An Analysis of Learning Landscapes

Lessons Learned for a National Movement

December 2023

Autocase

Economic Advisory

BIG SANDBOX

building healthy neighborhoods

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Grant Report

Prepared For
The Children & Nature Network

Prepared By

BIG SANDBOX
building healthy neighborhoods

Autocase
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PROJECT TEAM

The multi-sectoral and multidisciplinary team includes: Autocase™ (created by Impact Infrastructure) and their professionals across North America who are known for best-practice cost-benefit analysis approaches and tools that involve all facets of infrastructure development; Professor Lois Brink with 20 years of experience with the implementation and research of Learning Landscapes (LL); Peter Anthamatten, fellow LL researcher and Chair of Geography and Environmental Sciences at University of Colorado Denver supporting data analyses from the previous NIH & RWJF grants. Peter and Lois have co-authored papers on LL and the results from RWJF & NIH grants; and, Josh Griesbach, senior facility planner with DPS. Josh was our POC with the district.

ACKNOWLEDGMENTS

Additional support provided by the Denver Public School District.
Thank you for your guidance and sharing information included in this report.

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The project team is grateful for the valuable information and insights provided by staff at the Colorado Department of Education.

learning landscapes
building community through play

Cover photo: Harrington Elementary Banners 2012

Contents

1. Executive Summary

Schools are vital infrastructure for healthy, flourishing communities, and are essential to improving quality of life for city residents. In this report, Autocase, the Big SandBox and the Children and Nature Network, in partnership with Denver Public Schools (DPS), used a statistical regression analysis to determine actual outcomes using quantitative data from DPS and the Colorado Department of Education to determine benefits of the Learning Landscapes (LL) program, a large scale green schoolyard conversion project. From 2000 to 2012, Denver Public Schools (DPS) converted 99 elementary schoolyards encompassing 306 acres to Learning Landscapes. This report leverages empirical data to evaluate and generate quantitative insights on outcomes of green schoolyard projects. Results from the economic benefits analysis suggest that Learning Landscapes provide the following benefits:

Learning

- **7% statistically significant decrease in student mobility rate** which is equivalent to cutting the district wide elementary school student mobility rate by as much as one-third.

- **8.5% statistically significant increase in math growth annually.**

- **5.5% statistically significant increase in writing growth annually.**

- **.12% statistically significant increase in student performance framework annually.**

- **.01% statistically significant reduction in the truancy rate annually,** which is equivalent to over 700 less unexcused absence days.

Environment

- **15 degree reduction in the average ambient temperature during summer months** due to increased tree canopy and vegetation.

- **1,284 tons of carbon sequestered annually across all converted schoolyards.**

- **404 lbs of air pollutants removed annually across all converted schoolyards.**

Each of these contribute to climate change adaptation and resilience and stronger community health.

Economics

- **An annual average of $1,341,777 revenue increase** in state funding for 152 new students enrolled. Increase student enrollment is evident in both the longitudinal and cross sectional analyses.

- **Learning Landscapes cost $630,012(ave.) or $2.54 sq. ft. ($2022)** New funding from voter-approved general obligation bonds account for 80% of LL funding and the remainder is from public/ private partnerships.

- **Leveraging funds — Every $1 spent on a Learning Landscape $25** were realized for much needed deferred capital projects and education needs. Anecdotal evidence suggest LL is a highly visible and popular project among voters.

Students' garden at Steck Elementary. Source UCD.

Health & Wellness

- **Learning Landscapes catalyst for district farms.** By 2012, LL's were at every elementary school and DPS launched its farm program. Farm annual revenue averaged $85,000 from 2012 — 2017.

- **Over 55% of Learning Landscapes have school gardens.** In 2012, only 10% of schools had gardens. With growing awareness around fresh produce, the district installed a salad bar at every school that same year. In 2022, **12,250 lbs of produce was donated.**

- **13 Learning Landscapes have a garden to cafeteria program.** Student-grown vegetables are sold to their cafeteria. Revenue in 2019 was $321/school. These funds are used by students to sustain their gardens.

These significantly positive findings demonstrate the tipping point a green schoolyard can have when scaled across a district. DPS is an enthusiastic partner on this project. The district has a vested interest in understanding the impact of the Learning Landscapes as it continues to secure maintenance funds internally to sustain its green schoolyards.

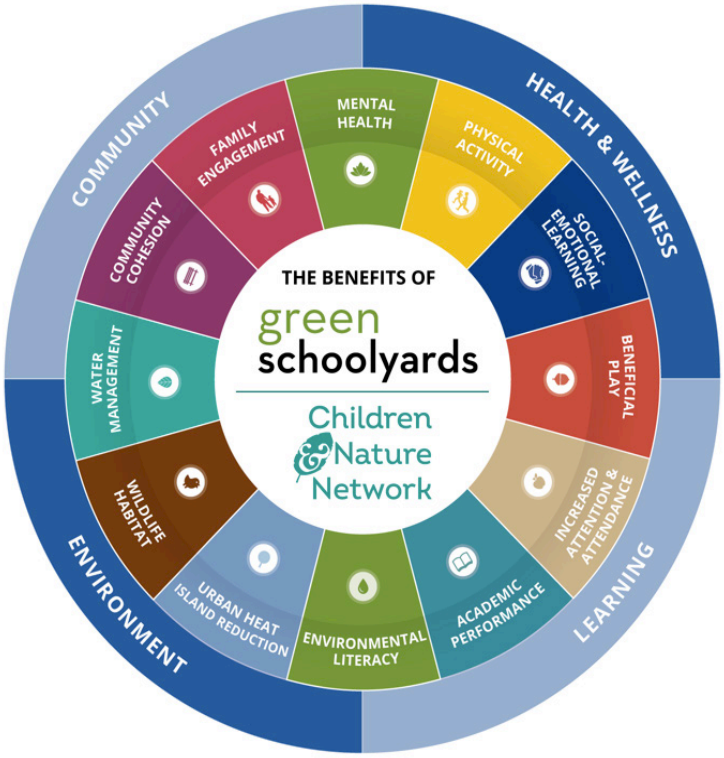
Learning Landscapes are an asset that benefits the broader community and are included as "breathing spaces" in Denver's Parks and Recreation Master Plan. By creating a shared understanding of the economic, social, and community value of green schoolyards, stakeholders within the community, district, and state can advocate for and integrate green schoolyards into capital planning and budgeting processes.

Pre and Post Schoolyard Photos of McGlone Elementary Learning Landscapes

2. Introduction

2.1 Background/Overview

The Children and Nature Network (C&NN) defines green schoolyards as multi-functional school grounds designed for and by the entire school community that include places for students, teachers, parents, and community members to play, learn, explore, grow, and connect. During the out-of-school time, these schoolyards are ideally open for community use. Green schoolyards might include outdoor classrooms, native and pollinator gardens, stormwater capture, nature play areas, traditional play equipment, edible gardens, trails and paths, trees and shrubs, and more[1].



Source: Children & Nature Network

This platform serves as the project's launch point for analyzing Learning Landscapes's (LL) economic benefits. The LL program, completed in 2012, is a district-wide schoolyard greening project (99 K-8 schoolyards) in the Denver public school system. These impacts can be sorted into occupant (students and staff) and community (neighborhood, municpality, and climate) impacts.

An initial literature review and an inter and intra-district economic benefits valuation determined the range of outcomes and potential "data buckets". This was followed by data collection and statistical analysis. The value of this undertaking is leveraging empirical data and generating quantitative insights to support scaling the development of green schoolyards across the country.

The research questions for this analysis are:

1. What quantifiable economic outcomes related to LL's are statistically significant?

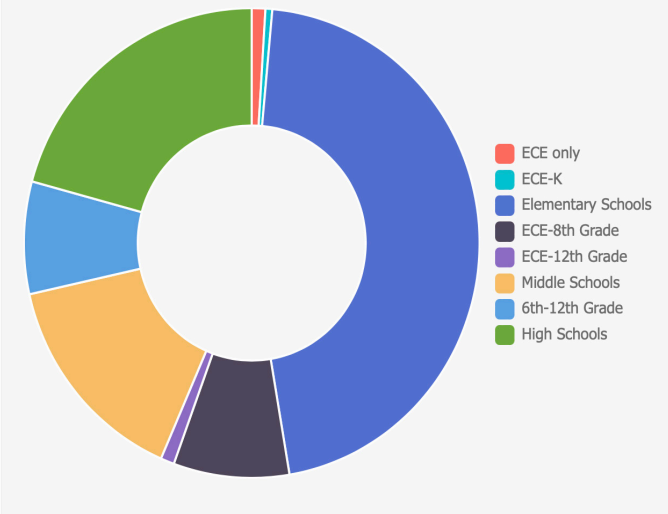
2. What are the long-term implications of schoolyard greening interventions on student outcomes and health and well-being ?

3. What quantitative/deterministic analysis can be conducted from the additional data gathered during this project?

2.2 Study Focus - Learning Landscapes

Denver Public Schools' district boundaries align with the city and county of Denver and is home to 90,250 students (October 2021). Facility Management maintains over 16 million square feet of enclosed building space at 207 schools, and just under 2,000 acres. As is illustrated below, the majority of the schools are elementary.

Breakdown of Student Population by Grade



Source: Denver Public Schools Website. 2023

DPS Pupil membership includes 72% English language learners (primarily Spanish-speaking students) with 59% of students eligible for Free/Reduced-Price Lunch. Gifted and Talented students account for 8% of the student body and students with disabilities make of up 12%. (DPS)

Learning Landscape schoolyards challenge the concept of traditional schoolyards with designs reflecting the unique culture and history of the people, the school, and the neighborhood it serves while providing opportunities for physical activity, socialization and creative play. On Learning Landscape schoolyards, students interact with educational elements such as fractions, historical timelines, common words, and quotes to help students learn as they play. Learning Landscape schoolyards are neighborhood parks used by the community on weekends and after school. The community is involved in all phases of development, building and stewardship of the Learning Landscape. The many people participating in Learning Landscape projects sends the essential message to the children and families of each community "We believe in you!"

Distinctive Elements of LL Schoolyards:

- Community gateways and gathering spaces with custom shade structures

- Colorful structured & unstructured asphalt games

- Age-appropriate play equipment

- Outdoor classroom and STEM elements

- Grass playing fields

- Public & student art

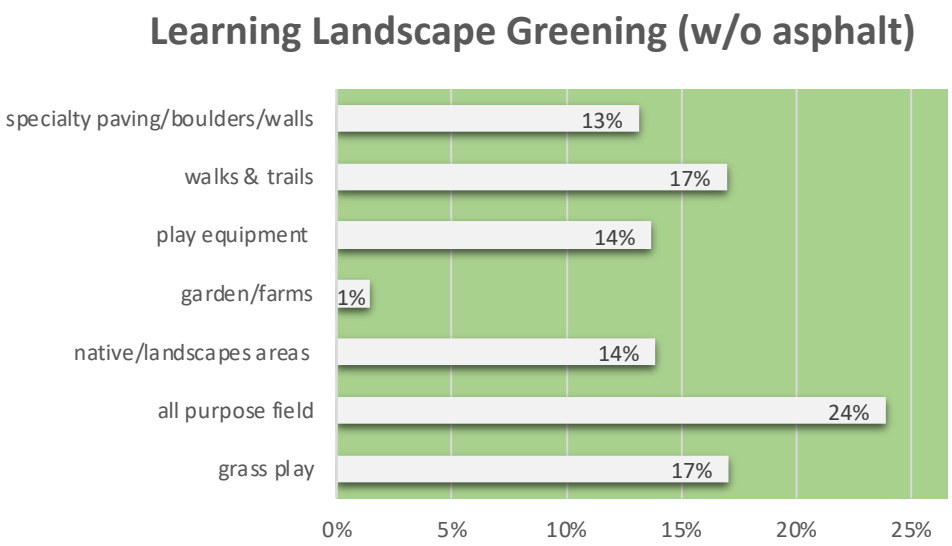
- Vegetable gardens

- Habitat areas/nature play

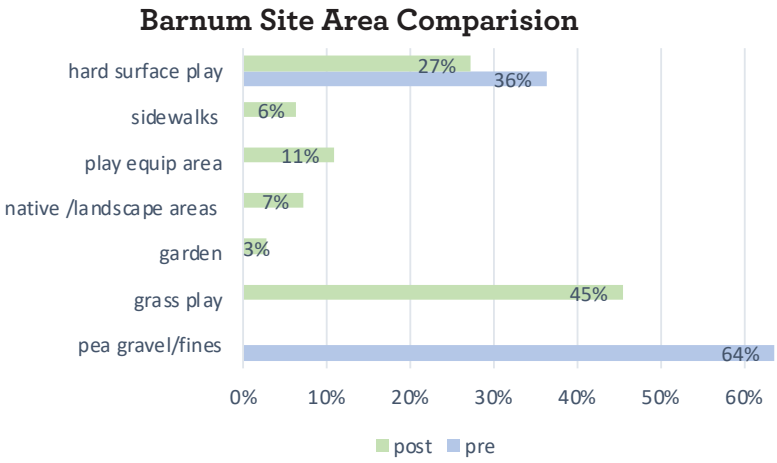
Students reading in their outdoor classroom at Harrington Elementary. 2012. Credit UCD

The LL district-wide schoolyard greening project encompasses 306 acres. Prior to Learning Landscape conversions, surfaces categorized as impervious or hard comprised 90% of an average schoolyard; pervious or soft surfaces comprised 10.2%.

After the conversions, the average pervious vegetative surfaces comprised 51% of an average schoolyard, pervious or soft surface 18%, while impervious or hard surface comprised only 31%.

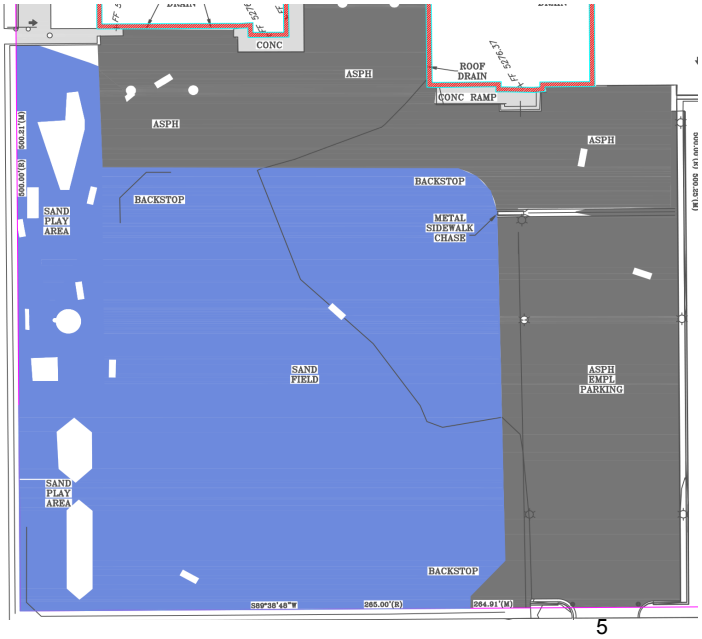


The chart to the right illustrates the breakdown of pervious conditions and the chart below illustrates the Barnum Elementary pre and post site area as example of a typical DPS schoolyard.



Funding for LLs occurred in three phases. In 2000, a public private entrepreneurial three-year campaign was launched raising a total of $9 million, improving 22 schoolyards, and generating significant political support. In response to this demand, the Denver Public School Board proposed two bond measures to expand Learning Landscapes to every elementary schoolyard in Denver. The 2003 bond measure included $10 million and the 2008 bond measure included $29 million.

Site Condition Comparison at Barnum Elementary - Post and Pre Learning Landscapes



3. Process

3.1 Literature Review

The Web of Science, Children & Nature Network Research Library, and Google Scholar were used to conduct searches for literature using key terms related to the targeted outcomes for Learning Landscapes. A list of 33 papers of interest were chosen for inclusion as examples of the state of the literature. The papers reviewed were selected according to the presence of quantitative and statistical analyses, in order to find gaps that could be filled with the subsequent econometric analysis. (See Appendix A for the full literature review.)

This review suggests that there is broad evidence to support the impact of schoolyard improvements on learning outcomes, but specific outcomes are lacking in research. Importantly, dropouts, enrollment, and unemployment are not commonly tied to schoolyard improvements in the literature. There is a good amount of literature on health and wellness outcomes, especially pertaining to increased play resulting from changes to the physical nature of schoolyards. Important gaps are the uncertain relationship between nutrition and school gardens, persistence of impacts into the future, and increases in school lunch sales.

Understudied Impacts
Some particular outcomes that have not been studied heavily that are important to quantify include:

- Effects of schoolyard improvements on enrollment rates and dropout rates
- Direct impacts on school lunch sales
- Absenteeism
- Principal referrals

Test Scores and Mental Health Improvements
Broad consensus has not been reached in the literature, making it important to evaluate directly as part of an econometric analysis. While these effects have been measured at length in the past, it will provide value to model them in this specific context for the benefit of local stakeholders and policy makers.

Community Outcomes
This represents the largest gap in the literature, including very little in the way of quantitative or statistical analysis.

A short list of C&NN outcomes were identified based on the opportunity for quantitative and statistical analyses. The table to the right reflects the four major categories and further delineates the outcomes accordingly.

C&NN OUTCOMES SELECTED (SHORT & LONG)	
LEARNING	INCREASED STUDENT ATTENDANCE
	INCREASED ACHIEVEMENT (EQUITY)
	EQUITABLE DISTRIBUTION OF GREEN SCHOOLYARDS
HEALTH & WELLNESS	IMPROVED PHYSICAL HEALTH STUDENT
	INCREASE IN MOOD & MOOD STABILITY
	INCREASED NUTRITION
	REDUCTION IN LONG-TERM HEALTHCARE COSTS
	IMPROVED PHYSICAL HEALTH COMMUNITY
ENVIRONMENTAL	URBAN HEAT ISLAND REDUCTION
	REDUCED CO2 EMISSIONS
	POSITIVE EFFECTS OF TREE CANOPY ON AIR QUALITY
COMMUNITY	INCREASED STEWARDSHIP OF SCHOOLYARD
	DECREASED ABANDONED BUILDINGS/VACANT PROPERTIES
	INCREASED PROPERTY VALUE
	INCREASED SENSE OF COMMUNITY

3.2 Outcomes Selection Process

The project team worked with DPS staff to collect data spreading across 17 different departments/offices. We recognize their efforts and appreciate their assistance throughout the study. The diagram to the right illustrates the breadth of departments contacted during the data gathering phase. Green denotes engagement and some level of data retrieval. Yellow denotes engagement with minor data retrieval and white denotes engaged but no data available. Obstacles to data retrieval included district's staffing capacity to retrieve data, absence of reporting or change in reporting methods and granularity of data requested.

Denver Public Schools Department Organization Chart

Data collection covered a 15-year period and was sorted into "buckets" based on outcomes and the granularity of data at the school level. DPS, as with most school districts, has a process for coordinating research activities through a Research Review Board (RRB). Given the availability of DPS and CDE data at the school level and time constraints on the project, the lengthy RRB process for pupil level date was not inititated. The chart below illustrates the final selection for data retrieval. The data types in pink, were not included as they require pupil-level data.

Learning Landscapes Outcome Data Buckets & Types Selected

DATA BUCKETS	DATA TYPES
ACHIEVEMENT	ADVANCED PLACEMENT ENROLLMENT
	PERFORMANCE FRAMEWORK
	MATH & WRITING GROWTH
ENROLLMENT TRENDS	TRUANCY / CHRONIC ABSENTEEISM
	DROP OUT RATES
	GRADUATION / COMPLETION RATES
	STUDENT ENROLLMENT
	MOBILITY / STABILITY RATES
EQUITY	NEIGHBORHOOD POVERTY
	EQUITY INDEX
	ENVIRONMENTAL JUSTICE ZONES
	TITLE 1-A SCHOOLS
STUDENT HEALTH / WELLBEING	SCHOOL LUNCHES
	VEGETABLE GARDEN PRODUCTION
	STUDENT'S PHYSICAL HEALTH
	NUTRITION LEVELS

DATA BUCKETS	DATA TYPES
GREEN SPACE EFFECTS	TREE CANOPY COVERAGE
	SITE SURFACES
	TEMPERATURES
FACILITIES	MAINTENANCE COSTS
	ENERGY COSTS
	COMPOSTING
COMMUNITY USE	FAMILY AND STUDENT SATISFACTION
	OUTDOOR SCHOOL PERMITS
COMMUNITY VOLUNTEERING	COMMUNITY VOLUNTEERING
VANDALISM	VANDALISM COUNTS
GRAFFITI	GRAFFITI COUNTS
SAFETY & DISCIPLINE	Expulsion Rates

Learning Landscapes is a valuable case study given its wealth of "impact over time" pre- and post-construction data spanning almost two decades. However, the study needed to account for changes in reporting and tracking programs that occurred during the study period and multiple construction phases where different groups of schools were constructed at different times.

Learning Landscapes Construction Timeline

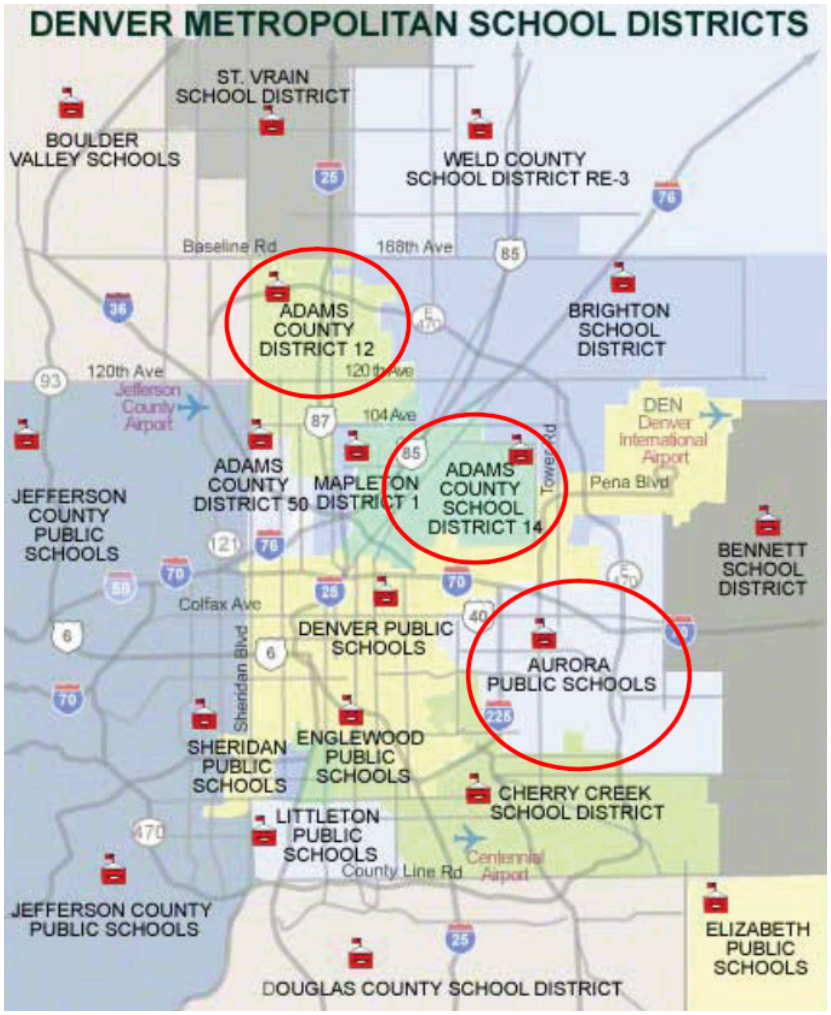
Treatment Group Number	Treatment Year	Number of Schools in Group	Used as a Treatment School	Used As a Not Yet Treated school
1	2000	3	Used 2004-2019	Never Used
2	2001	3	Used 2004-2019	Never Used
3	2002	9	Used 2004-2019	Never Used
4	2003	6	Used 2004-2019	Never Used
5	2004	10	Used 2004-2019	Never Used
6	2005	12	Used 2005-2024	Used 2004
7	2006	3	Used 2006-2019	Used 2004-2005
8	2007	2	Used 2007-2019	Used 2004-2006
9	2009	20	Used 2009-2019	Used 2004-2008
10	2010	14	Used 2010-2019	Used 2004-2009
11	2011	13	Used 2011-2019	Used 2004-2010
12	2012	4	Used 2012-2019	Used 2004-2011

The table above illustrates how some schools are both post- (treated) and pre- (non treated) construction schools given a particular year. In addition to pre- and post-construction Denver Public Schools, the analysis incorporated control schools (80) from neighboring districts, including Aurora Public Schools, Adams 12 and Adams 14 school districts.

Control Schools Chart

Neighboring Districts	Number of Schools
Aurora	44
Adams 12	29
Adams 14	7

These districts served as control/ pre-constuction schools for the 2012 Intervention of Physical Activity in Youth (IPLAY) study, which investigated the impact of environmental (playground renovations) and curriculum interventions for elementary school children during the recess period.



4. Results

4.1 Research Questions

1. What quantifiable economic outcomes related to LL's are statistically significant?

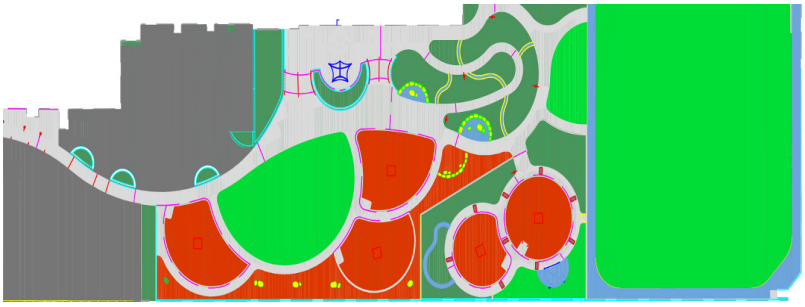
Since most research to date aggregates data to a school or class level, the impacts-over-time at multiple schools approach adds a new level of granularity to current research. This group-time average method looks at outcomes over time from 2004 to 2019, stopping prior to the COVID pandemic. Regression-based statistical modeling using Colorado Department of Education data revealed statistically significant Learning Landscape benefits with a confidence beyond 95% for seven student outcomes.

The CDE did not start collecting math and writing scores until 2012 and school performance until 2010 which presents limitations on pretreatment data. Hence, another model approach was used incorporating matching demographics and post-2021 data. When observing these results, they suggest a statistically significant increase in annual math mean growth of 8.5 percentage points, an increase in annual writing mean growth of 5.5 percentage points annually and an increase in an annual school performance framework of .12 percentage points.

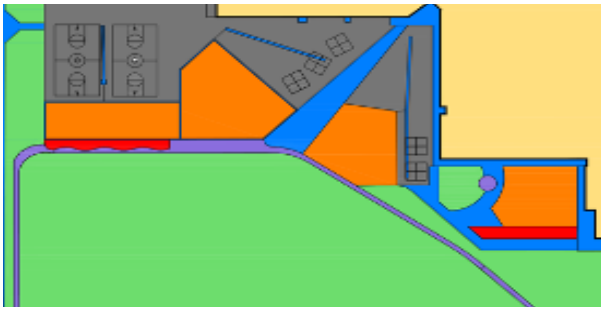
Statistically Significant Learning Landscape Outcomes Annually

Student Outcomes	Coefficient	Data Availability
Math Growth Increase	8.5%pt.	2012-2019
Mobility Reduction	7%pt.	2007-2019
Writing Growth Increase	5.4%pt.	2012-2019
Student Enrollment Increase	152/yr	2004-2019
Free & Reduced Lunches reduction	.17%pt.	2005-2019
School Performance Framework Increase	.12%pt.	2010-2019
Truancy Reduction	.009%pt.	2005-2019

What additional impacts from the presence of Learning Landscape schoolyards can be gleaned? The pre(2012) and post(2018) site surfaces data captured can determine if some LL's elements have stronger associations than others with learning outcomes. To achieve this objective, a "snapshot" or cross-sectional statistical regression model at one point in time(2018) is used. DPS Facility Management shared their Grounds Work Book, an extensive data base of maintenance expenses and levels of service the grounds department achieves given its current funding and staff. The Grounds Work Book includes 22 site characteristics. Based on previous LL research, seven additional characteristics deemed valuable were included in the analysis. One of these entries, the number of CAD space entries, was included as a design indicator or density of the Learning Landscape elements. An example of two LLs with low and high space entries is provided on the following page.



Example of High Density Design Elements
Beach Court schoolyard site surface categories



Example of Low Density Design Elements
Castro Schoolyard Site surface categories

While the majority of outcomes proved insignificant, student enrollment's statistical significance is reflected in 9 schoolyard characteristics with density of the design (number of space entries) and swings being most significant. Green schoolyards are a visual asset in a community and serve as an attraction to increase enrollment at LL schools. This is further corroborated in the previous statistical analysis and is supported in the financial valuation section of this chapter.

Student Enrollment Statistically Significant Indicators

Schoolyard Characteristics/Indicators	Coefficient
Number of CAD space entries	9.5%
Presence of Swings	9.3%
Sports/All Purpose Fields	1.4%
Small Grass Play	3%
Total Irrigated Turf W/O Fields	2.5%
Edging (LF)	3.2%
Trimming (LF)	.009%
Asphalt Parking Lot & Driveway	3.7%
Total Asphalt	3.1%

Among schools with vegetable gardens or farms, the annual school performance framework increased by a statistically significant 8.25 percentage points. By 2019, 55% of Learning Landscapes had school and/or community gardens. Of those only ten schools had vegetable gardens prior to the Learning Landscapes program. Curretnly, 13 Learning Landscapes schools have garden-to-cafeteria programs.

The presence of vegetable gardens and the shift regarding student nutrition will be discussed further in the next section.

Students at Steele Elementary School and their summer harvest. 2012 credit Andy Knowak

2. What are the long-term implications of schoolyard greening interventions?

Learning Outcomes - As mentioned previously, this study is the first of its kind to explore 1) the impact of schoolyard greening over an extended period of time, and 2) a greening project district-wide. Browning and Rigolon (2019) examined 13 peer-reviewed articles to understand associations between academic outcomes, types of green spaces, and distances at which the green spaces were measured around schools. Greenness, and tree cover at the school and within 200 meters were associated with some increased academic performance especially in math and reading test scores. The results of this study corroborate previous research. Student outcomes in math and writing growth and student performance framework showed consistently better annual performance over a seven-year period.

Nutritional Health - Interviews with the District's Food and Nutritional Services (FNS) and the Office of Sustainability(OS) corroborate the long term positive impact of LL infrastructure improvements over the past twelve years that includes expanding vegetable gardens to over 50% of elementary schools, implementing a garden to cafeteria program and launching a district farm program. The gardens are sustained with support from NGO's, parents, teachers and community residents. Recently, OS acquired a garden coordinator and in FY22 12,250 lbs of garden-grown produce was donated from these gardens.

Garden Place Academy vegetable garden and orchard. 2018 photo credit Lois Brink

The Garden to Cafeteria Program makes a connection between the fresh produce that the students grow in the school garden to the salad bars in the cafeteria at lunch. In 2012, every DPS school received a salad bar. Using food safety protocols developed with the local health department, students and garden leaders harvest fruits and vegetables weekly from the school gardens, learn how to wash the large chunks of dirt off, weigh and record the amount of produce and then present the harvest to the cafeteria staff. This not only improves the health of the students, but it also generates revenue from lunch sales. The number of participating schools dropped during COVID, but FNS is looking forward to bringing on more schools. The chart below shows the annual total revenues in 2022 dollars, along with the number of schools participating each year. The gardens are co managed with FNS and OS.

Garden to Cafeteria Program Revenue

Year	# of Schools	Total Revenue	Revenue/School
2011	13	$2,010	$155
2012	15	$1,574	$105
2013	13	$1,323	$102
2014	17	$1,693	$100
2015	13	$1,918	$148
2016	13	$1,480	$114
2017	17	$2,304	$136
2018	12	$1,499	$125
2019	7	$2,250	$321
Total	**120**	**$16,051**	**$1,304**

Total Revenues	$16,051
Revenue Per School	$1,304

The district managed school-farm program began as part of the Learning Landscapes in 2012 with research provided from a grant with the Colorado Health Foundation. The study suggested that DPS could potentially grow 340,000 lbs of seasonally fresh produce on 21 acres of DPS land with a potential cost savings to FNS of $150,000 per year. This could account for 40% of the fresh produce DPS purchases annually. By farming on schoolyards, children and the community are exposed to locally grown food produce.

District Managed Farm Revenue Timeline

Year	Total Revenues	Bradley School Revenues	McGlone School Revenues	Schmitt School Revenues
2012-2013	$57,064	$21,019	$36,045	
2013 - 2014	$78,339	$37,241	not farmed due to construction	$41,098
2014 - 2015	$92,286	$39,022	$30,196	$23,068
2015 - 2016	$92,115	$39,803	$27,891	$24,421
2016 - 2017	$79,111	$25,620	$22,610	$30,882
2017 - 2018		not farmed water issues	not farmed school expansion	farmed by DPS
Total	**$398,915**	**$162,704**	**$116,742**	**$119,468**

In 2017, three Learning Landscapes were part of the school farm program with an annual revenue of $80,000. While two of the school sites have been dropped due to site constraints, the program is sustaining itself with the remaining site, Schmitt Elementary. This school continues to be farmed by DPS and a massive 1/2 acre district greenhouse was completed in the spring of 2022 allowing FNS to expand the growing season through out the academic calendar.

Environmental Health - Investing in a cool or green vegetative surface reduces the severity of extreme heat events by controlling the level of heat absorbed, radiated, conducted, and emitted into the surrounding area, i.e. affecting the ambient temperature. Cooling effects from better choices in vegetative cover and lighter surfaces can work towards sufficiently reducing heat stress-related fatalities, strokes and illnesses during extreme heat wave events, thereby a benefit to the community. Trees also provide a cooling effect due to the shade and respite provided by the increased canopy coverage. This is especially beneficial for play areas when children spend time outdoors during the day and can have important long term health impacts.

DPS Head of Food and Nutritional Services Theresa Hefner at the new greenhouse. Feb 23'. Photo Credit Lois Brink

The effects of green space on ambient temperature as the land cover changes before and after Learning Landscapes can be used to estimate the change in ambient temperatures in the surrounding area (Parshall et al., 2011; Sailor & Hagos, 2011, Ibsen et al., 2022). In addition to temperature, other environmental impacts covered as a part of the site surface analysis included the level of carbon sequestration, storage capacity, and the change in air contaminants deposited on vegetative surfaces (iTree Landscape, 2022).

A sample set of 19 school sites in the southwest planning region were mapped pre and post. This accounts for almost 20% of the LL schools in the district. This region was selected for its range of equity index levels as well as its relatively stable population since 2012. With the interest of understanding district level impacts, analysis of the southwest schools are used to provide a scaled up analysis to infer impacts to the district as a whole. Changes in ambient temperature in the surrounding area are estimated based on changes in land cover before and after Learning Landscape construction. On average, a 15 degree Fahrenheit reduction was observed during the peak of summer season (estimated to be between the middle of May to August every year). In addition to temperature, site surface analysis estimated the level of carbon sequestration, storage capacity, and the change in air contaminants deposited on vegetative surfaces. In Carbon sequestration and air pollution reduction values were analyzed over a 40-year period. When adjusted for an annual rate, 1,284 tons of carbon are sequestered annually across all converted schoolyards and 404 lbs of air pollutants are removed annually across all converted schoolyards.

3. What quantitative/deterministic analysis can be conducted from the additional data gathered during this project?

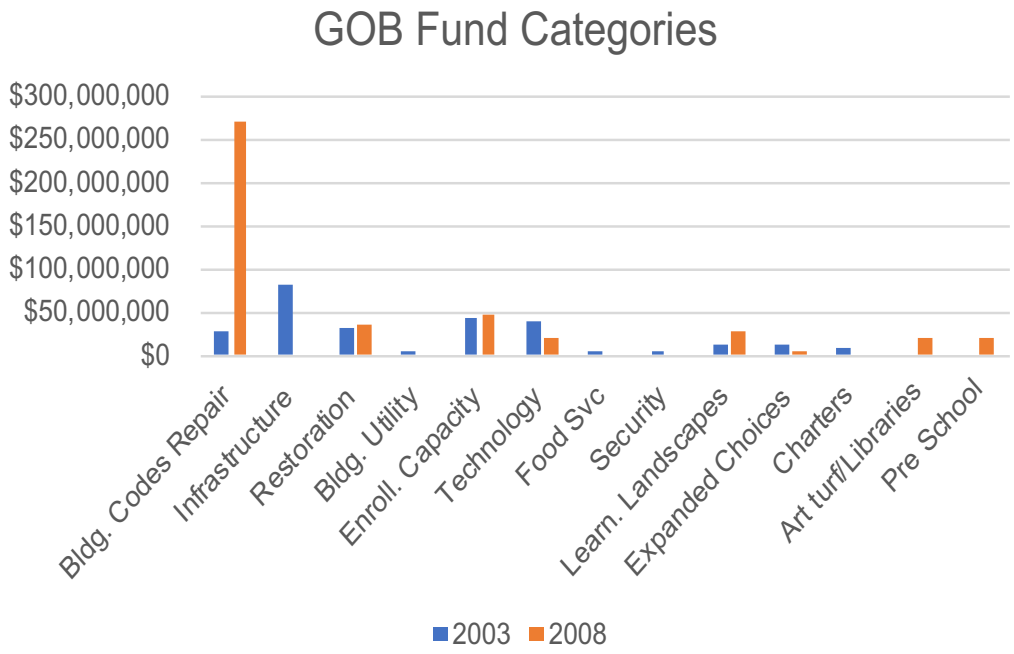
District Economics - The longitudinal analysis regarding student enrollment and revenue generated was calculated by taking the product of the inflation-adjusted per student funding that schools receive from the state based on their total enrollment. The Colorado Department of Education accounts for this increase by assuming a per student funding amount and appropriating the funds accordingly on the basis of total student enrollment. By retrieving the average annual increase in student enrollment of 152 the district has realized $1,341,777 of real income annually. The long term income realized from 2004 — 2019 is $20,126,655. This further substantiates the correlation between student enrollment and schoolyard greening/ redevelopment. The importance of the outward appearance of schools builds confidence in communities. We suspect this enrollment revenue will continue.

Ever since the successful completion of the initial Learning Landscape public/private funding campaign in 2003, the district has realized long term funding for schoolyard greening through General Obligation Bonds(GOB). The GOB funding process establishes a citizen advisory board who, during the course of 6 months, ranks and makes recommendations to the school board. Prior to the 2003 GOB, DPS had only one voter-approved bond. Of the $310,000,000 in the 2003 bond, 3.43% of the funding went to LL's. Over half of the funding went toward deferred building maintenance. In reviewing the fund categories, LL is the most forward facing/highly visible capital improvement project in the bond and covers all planning regions. The report from the board of education minutes is no longer available on line nor was DPS able to recover this information during the course of this project. Anecdotally, we have been told LL ranked high and was instrumental in voter confidence. In essence, for every dollar spent on LL's, $25 were realized in differed maintenance and several new charters. The same holds true for the 2008 bond where LL funding accounted for only 6% of the funding and deferred maintenance accounted for 70%.

Learning Landscapes Capital Costs

Learning Landscapes Periods	Capital Costs (2022 Dollars)
2000-2003	$8,920,724
2004-2008	$14,741,828
2009-2012	$36,818,629

Total Capital Costs	$60,481,181
Cost Per School	$630,012
Cost Per \SQFT	$2.23



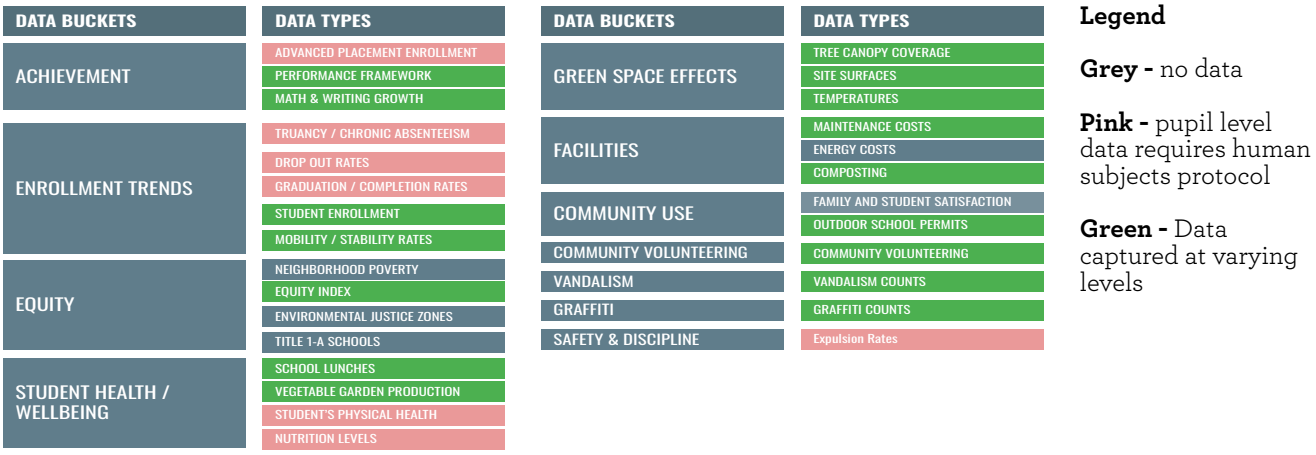
In summary, when schoolyards are a community asset, GOB's are a powerful financial tool for districts to address deferred maintenance and access significant funding to scale schoolyard greening. Both issues plague many urban school districts.

4.2 Limits of Study & Next Steps

The result of this study offer substantial justification for investing in schoolyard greening. Most importantly it demonstrates that a greening program that is scaled across all elementary schools in a district creates a catalytic effect with quantifiable and statistically significant results in student outcomes and a district's financial health.

The DPS Research Review Board (RRB), which reviews research requests from external researchers, determined that CDE and DPS school-level data were sufficient for the analysis. The data types in pink require RRB approval in order to access pupil-level data..

Data Availability by Type



Furthermore, due to DPS limited staffing capacity, accessing pupil-level data and information related to community use was not feasible. Other limitations include shifts in data storage, data conversion to new programs, and conflicting naming protocols.

The completion of this research and analysis opens opportunities to monetize impacts found to be significant at a granular level. Using the 12 LL treatment schools with the 12 control schools used in the 2012 research from adjacent districts we can investigate pupil-level variables and the effects on physical and emotional student health outcomes such as physical activity, nutritional offerings, and behavioral differences as well as graduation rates.

A priority for future research is securing funding for DPS to dedicate a staff person to the research project in order to access pupil-level and community use data. The district has in storage 20 years of satisfaction surveys by students and parents for each school. Given that community use is one of the biggest data gaps, this information would be invaluable to retrieve. Conducting audits at a cohort of LL sites would glean granular data regarding community and school use. Next steps would include, exploring further monetization of variables with demonstrated differences between experimental and control groups and developing a pupil-level analysis framework that facilitates additional cost-benefit analysis to be performed.

Endnotes

1 https://www.childrenandnature.org/schools/greening-schoolyards/

List of References are located in the Appendix A.