proximity bound was set based on the furthest distance a student would likely walk from. This range establishes a trade-off of 1 additional mile in exchange for a 40-point walkability increase. This trade-off was decided based on stakeholder discussions and comparison of potential projects, and could easily be adjusted as the user sees fit and as needs change.

Step 3: Visualize project rankings in context

The top scoring projects are compiled on one interactive dashboard used to direct the attention of decision-makers to key information. The decision to integrate cost into Step 3 instead of directly into the priority score is based on talks with key stakeholders. Showing each project's potential benefit separately from the cost better matches the realistic, unique aspects of each funding source. Integrating cost into the priority score would have assumed a linear trade-off between dollars of project cost and the two other measures, walkability improvement and school proximity. Funding sources, however, are not linear. They each have their own maximum budgets and particular goals, some require cost matching, etc. The dashboard includes a table showing values of change in walkability scores, distance from school, priority, as well as an inclusion of projected cost and the school district it impacts. The user can sort by any of these metrics.

TABLE III. PROJECT PRIORITIZATION TABLE WITH COST ESTIMATES AND FINAL PRIORITY SCORES

Top 5 Projects Based on Priority Score	Distance (miles)	Change in Walka-bility	Cost ($)	Priority Score	School
Project A	0.08	40	$7,550	1.84	Buford
Project B	0.07	25	$25,313	1.51	Walker
Project C	0.01	15	$9,000	1.33	Clark
Project D	0.01	15	$300	1.33	Clark

Additionally, a user can generate visualizations with the click of a button. The visualizations allow the user to compare project impact alongside equity and cost (Fig. 6).

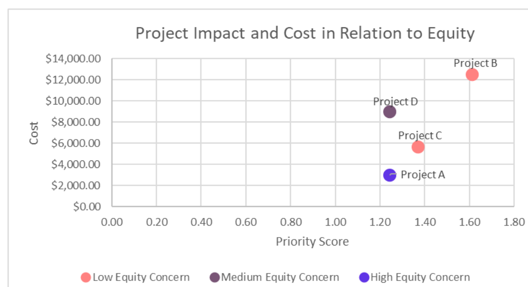

Figure 6. Project impact, cost, and block equity visualization

The visualization was the selected option for the demonstration of the various projects as it clearly presents the project's priority score and cost in the various equitable areas. The visualization is clear and informative with limited confusion and at the same time allows the user to present the visualization as a justification for the projects the user selects.

V. DISCUSSION

The aim of the three-step approach is to provide an effective way to prioritize school walkability projects in terms of usability, transparency, equity, and measurability. In this section, we evaluate the approach against each of these objectives. To make the method user-friendly, one goal was to minimize the need to manually collect and input data. This is why the first and second steps of the method use data that is available publicly (demographic data from the census, road segments, and sidewalks) or that has already been collected by the city (crosswalks and traffic controls). The process was also automated as much as possible for the user. This includes auto-filling data and automatically calculating priority scores. The user is then able to create visualizations of the analysis run by the tool with a few clicks. These visualizations make it easier for the user to compare projects, in addition to providing the user with a resource to explain to other stakeholders why certain projects should be prioritized.

Equity was intentionally set apart from other factors used to compare and prioritize projects in this method. By incorporating equity at an earlier stage, it plays a bigger role in shaping which areas are considered for funding. This is why the first step in the method is a visual assessment based on the level of equity concern and current walkability across different areas of the city. A project that is not in a high need area will not make it to the second step (where projects are prioritized), thereby ensuring that projects that have the potential to be funded are located in areas that really need it. A non-compensatory decision approach in Step 1 means that equity cannot be traded-off with the other factors.

It was also important for the method to produce measurable results. Part of this objective is predicting how different projects could affect the community. The priority score assigned in Step 2 achieves this by ranking projects according to the change in walkability along with their distance from the school. This approach has limitations in terms of measurability and what types of projects can be prioritized due to data availability and complexity. Projects such as reconfiguring street design (e.g., closing a slip lane), or simple infrastructure additions (e.g., bike parking) cannot currently be evaluated with this approach. These limitations were the result of prioritizing user-friendliness - in order to make the approach easily adoptable it utilizes data that the user does not have to manually collect, which would be required in the projects mentioned above.

VI. CONCLUSION

This project used Charlottesville, Virginia as a case study to develop an equitable infrastructure prioritization process that focused on increasing walkability to and from schools. The development of this prioritization approach was completed in several iterations, and incorporated the feedback of a variety of stakeholders throughout the Charlottesville community. The three-step prioritization approach includes the identification of the areas of highest need (based on current walking conditions and equity concerns), the calculation of a prioritization score for proposed projects, and the visualization of the top scoring projects. This process allows for an equitable approach to building infrastructure in the city of Charlottesville, and can be extended for use in other similar municipalities. The application of this methodology will ideally help alleviate strain on the bus system in the short term, and in the long term provide new resources to areas of high need within the city.

ACKNOWLEDGMENT

The capstone team would like to thank Kyle Rodland and Amanda Poncy of the City of Charlottesville, Kimberly Powell and Beth Baptist of the leadership team of the Charlottesville City Schools, Principal Muggsie Marini, Assistant Principal Juanita Eddy and the Parent-Teacher Organization of Clark Elementary School, Professor Andrew Mondschein of U.Va. School of Architecture, Professor Julianne Quinn of the U.Va. Department of Engineering Systems, Chris Gist and Drew MacQueen of U.Va. Scholars' Lab, Peter Ohlms of the Virginia Department of Transportation, and the community representatives of the Friendship Court Apartments.

REFERENCES

[1] Wright, A. (2021). *Bus driver shortage stresses rural school districts*. The Pew Charitable Trusts. Retrieved April 8, 2022, from https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2021/10/11/bus-driver-shortage-stresses-rural-school-districts

[2] Solochek, J. S. (2022). *Ongoing school bus driver shortage sparks route cancellations*. Tampa Bay Times. Retrieved April 8, 2022, from https://www.tampabay.com/news/education/2022/04/01/ongoing-school-bus-driver-shortage-sparks-route-cancellations/

[3] CBS Interactive. (2022). *School bus driver shortages affecting families across the country*. CBS News. Retrieved April 8, 2022, from https://www.cbsnews.com/news/school-bus-driver-shortage-national-guard/

[4] *Safe routes*. Safe Routes: National Center for Safe Routes to School. (2016). Retrieved April 8, 2022, from https://www.saferoutesinfo.org/

[5] City of Charlottesville. (2012, December). Safe Routes to School travel plan: Clark Elementary. Retrieved October 12, 2021, from https://drive.google.com/file/d/1PA1gxd6ZjNnnCWafojf -tHDsVvjVfEld/view?usp=sharing.

[6] Talen, E., & Koschinsky, J. (2013). The walkable neighborhood: A literature review. *International Journal of Sustainable Land Use and Urban Planning*, *1*(1). https://doi.org/10.24102/ijslup.v1i1.211

[7] City of Charlottesville. (2015, September). 2015 Bicycle and pedestrian master plan update. Retrieved October 13, 2021, from https://www.charlottesville.gov/DocumentCenter/View/1203/Master-Plan-Implementation-Progress-Update-PDF?bidId=.

[8] Sinkhorn, E., Weiss, J., Dickman, D., & Salomone, T. (2012). *HCAOG Regional Safe Routes to Schools Prioritization Tool*. Humboldt County Association of Governments. Retrieved March 24, 2022, from https://hcaog.net/documents/safe-routes-school-whats-happening-humboldt

[9] Moudon, A. V., Shi, X., & Chen, Y. (2020). *Washington State School Walk Score*. University of Washington ResearchWorks Archive. Retrieved March 24, 2022, from https://digital.lib.washington.edu/researchworks/handle/1773/45599

[10] Williams, K. M., Kramer, J., Keita, Y., & Boyd, T. (2020, June). *Transportation Equity Scorecard – A Tool for Project Screening and Prioritization*. USF Center For Urban Transportation Research.

[11] Krapp, A., Barajas, J. M., & Wennink, A. (2021). Equity-oriented criteria for Project Prioritization in Regional Transportation Planning. *Transportation Research Record: Journal of the Transportation Research Board*, *2675*(9), 182–195. https://doi.org/10.1177/03611981211001072

[12] *Ottawa Neighborhood Equity Index*. Social Planning Council of Ottawa. (2021). Retrieved April 8, 2022, from https://secureservercdn.net/104.238.71.140/r3s.8d0.myftpupload.com/wp-content/uploads/2021/02/NEI-Report-Feb-22-2001.pdf

[13] Bereitschaft, B. (2017). Equity in neighborhood walkability? A comparative analysis of three large U.S. cities. *Local Environment*, *22*(7), 859–879. https://doi.org/10.1080/13549839.2017.1297390