ADDRESSING A

Multi-Billion Dollar
CHALLENGE

Advancing Knowledge of How
High-Quality School Environments
Can Positively Affect Educational Outcomes

DECEMBER 2023

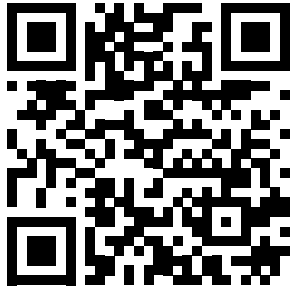PERKINS—EASTMAN

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Study Definitions

Modernized schools were considered facilities that had received within the past decade a major capital reinvestment with the goal of comprehensively updating, realigning, or replacing program spaces, building systems, and furniture, fixtures, and equipment, as well as bringing the facilities into code compliance, to better serve school and community needs. In some cases, but not all, modernized schools are new buildings that replaced existing, obsolescent facilities.

Non-modernized schools were considered environments that did not meet the above definition.

Indoor Environmental Quality (IEQ) considered the following properties of the built environment: thermal comfort, air quality, acoustics, and lighting.

Educational Adequacy (EA) considered how well a school's spaces and design features—inside and outside the classroom as well as inside and outside the building—supported learning and teaching within that environment.

Community Connectivity (CC) considered how a school's spaces and design features, both inside and outside the building, supported stakeholders' perceptions about, use of, and engagement with the school, including how well the school enabled interaction between its stakeholders.

Stakeholders included two groups: internal (a school's administrators, teachers, staff, students, and students' parents/caregivers) and external (including but not limited to the residents and businesses in the surrounding neighborhood). Data collection sites included primary and secondary schools (elementary, middle, and high schools).

Well-being considered both health/wellness and quality-of-life indicators by exploring how a school's spaces and design features, both inside and outside the building, contributed to stakeholders' physiological health, psychological health, and cognitive function.

Analysis terminology: In this synopsis report, the term **"significant"** is used to identify a statistical significance, meaning there was a difference between the modernized and non-modernized schools and that the findings were not due to chance. The term **"slightly"** is used to indicate a noted difference that did not result in a high level of statistical significance. **"Effect size"** indicates how large a difference there is between the two groups. A large effect size indicates the finding has greater practical application, whereas a small effect size means the real-world applications are limited. For this study, eta-squared values were interpreted such that 0.10 to 0.29 were small effects, 0.30 to 0.49 were moderate effects, and 0.50 or greater were large effects.[1]

Learning environments impact the well-being of building occupants, education, and the communities where they are located. Addressing the nation's inadequate school facilities is an important and necessary step toward supporting equitable educational and community improvement.

School Modernization Enhances Education and Well-being

An alarming disinvestment in public schools across the United States currently affects more than 49.4 million students,[2] not to mention their families and communities. Many of these students do not have the privilege of attending a school that provides appropriate facilities to support learning. This is even more important considering there is a growing body of knowledge that demonstrates how people's health and cognitive, social-emotional, and physical development are related to the built environment. In terms of schools specifically, "researchers have found that school conditions significantly impact learning experiences and student outcomes."[3] Teachers also report greater job performance and satisfaction as well as overall better health within higher quality school environments.[4,5] Further, schools have the potential to increase community wellness, health, and access to food and services,[6,7,8,9] in addition to impacting a community's housing prices and local economies.[10,11,12] Tackling the nation's inadequate school facilities is a necessary step toward supporting equitable educational and community improvement.

Educational success requires school facilities that provide healthy and safe environments.[13] However, data are not yet sufficient to ensure consistency across schools, much less inform large-scale modernization programs. This is not a trivial matter given that, nearly a decade ago, an estimated 53% of public schools in the United States needed renovations or modernizations to be considered in good overall condition, the cost of which was estimated at the time to total around $197 billion.[14] By 2021, the total shortfall in maintenance, operations, and capital expenditures for school facilities in the United States had grown to $85 billion annually.[15] This deficit marked a dramatic increase of more than $25 billion from a previous estimation made just five years earlier[16]—a concerning trend that has serious negative implications if not reversed.

To address this multi-billion dollar challenge of modernizing the nation's schools, we decided to conduct this study to advance the industry's knowledge on how high-quality school environments can positively affect educational outcomes. To do so, we explored the impact of several key areas of school modernization on various stakeholders in the Baltimore City and District of Columbia public school districts, from students and staff to community members, to better inform the decision-making about future school construction projects. Specifically, **this study investigated the differences between modernized and non-modernized schools in terms of Indoor Environmental Quality (IEQ), Educational Adequacy (EA), and Community Connectivity (CC) and the effect of these variables on performance and well-being outcomes.** (For more on how we conducted this study, see page 28 herein, or refer to the full report.)

Based on this study, we are able to share herein specific data about the benefits of school modernization to help jurisdictions make a stronger case for the importance and funding of school modernization. In addition, we are providing guidance for designers and school district administrators about actionable interventions that have a demonstrably positive impact on well-being, educational, and community outcomes, such that decision-makers can effectively spend the forecasted billions in modernization dollars to achieve their core mission of educating students for life in the 21st century.

The purpose of this study was to understand the differences between modernized and non-modernized primary and secondary education schools in terms of Indoor Environmental Quality (IEQ), Educational Adequacy (EA), and Community Connectivity (CC).

Educational Performance, Well-Being

Existing Buildings (Modernized vs. Non-Modernized)

Indoor Environmental Quality (IEQ)

Educational Adequacy (EA)

Community Connectivity (CC)
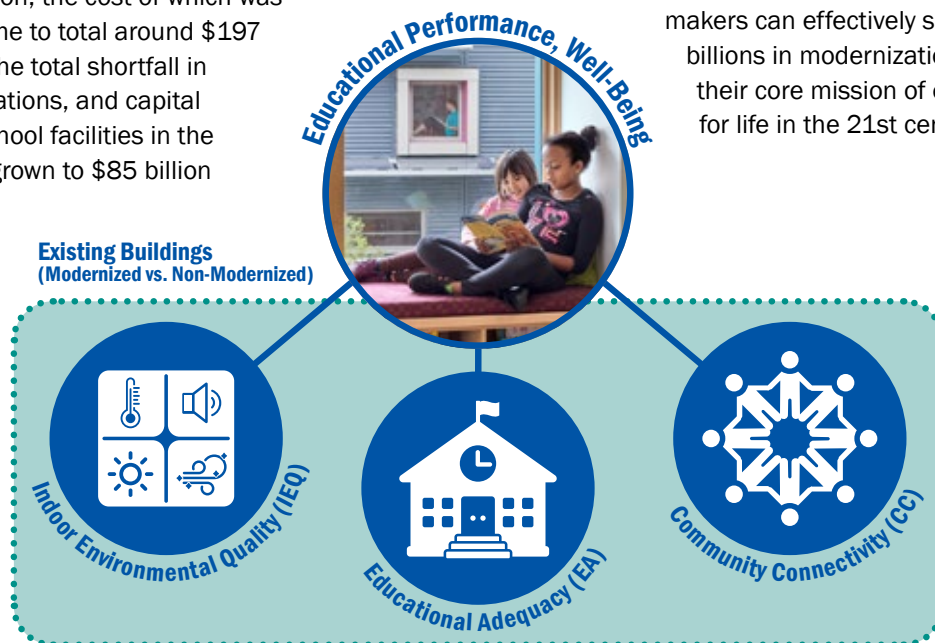
This study aimed to improve 21st-century learning environments by:

- Understanding the impact of school modernization efforts on occupants' well-being, satisfaction, and performance—requirements that need to be considered for an equitably designed educational facility
- Identifying spaces and design features of educational environments that impact students and teachers interacting with the school environment
- Exploring the connection between the quality of design features and overall school facilities with the connectedness of a school to its surrounding community
- Developing new knowledge that would be of value to both school district leaders and designers working on modernization plans for new and renovated schools
- Empowering districts to advocate for greater funding, while also enabling them to more effectively spend the limited funds they do have, to help create school facilities that better enhance education and offer greater support for their communities

Our analysis revealed that the modernized schools outperformed non-modernized schools in a statistically significant manner on several Indoor Environmental Quality factors, including greater thermal comfort, better air quality in terms of reduced particulate matter, lower background noise levels, and better daylighting. However, modernized schools were not as successful at addressing some other IEQ factors, such as carbon dioxide levels and occupied noise levels in classrooms, suggesting these are areas for further study.

Modernized schools also came out ahead on several Educational Adequacy categories, including Instructional Space, Presence, Safety and Security, Community, and Organization. In particular, the modernized schools provided a more positive first impression, an enhanced learning ambiance, and more safety strategies than non-modernized schools.

When it came to Community Connectivity, results were more varied. Parents/caregivers were inclined to rate their own children's school favorably, regardless of whether the school was modernized or not. Those who had children in non-modernized schools tended to place a higher value on the fact that their school provides community services rather than on the school's modernization status. They also focused on a school's overall strengths even while recognizing the shortcomings of the physical facilities. They acknowledged, however, that a modernized building would enhance the good work their school was already doing.

This study demonstrates that modernized learning environments improve their occupants' well-being and satisfaction; and the modernization process enhances community engagement and connectivity. We also found evidence that school modernization has a significant positive impact on key educational indicators, including test scores, graduation rates, and enrollment over time. When evaluating the study's collective findings in relation to the research questions and hypotheses, we conclude that, **in multiple categories, modernized schools offered greater Indoor Environmental Quality and Educational Adequacy than non-modernized schools, while Community Connectivity had mixed, though favorable, results. The bottom line is that modernized schools return better outcomes.**

When evaluating the study's collective findings, we conclude that, in multiple categories, modernized schools offered greater Indoor Environmental Quality and Educational Adequacy than non-modernized schools, while Community Connectivity had mixed, though favorable, results. The bottom line is that modernized schools return better outcomes.

Design Recommendations

Based on the study's findings, the following recommendations can be used to inform the planning and design of modernized school facilities, with the goal of creating environments that positively impact school stakeholders and the communities surrounding schools, helping to prepare students for success in the 21st century. For more details and examples, refer to the study's full report.

Improve the Learning Ambiance in Instructional Spaces

Learning ambiance is a way of thinking about the experience of the learning environment, and asks the questions: Is the environment visually appealing, orderly, well-maintained, and comfortable, or is it chaotic, haphazard, poorly maintained, and/or monotonous? As this study demonstrated, large-scale modernization efforts have considerable opportunity to create a positive learning ambiance, but when carefully planned, even smaller-scaled interventions in existing buildings can have a notable impact. As updates to a school building frequently occur incrementally over time, these smaller changes can either enhance or detract from the learning ambiance. Accordingly, even in the absence of a large-scale modernization effort, school districts can take incremental steps to enhance their schools' interiors and thereby have a positive impact on teaching and learning through smaller, more targeted investments in the fixed and semi-fixed features of a school. Beyond thoughtful updates to furnishings and finishes, the findings from this study recommend that infrastructure interventions into a building over its lifecycle (e.g., HVAC upgrades) should be carefully coordinated to avoid diminishing the learning ambiance.

Enhance Civic Presence, Arrival, and Community Access

First impressions matter. Arriving at a school is the first opportunity to show students, teachers, staff/administrators, and even community members that they are valued. It also demonstrates to the greater community that what happens within the walls of the building, and on the campus more broadly, is important. Architectural style can vary, but a school's front door should be accessible, welcoming, and free from visual clutter. The façade and landscaping should be well-maintained. Windows should be clear and allow staff in the main office to subtly monitor arrivals. The study also found it is valuable to have high-quality assembly spaces and the ability to close off portions of a school to facilitate after-hours community access. Thus, not only does the building's streetside design make a difference but so does its interior layout.

Control Access for Safety and Security

Welcoming the educational community while providing a safe and secure place to foster learning begins at the entry to the school. It should be orderly and welcoming while limiting access to people from outside the school community. A secure vestibule should control access to the instructional environment beyond the entry, with security features/equipment seamlessly integrated into the building's design. The main office should be directly adjacent to and accessible from the entry lobby to facilitate wayfinding while serving as a checkpoint for arriving visitors. Windows with views of the arrival area in front of the building and within the secure lobby can also help enhance the safety of students, teachers, and staff/administrators within the school.

Invest in Indoor Environmental Quality for Healthier, Higher-Performing Spaces

School modernization efforts can make considerable improvements to the quality of the indoor environment, which can thereby influence building occupants' health, satisfaction, and performance. We found that current modernization strategies are bettering thermal comfort conditions by stabilizing temperatures within the comfort zone, improving air quality by reducing particulate matter, decreasing background noise levels typically caused by mechanical equipment, and increasing daylight distribution and exposure to natural light. Modernization was also found to result in higher satisfaction ratings of the educational environment among teachers and students alike, suggesting that even though Indoor Environmental Quality factors may be "invisible" to building occupants, they have a tangible impact.

Create a "Heart" of the Community

This study found value in the creation of a place that centers the learning community and the building around a "heart" of the school. These centralized interior spaces, typically located at a crossroads in the school, could be either a programmed space (e.g., dining or the library) or informal gathering spaces/extended learning environments. Inclusion of this kind of space can extend both formal and informal learning opportunities and supports a school's overall sense of community.

Accommodate Community Partners On-Site to Magnify Their Impact

Community agencies and service providers can have a greater impact when they partner with a school. These partnerships, in turn, greatly increase Community Connectivity. Co-location on the school's campus can be valuable, as well. This was evident in both modernized and non-modernized schools, demonstrating that community programming can enhance engagement with a school and its surrounding neighborhood, regardless of a school's modernization status.
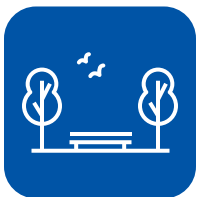
Consider How the Community Can Engage with a School's Campus/Grounds

Open space adjacent to or surrounding a school greatly enhances Community Connectivity. That space can take different forms and be used in numerous ways. Playgrounds, ballfields, running tracks, gardens, and other positive features on a school's campus can create opportunities for community members to benefit from a school modernization program, even if they never enter the building. These benefits may then stimulate increased community support for the school.

Recognize That Modernization Impacts Community Members Differently

Care must be taken to ensure that community members across a wide demographic spectrum can benefit from a school modernization. The process of planning for a new school or the renovation of an existing facility can boost Community Connectivity. Engaging long-time residents in the modernization process can help to mitigate the potential for gentrification that may drive those individuals and families out of the school and neighborhood. School Improvement Teams, or similar advisory groups, can engage a broad array of stakeholders—students, teachers, staff/administrators, parents/caregivers, and members of the greater community. These groups can improve students' educational experiences, enhance parent/caregiver involvement in the school, boost community support, and provide more opportunities for community members to use the school facilities.

Study Findings | Indoor Environmental Quality

Indoor Environmental Quality (IEQ) consists of a complex relationship of several factors that impact the well-being of occupants within a building. While there is ongoing research into which physical, psychological, or social indicators best reflect how occupants respond to these factors, there are also several techniques for measuring the IEQ indicators themselves, such as thermal comfort, air quality, acoustics, and lighting.[17] Researchers also note that, to have a truly comprehensive model of IEQ, data must be gathered through both objective measurements and occupants' perceptions.[18] As the United States strives to provide a more equitable educational system and facilities designed around holistic well-being, examining how IEQ differs from building to building is vital.

Overall, the results around Indoor Environmental Quality support the study's hypothesis: **In general, the modernized schools outperformed non-modernized schools in terms of IEQ factors of thermal comfort, air quality, acoustics, and light.**

Thermal Comfort

Thermal comfort is an important consideration in school design because research has shown that uncomfortable temperatures can cause feelings of fatigue, irritability, and stress.[19] Further, for every 1.8°F reduction in temperature from 77°F to 68°F, student performance improves in terms of speed by 2-4%.[20] For this study, the four environmental factors associated with thermal comfort (air temperature, humidity, air velocity, and mean radiant temperature) were assessed using on-site data-logging sensors , alongside occupants' questionnaire data. Personal factors, including occupants' clothing and metabolic rates, were not measured in our evaluation.

When analyzing thermal comfort in modernized versus non-modernized schools, we found:
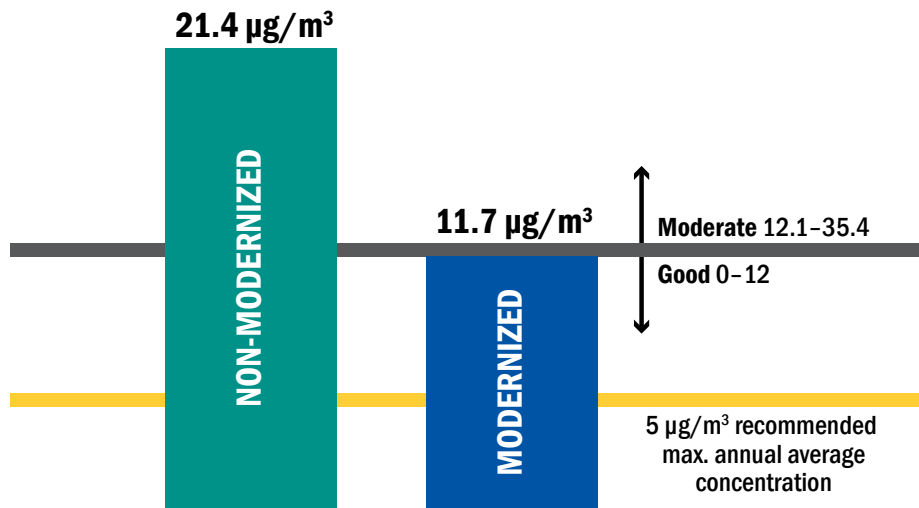
- Modernized schools spent 24% more time in the comfort zone on average compared to non-modernized schools.
- Temperature swings in modernized schools were an average of 4°F lower.
- The coldest and hottest temperatures documented during the study were measured within non-modernized schools.
- Students in modernized schools were significantly more satisfied with the temperature of their classrooms throughout the year compared to students in non-modernized schools.
- Teachers in modernized schools were significantly more satisfied with thermal comfort in the winter compared to teachers in non-modernized schools.

The non-modernized schools in the study generally provided less thermal comfort in the winter months than the modernized schools, often over-heating their interiors, which creates uncomfortable conditions and wastes energy and funds. Interestingly, students (i.e., children who typically have higher metabolic rates) in the study seemed to prefer being warm, while the teachers were generally more comfortable with cooler indoor temperatures. This dichotomy brings into question ASHRAE Standard 55 calculations, which would suggest the opposite. We propose closer investigation of the ASHRAE Standard 55 calculations following the PMV and PPD method* to better understand the two groups' perceived comfort differences.

* Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD) are methods to determine thermal comfort.
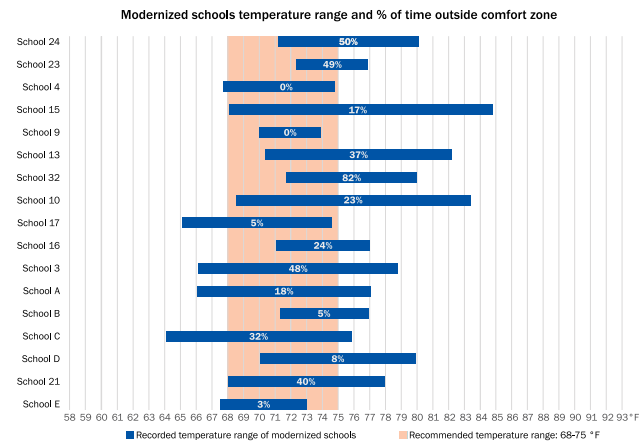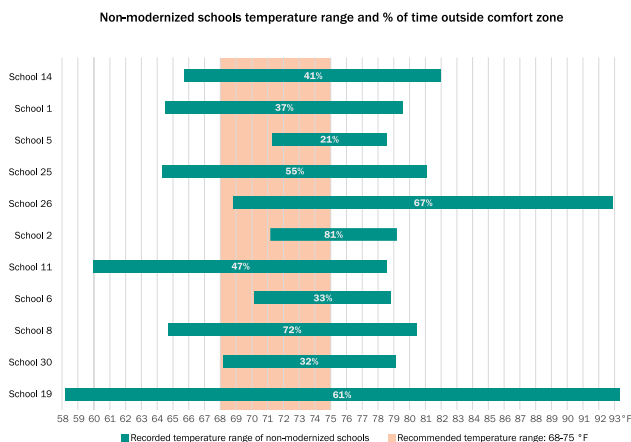
These charts, with schools listed by their anonymized identification code, show how the modernized schools spent more time in the comfort zone on average compared to non-modernized schools, and experienced temperature variations that were not as disparate between the thermal highs and lows. We found that non-modernized schools often over-heat their interiors, which creates uncomfortable conditions and wastes energy and funds.

21.4 µg/m³ — NON-MODERNIZED

11.7 µg/m³ — MODERNIZED

Moderate 12.1–35.4

Good 0–12

5 µg/m³ recommended max. annual average concentration

This chart shows how modernized schools had significantly lower particulate matter values on average compared to non-modernized schools. The modernized schools also fell within the "good" air quality range on the Air Quality Index (AQI) scale, whereas non-modernized schools only had "moderate" air quality according to the AQI. The study also found that carbon dioxide levels were widely variable across the entire sample, regardless of modernization status, suggesting current best-practices for school modernization are decreasing particulate matter but not having a significant impact on improving carbon dioxide levels.

Air Quality

Air quality can impact building occupants considerably, especially children who naturally have higher respiratory rates. Improved ventilation rates and systems in schools have been shown to decrease instances of respiratory illness, improve student attendance, boost task completion speed, and increase test scores and grades.[21] Students in classrooms with higher air ventilation rates have also been shown to score 14-15% higher on standardized tests.[22] To assess air quality for this study, carbon dioxide (CO_2) and particulate matter (PM 1.0, 2.5, and 10) data-logging sensors were used on-site, alongside occupants' questionnaire data.
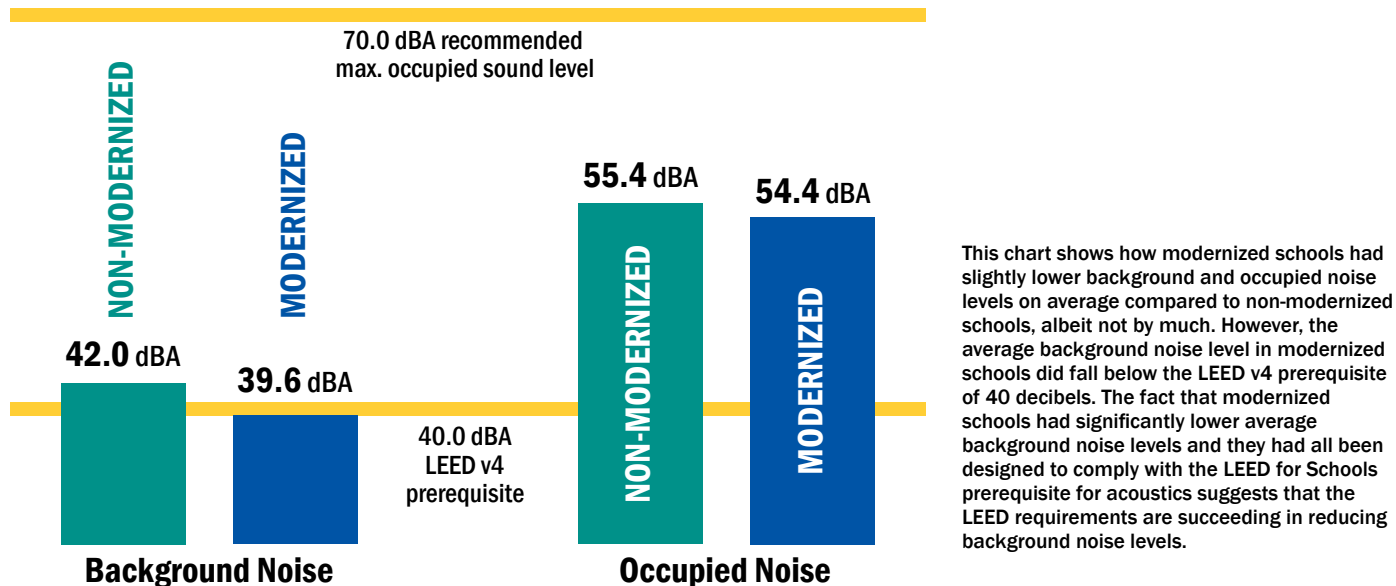
When analyzing the air quality in modernized versus non-modernized schools, we found:

- Non-modernized schools had both the lowest and highest CO_2 readings documented during the study. However, there was a wide variability in CO_2 levels across the entire sample, with no clear correlation between CO_2 levels and modernization status.
- Modernized schools had significantly lower average particulate matter values compared to non-modernized schools.
- The data showed no significant correlation between CO_2 and particulate matter within the schools studied.
- Students in modernized schools said they were significantly more satisfied with the air quality in their classrooms than their counterparts in non-modernized schools.

- Teachers in modernized schools rated the air significantly fresher and were significantly more satisfied with the air quality in their schools compared to their peers in non-modernized schools.

The wide variability in CO_2 levels in both the modernized and non-modernized schools in the study suggests that current best-practices for school modernization are not having a significant impact on improving CO_2, thereby warranting further study. Perhaps standards such as LEED or even local building codes can do more to improve minimum ventilation requirements to help maintain low CO_2 levels and reduce other indoor air pollutants.

Air quality is a complex factor, however, and this study only assessed CO_2 and particulate matter. Even though the on-site CO_2 measurements showed no difference in the modernized versus non-modernized schools, significant differences were found between particulate matter values. Further, questionnaire data showed a difference in terms of occupants' satisfaction. This could mean that CO_2 may not be the best indicator to correlate to occupants' satisfaction with air quality, suggesting that particulate matter may be a more relevant metric to connect to or perhaps even predict occupant satisfaction.

70.0 dBA recommended max. occupied sound level

NON-MODERNIZED

MODERNIZED

55.4 dBA

54.4 dBA

42.0 dBA

NON-MODERNIZED

MODERNIZED

39.6 dBA

40.0 dBA LEED v4 prerequisite

Background Noise

Occupied Noise

This chart shows how modernized schools had slightly lower background and occupied noise levels on average compared to non-modernized schools, albeit not by much. However, the average background noise level in modernized schools did fall below the LEED v4 prerequisite of 40 decibels. The fact that modernized schools had significantly lower average background noise levels and they had all been designed to comply with the LEED for Schools prerequisite for acoustics suggests that the LEED requirements are succeeding in reducing background noise levels.

Acoustics

Proper acoustics can affect students' ability to hear their teachers and can reduce fatigue in teachers.[23] Research has also shown that students who attend school in noisy environments, such as near a highway or under regular flight paths, have lower academic performance.[24] To assess acoustics, alongside occupants' questionnaire data, sound levels (decibels, dBA) were collected on-site using data-logging sensors, with data divided during analysis into "occupied" and "unoccupied" hours so average background noise levels could be evaluated separately from occupied noise levels.

When analyzing the acoustic conditions in modernized versus non-modernized schools, we found:

- Modernized schools had statistically significant lower average background noise levels compared to non-modernized schools, albeit only 2.4 dBA lower.
- When we measured occupied noise levels, both the lowest and highest values documented during the study were found within modernized schools.
- Students in modernized schools reported classroom noise levels as significantly louder (both for inside and outside noises*) compared to their peers in non-modernized schools. However, students in modernized schools were also slightly more satisfied with noise levels than students in non-modernized schools.

- Teachers in modernized schools reported their classrooms as slightly louder from an inside noise perspective and slightly quieter from an outside noise perspective compared to their counterparts in non-modernized schools. The teachers in modernized schools were also slightly more satisfied with both indoor and outdoor noise levels compared to teachers in non-modernized schools.

Interestingly, this study saw perceived satisfaction with noise levels contrasting with actual data measured on-site, suggesting further research is necessary to understand the complex relationship between noise, engagement, and learning. Understanding the acoustic needs of special education students and non-native-language-learners in classroom environments would also be of value.

The fact that modernized schools had significantly lower average background noise levels and they had all been designed to comply with the LEED for Schools prerequisite for acoustics suggests that the LEED requirements are succeeding in reducing background noise levels. However, since there was no significant difference in occupied noise levels between modernized and non-modernized schools, further research is necessary to better understand and address acoustics within school environments.

* Inside noise for the questionnaire was defined as noise that comes from *people* inside the room, whereas outside noise was defined as noise that comes from the *building or from outside* (e.g., street noise, hallway noise, etc.).

Light

Daylight in classrooms and views to the outdoors have been shown to enhance concentration, increase alertness, and improve standardized test scores.[25] Researchers have also found that students in daylit classrooms progress 20% faster on math tests and 26% faster on reading tests.[26] To investigate lighting for this study, photographs of the schools' classrooms were evaluated to assess luminance throughout the images to study glare. Along with occupants' questionnaire data, point-in-time light meter measurements were also collected on-site to understand the distribution of daylight and electric lighting. We assessed under-lit versus over-lit conditions in classrooms using the LEED v4 credit for Daylight, which identifies a threshold of under 300 lux to be considered under-daylit (i.e., the room is not daylight autonomous) and 1000 lux or higher to be considered over-daylit, such as from excessive sunlight exposure or glare.
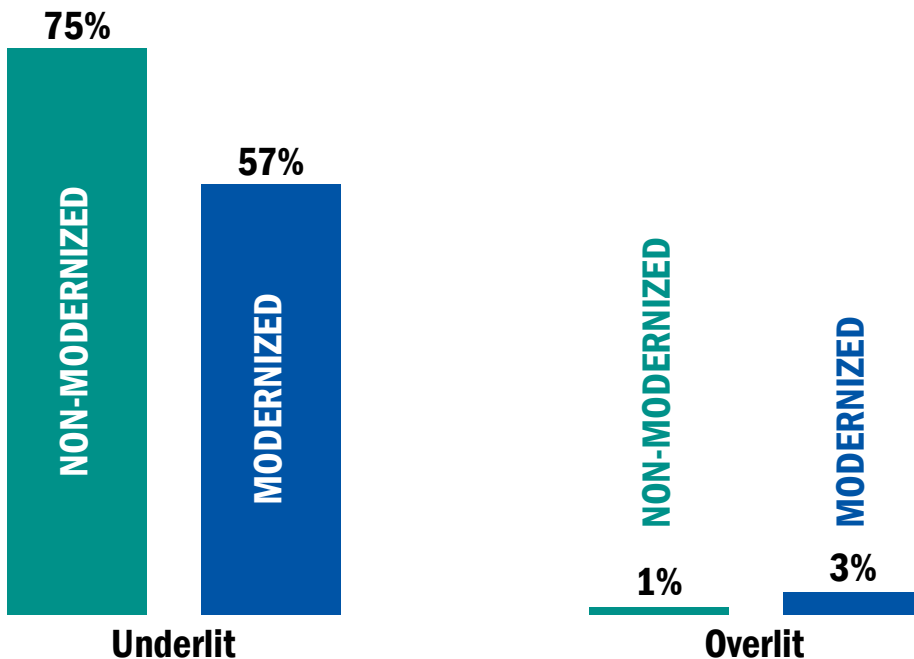
When analyzing the lighting conditions in modernized versus non-modernized schools, we found:

• Modernized schools had, on average, significantly less floor area that was under-daylit (18.2% less under-lit) compared to non-modernized schools. However, modernized schools also had slightly greater floor area that was over-daylit. This difference, though, was largely balanced with electric lighting, leaving next to no variation between modernized and non-modernized schools once electric lighting was turned on (i.e., electric light plus daylighting values).

• Students in modernized schools described their classrooms as slightly darker on sunny days and significantly brighter on cloudy days compared to the questionnaire responses from students in non-modernized schools. However, they were slightly less satisfied with the daylighting, on average, compared to students in non-modernized schools.

• Teachers in modernized schools reported their classrooms as significantly brighter and were significantly more satisfied during both sunny and cloudy conditions compared to their peers in non-modernized schools.

The study's data showed that modernized schools performed better when all electric lighting was turned off compared to non-modernized schools, meaning that the non-modernized schools were more reliant on electric lighting for both function and occupants' satisfaction. This likely associates with more electric lighting usage among non-modernized schools, resulting in higher energy demand and greater operating costs. Additionally, modernized schools did a better job at distributing daylight within the classrooms, especially on cloudy days.

75%
57%

NON-MODERNIZED

MODERNIZED

NON-MODERNIZED

MODERNIZED

1%
3%

Underlit

Overlit

This chart shows how modernized schools had, on average, significantly less floor area that was under-daylit compared to non-modernized schools. Although slightly more over-lit on average, modernized schools also had better average daylight distribution and were more evenly lit than classrooms in non-modernized schools. Non-modernized schools were more reliant on electric lighting for both function and comfort, resulting in more electric lighting usage and therefore higher energy demand and greater operating costs.
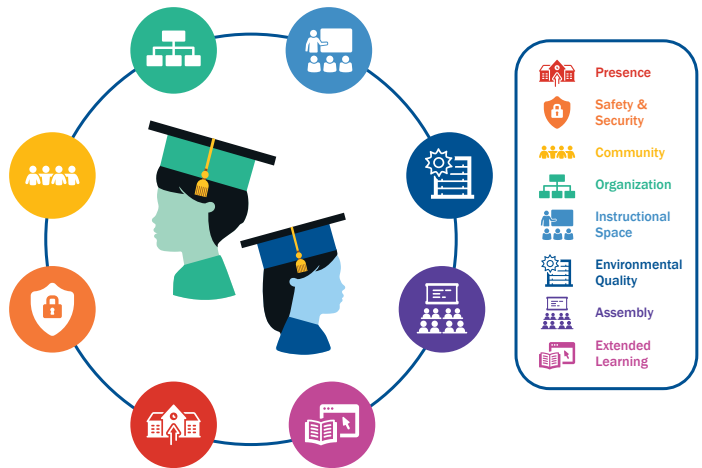
Study Findings | Educational Adequacy

I t is important that schools be considered safe, healthy, and attractive places where students feel they can thrive.[27] Further, research has found that schools in better physical condition and that had taken steps toward modernization had higher teacher retention rates compared to buildings that were non-modernized and/or had poor physical conditions.[28] Also, when Educational Adequacy (EA) is low, it has been recognized as a barrier for teaching and the implementation of specialized curricula—a key component for meeting 21st-century learning goals.[29]

To answer the study's research question regarding EA, data were collected using an occupant questionnaire and a visual assessment tool (VAT), which we created for this study. The VAT evaluated EA across eight categories: Presence, Safety and Security, Community, Organization, Instructional Space, Environmental Quality, Assembly, and Extended Learning Environments. The VAT's category-based scores were equally weighted and compiled into an overall summary score for each school. Analysis of these scores revealed that the modernized schools generally outperformed the non-modernized schools by statistically significant margins.

Significant differences were also found among students' questionnaire responses, in that modernized schools were considered more favorably in terms of the presence of the school, the organization of the building, the sense of community within the building, the ambiance of the classrooms, and the perceived safety of the buildings and grounds.

The visual assessment tool created for this study featured 234 questions to assess eight factors defining the Educational Adequacy of a school's learning environment.

Based on the VAT data and student questionnaire responses, we found that **the modernized schools generally outperformed the non-modernized schools in terms of Educational Adequacy**, particularly regarding school presence, building organization, the sense of community within the building, classroom ambiance, and the perceived safety of the school buildings and campuses.
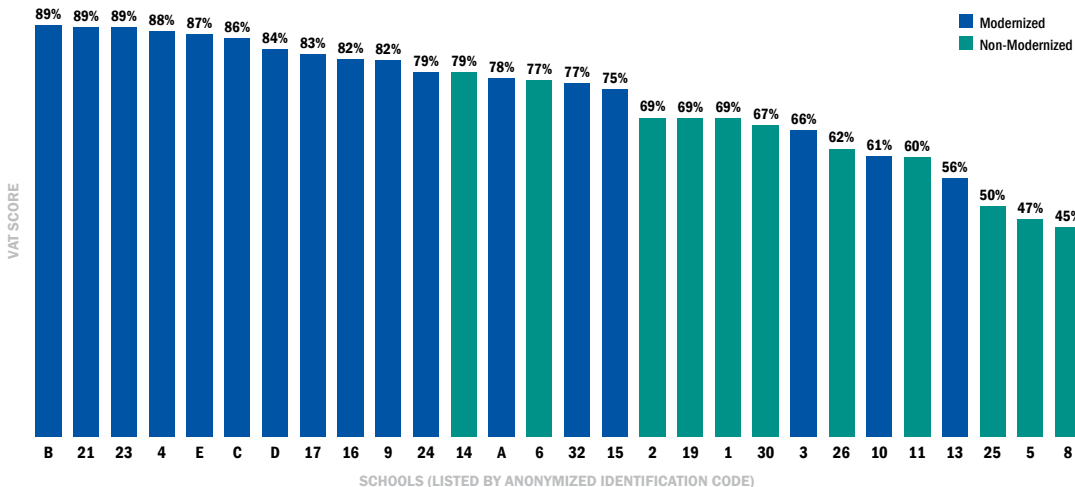
This chart shows the visual assessment tool's overall summary scores for all 28 schools in the sample, listed here by their anonymized identification code. The higher the percentage indicates the greater the Educational Adequacy, such that a score of 100% would equate to the best possible summary score on the visual assessment tool. As can be seen, modernized schools generally outperformed the non-modernized schools.

Instructional Space

The Instructional Space category of the VAT assessed classrooms' size and shape; evident mode of instruction and presentation capability; educational technology; furniture and fixtures; display areas and opportunities for personalization; biophilic elements, windows, and exterior views; transparency/connectivity; ambiance in terms of infrastructure; ambiance in terms of color and finishes; materiality; and cleanliness and odors.

- Instructional Space–Ambiance–Infrastructure had a statistical effect size* of 0.76. For example, modifications to a school's infrastructure, like an HVAC unit that blocks a window and adds unsightly conduit to a classroom, were often found to negatively impact the VAT scoring for an instructional space's ambiance.

- Instructional Space–Ambiance–Color and Finishes had a statistical effect size of 0.58. For example, an accent color on a wall can add to a "warm" ambiance and helps reduce visual monotony and eases eye strain.

- A significant correlation was found between modernization status and students' feelings about their classrooms, with students in modernized schools rating classrooms more positively than their peers in non-modernized schools.

* For this study, effect sizes of 0.10 to 0.29 were small effects, 0.30 to 0.49 were moderate effects, and 0.50 or greater were large effects. The greater the effect size, the greater the practical, real-world application.

Presence

The Presence category of the VAT assessed the first impression or "civic presence" of the building and its site, plus a school's ability to be welcoming to the surrounding community.

- In this category, all but one of the modernized schools in the study's sample ranked higher than the non-modernized schools.
- Presence–Architecture had a statistical effect size of 0.75. For example, the modernized buildings often had external security apparatus and HVAC installations that were visually unobtrusive, windows that were clean and clear, the building appeared generally well-maintained, and embodied civic architecture (which feels "important").

- Presence–Entry had a statistical effect size of 0.59. The modernized and non-modernized buildings differed notably when it came to the ease of identifying a school's primary entrance, whether that entrance was inviting, and whether there were sight lines from within the building to supervise people approaching.
- Presence–Community Access had a statistical effect size of 0.45. Non-modernized schools in the sample often lacked the ability to close and lock doors to limit after-hours access between community-facing spaces and the rest of the building. In addition, modernized buildings more often had "impressive" community-facing facilities, such as gyms, auditoria, and dining spaces.

Safety and Security

The Safety and Security category broadly assessed sightlines, transparency, program locations, and other factors that represent both "hard" and "soft" approaches to school safety.

- Overall, all but four of the modernized schools rose to the top of the VAT scoring in the category of Safety and Security.
- Safety and Security–Entry had a statistical effect size of 0.59. The modernized buildings notably allowed for greater supervision of the approach to their entrances and provided more welcoming, well-designed, and secure entry vestibules that control visitor access.

- Safety and Security–Building Design had a statistical effect size of 0.38. For example, modernized buildings had more clearly identifiable "front doors" (main entrances) than non-modernized schools.
- Students in modernized schools reported feeling significantly safer compared to those in non-modernized schools, both inside and outside the buildings.

Community

The Community category of the VAT assessed aspects that help foster a sense of a strong learning community within the school.

- Among the ten highest-scoring schools in this category, all but one were modernized.
- Community–Assembly Space had a statistical effect size of 0.42. For example, a school may provide a "heart" of the school where the whole school can gather, typically at a crossroads that organizes assembly and other publicly oriented spaces, and that connects multiple levels of the school.

- Students in modernized schools said their building contributed to a feeling that they belonged to "one big community."
- Students in modernized buildings reported their schools to be friendlier and more welcoming compared to the questionnaire responses from students in non-modernized schools.

Organization

The Organization category of the VAT assessed the overall academic organization of the school.

- Organization–Main Office had a statistical effect size of 0.57. The main office location (adjacent to the school's front door and directly accessible from the entry lobby) and its ability to control the entrance and limit public access to the rest of the school was the greatest organizational differe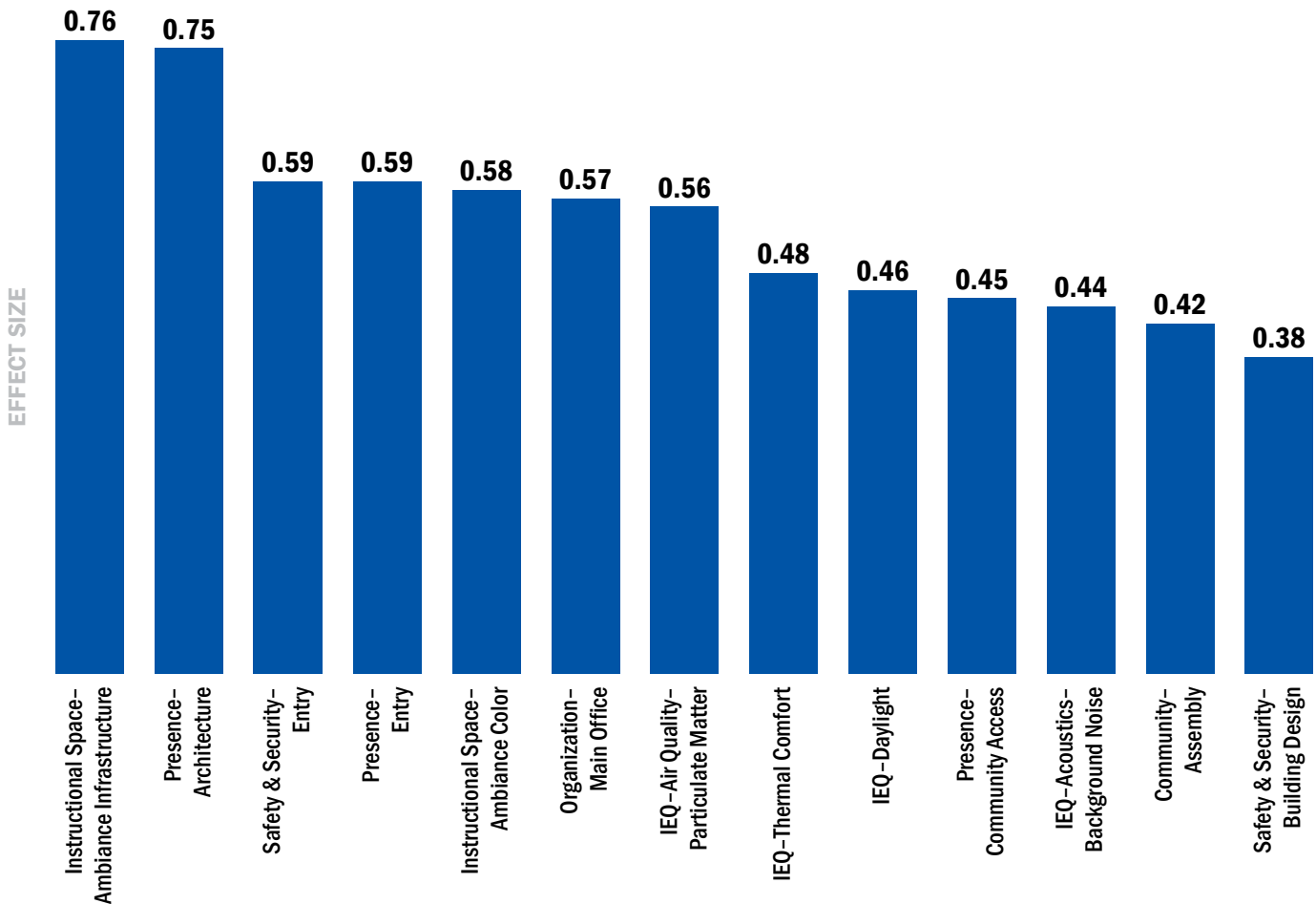nce between the modernized and non-modernized schools. This variation was not surprising, however, considering non-modernized schools were constructed when design principles regarding arrival into a school were notably different from more recent standards.
- Students in modernized schools reported wayfinding to be significantly easier compared to the ratings from those in non-modernized schools.

VAT and IEQ Effect Sizes

We found that school modernization made a significant impact across multiple Indoor Environmental Quality and Educational Adequacy factors. The greatest differences between modernized and non-modernized schools occurred within the following areas:

- Instructional space ambiance in terms of infrastructure, color, and finishes
- Exterior presence in terms of the building's architecture, entry, and community access

- Safety and security in terms of the building's entry and overall design
- Community assembly space
- Main office location
- IEQ properties of thermal comfort, air quality in terms of reduced particulate matter, acoustics in terms of background noise, and daylight

EFFECT SIZE

Category	Effect Size
Instructional Space–Ambiance Infrastructure	0.76
Presence–Architecture	0.75
Safety & Security–Entry	0.59
Presence–Entry	0.59
Instructional Space–Ambiance Color	0.58
Organization–Main Office	0.57
IEQ–Air Quality–Particulate Matter	0.56
IEQ–Thermal Comfort	0.48
IEQ–Daylight	0.46
Presence–Community Access	0.45
IEQ–Acoustics–Background Noise	0.44
Community–Assembly	0.42
Safety & Security–Building Design	0.38

This chart shows the effect sizes of the statistically significant aspects of school modernization across multiple Indoor Environmental Quality and Educational Adequacy factors, where the larger the effect size indicates the finding has greater practical, real-world application.

Study Findings | Community Connectivity

The connectedness that students feel to their school has been shown to help establish positive behavior patterns and life choices for their current and future health.[30] Schools also play important roles that transcend the core mission of educating children. Having traditionally served as anchors for their communities, schools are also connecting points for people in the surrounding neighborhoods. Researchers have found this concept of Community Connectivity (CC) to be critical to sustaining a vibrant town or city.[31,32]

During times of community-wide upheaval, schools also become "sites and sources of community resilience in five distinct ways: they distribute social welfare services, promote human development, care for children, provide stable employment, and strengthen democratic solidarity."[33] The United Nations has also recognized schools as an important mitigating factor in disaster response.[34] As whole child well-being in a 21st-century learning environment becomes a critical priority for schools across the nation, we must focus our attention on how existing school buildings, plus new or renovated ones in the future, can encourage Community Connectivity.[33,35]

Although the CC-related questionnaire data were insufficient for true statistical analysis (primarily due to the study's COVID-19 pandemic-related challenges) and there were a limited number of interviews and focus groups with community stakeholders and students' parents/caregivers (for whom the demographic characteristics of the participants may not have been representative of a school's overall parent/caregiver population), **the study suggests that modernized schools tend to provide more Community Connectivity than non-modernized schools.**

We learned that the majority of parents/ caregivers associated with modernized schools felt their school:

- Is a hub for neighborhood activities
- Provides a community anchor for the neighborhood
- Attracts people to the neighborhood
- Is a physically attractive addition to the neighborhood
- Served as an important source of information and/or services during the COVID-19 pandemic

The majority of parents/caregivers associated with non-modernized schools explained to us:

- Their school is a provider of important neighborhood services
- The community's perception of their school changed in a positive way during the COVID-19 pandemic

Schools play important roles in communities, transcending their core mission of educating children.

There is a need to gather more data to support or clarify this study's CC findings. A broader audience of community stakeholders should also be engaged, given this area of the study was the most impacted by COVID-19 pandemic-related limitations to the methodology. However, based on the data that were collected regarding CC, there are several observations worth making:

- Perceptions of the physical condition and spaces within the school buildings did matter in how community members (i.e., parents/caregivers and external stakeholders) viewed the school overall.
- Parents/caregivers who may never have considered sending their children to a particular school can be swayed by the school's modernization.
- The modernization process, if done well, can result in greater CC once the work is completed.
- Partnerships between schools and outside entities, as well as the presence of external partners on the school's campus, can enhance CC regardless of whether a school has been modernized or not.
- A school's outdoor spaces play a considerable role in developing or contributing to CC and should not be overlooked.

The two-way-street between the community and the school makes this relationship complex and hard to fully understand. For example, participants who expressed negative opinions were willing to dismiss poor physical conditions in a non-modernized school because they had so many other positive feelings about it. Even community members who made statements like "the building does not reflect what the school actually does" were prone to add that modernization could only serve to enhance the positive aspects of the school's operations. Thus, we came to understand that Community Connectivity can exist whether a school is modernized or not—but overall, modernization seems to be a positive factor in supporting this phenomenon.

Community Connectivity can exist whether a school has been modernized or not. However, modernization seems to be a positive factor in supporting this phenomenon.

Study Findings | Archival Data

In addition to the data we collected ourselves for this study, we also examined existing archival data from the two school districts, including enrollment, truancy, graduation rates, and student scores on the Partnership for Assessment of Readiness for College and Careers (PARCC) test. For some of our analyses, only data about DCPS schools were available. Our goal was to determine what relationship, if any, exists between these performance indicators and a school's modernization status. Our analyses did not test for correlation but instead were used to determine whether there are general differences on each measure over time for modernized versus non-modernized schools.

In the school enrollment category, modernized schools had significant enrollment increases over time; non-modernized schools did not. Thus, the data show that a school's enrollment is likely to increase over time after a school is modernized. For student performance on the Partnership for Assessment of Readiness for College and Careers (PARCC) test, significant improvements in English language arts and mathematics scores over time were found for students attending modernized schools.

In the areas of truancy and graduation rates, the research team found mixed results. For truancy, there was a significant increase over time for students attending modernized schools—a finding that ran counter to our expectations. There was no significant difference in truancy over time for students attending non-modernized schools. Graduation rates improved over time at most of the modernized schools, but these increases were not statistically significant. We could not analyze graduation rates at non-modernized schools nor compare non-modernized to modernized schools due to insufficient data.

From these analyses, we concluded that **students in modernized schools had better English language arts and mathematics test scores; and modernized schools experienced significant growth in enrollment, while graduation rates also trended upward.**

About the Study

Conducted between 2019 and 2023, we employed a multi-method approach plus a literature review for the study. Data collection included: IEQ data logging with live measurements; visual assessments, with floor plan analysis and photography; stakeholder questionnaires; stakeholder interviews and focus groups; and an analysis of archival data regarding community socio-demographics, school enrollment, truancy, graduation rates, and test scores over time. Of note, multiple aspects of the originally planned methodology, data collection tools, and study timeline had to be adjusted given the challenges of conducting the study during the COVID-19 pandemic. Still, we believe this study has yielded important insights and valuable information.
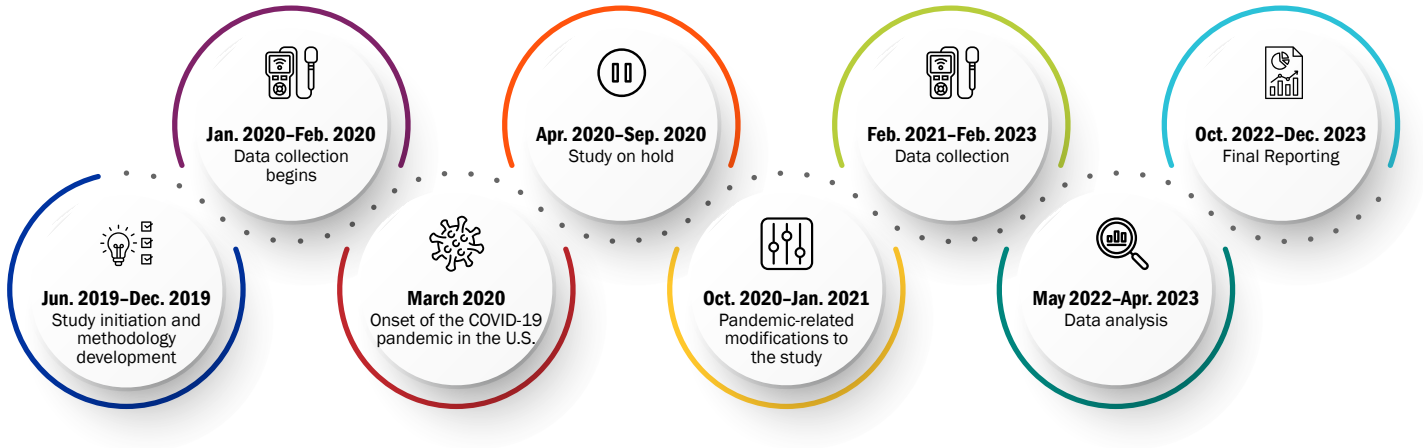
We collected data in 28 schools, from their internal and external stakeholders, and from the schools' surrounding neighborhoods. The sample was selected from a single pool of potential sites within two urban school districts: Baltimore City Public Schools (BCPS) and District of Columbia Public Schools (DCPS). School selection was based on a set of inclusion and exclusion criteria, with the goal of obtaining comparable schools between both the modernized and non-modernized groups.

Typical of many urban school districts on the east coast of the United States, many of the schools in the sample are housed in buildings that were constructed mainly in the periods of 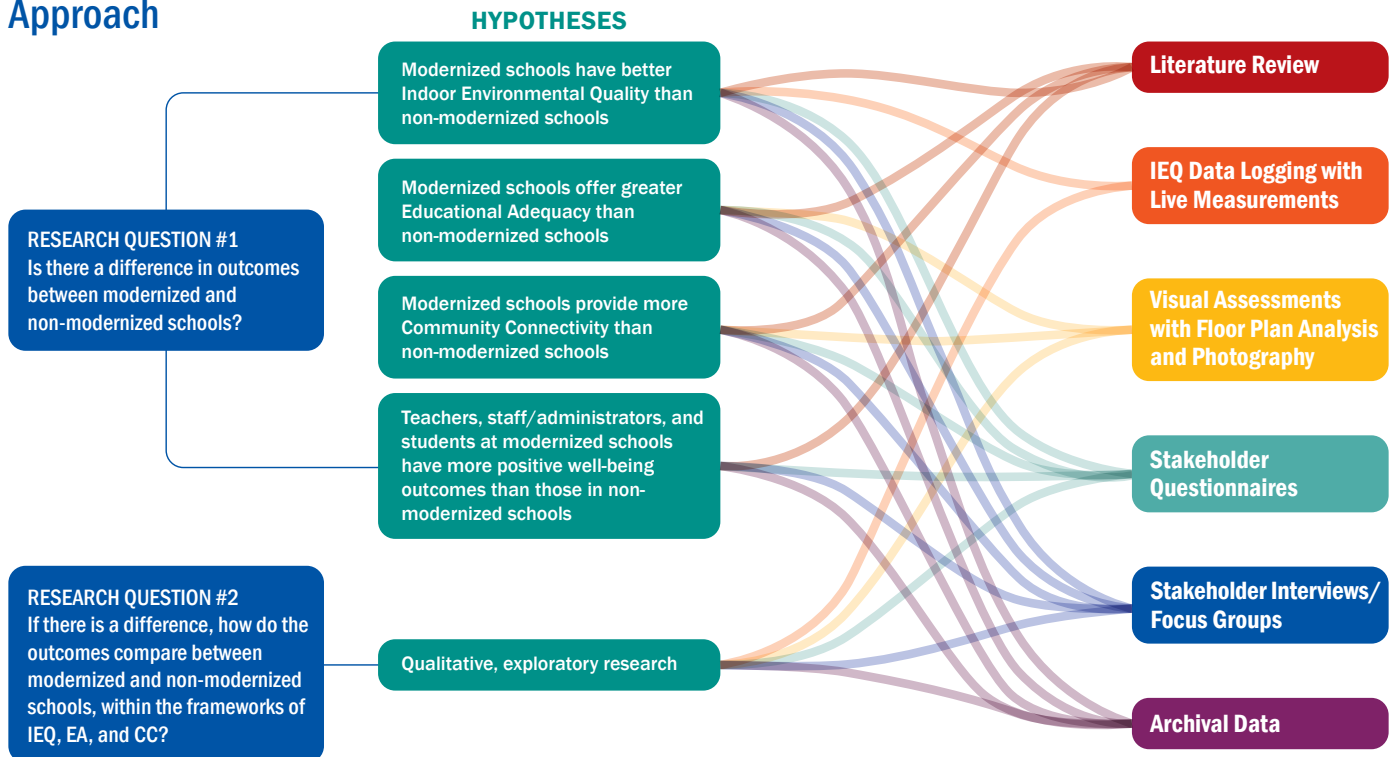1920-1940, 1960-1980, and 2000-2010. The modernized buildings included facilities that were renovated and often expanded, as well as several new buildings that replaced prior facilities. While some of the non-modernized buildings had additions constructed or minor improvements made to such things as furniture or interior finishes plus some capital reinvestment over time, that work had occurred sufficiently long ago or in such minor amounts for the building to be considered non-modernized at the time of the study.

This study was conducted by a multi-disciplinary team of researchers from the global design firm Perkins Eastman and the Drexel University School of Education. The research team also included faculty from Drexel University's Dornsife School of Public Health and the Architecture program at Drexel University's Westphal College of Media Arts and Design, along with statistical analysis by Invontics. This work was supported by BCPS and DCPS and done under the auspices of the Drexel-based Consortium for Design and Education Outcomes (CDEO). A grant for this study was awarded by the American Institute of Architects College of Fellows Latrobe Prize with additional funding provided by J+J Flooring.

Study Timeline

Jun. 2019–Dec. 2019
Study initiation and methodology development

Jan. 2020–Feb. 2020
Data collection begins

March 2020
Onset of the COVID-19 pandemic in the U.S.

Apr. 2020–Sep. 2020
Study on hold

Oct. 2020–Jan. 2021
Pandemic-related modifications to the study

Feb. 2021–Feb. 2023
Data collection

May 2022–Apr. 2023
Data analysis

Oct. 2022–Dec. 2023
Final Reporting

Methodological Approach

HYPOTHESES

RESEARCH QUESTION #1
Is there a difference in outcomes between modernized and non-modernized schools?

Modernized schools have better Indoor Environmental Quality than non-modernized schools

Modernized schools offer greater Educational Adequacy than non-modernized schools

Modernized schools provide more Community Connectivity than non-modernized schools

Teachers, staff/administrators, and students at modernized schools have more positive well-being outcomes than those in non-modernized schools

RESEARCH QUESTION #2
If there is a difference, how do the outcomes compare between modernized and non-modernized schools, within the frameworks of IEQ, EA, and CC?

Qualitative, exploratory research

Literature Review

IEQ Data Logging with Live Measurements

Visual Assessments with Floor Plan Analysis and Photography

Stakeholder Questionnaires

Stakeholder Interviews/ Focus Groups

Archival Data

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Refer to the full report for more information about the study, including the sample, methodology, findings, limitations, suggestions for further research, and resources for study replication.

CLICK OR SCAN WITH YOUR SMARTPHONE TO DOWNLOAD THE FULL REPORT ABOUT THIS STUDY

Image Credits

The locations and names of the schools pictured in the photography used throughout this report are not identified because the schools participating in this study were anonymized for publication. In addition, the photographs herein are intended to be exemplars and, therefore, do not necessarily reflect the actual schools that participated in the study.

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We welcome further inquiry about the study and how to apply the findings to the modernization of schools.

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