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Learning by Design, Design by Learning: an investigation into (re)designing a Rochester school for the future of learning

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Learning by Design, Design by Learning

an investigation into (re)designing a Rochester school for the future of learning

A Master of Architecture Thesis
Presented by
Catherine C. Lange

Submitted to the Rochester Institute of Technology
Golisano Institute for Sustainability
Department of Architecture

MASTER OF ARCHITECTURE

December 2015

Date of Approval:

____________________
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Thank you also to Dennis A. Andrejko, FAIA for your insight and guidance.
ABSTRACT

“You can’t expect children to learn 21st-century skills in schools built for the 1950s. We need schools designed for 21st-century success.”
- Chad P. Wick, president and CEO, KnowledgeWorks Foundation

School buildings and their learning environments have remained relatively static over time. Many of the classrooms still in use today were built for traditional, “chalk-n-talk” pedagogies and passive learning; they are not prepared for today’s more active learning approaches.¹

Innovative schools are beginning to adopt new curricula and pedagogical strategies that align with research being done on student learning outcomes. In Rochester, New York, an initiative called the Rochester Schools Modernization Program (RSMP) has secured $325 million from New York State for Phase I of an effort to redesign, renovate and update 12 existing schools. Later phases will address the remaining schools in Rochester, NY.

How can physical environments accommodate these new learning models, and continue to inspire students? School developers and designers are rethinking all physical resources to create “breakthrough environments”: ones where their new school models can thrive and where students can be fully engaged in their learning.² Because students will continue to spend less seat time in traditional classrooms, new school designs are built to foster learning anytime and everywhere, through both purposeful and unscheduled social interaction.³

This thesis will combine research of how students learn, environmental factors of learning, and the benefits of sustainable schools into a schematic redesign of Nathaniel Hawthorne School #25, a struggling elementary school in Rochester, New York. This school building redesign will then serve as a model for the Rochester School Modernization Project (RSMP), offering insights and researched ideas that will support the project as a whole.

¹ Active Learning Spaces: insights, applications & solutions. Steelcase
³ Jodi Lewis. E3 Civic High School. Next Gen Tools
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INTRODUCTION + CONTEXT
INTRODUCTION

“Our education system looks a lot like the U.S. auto industry in the 1970s, stuck in a flabby, inefficient, outdated production model.”
- Michael Bloomberg, former mayor of NYC

In 2007, the public perception of schools in the U.S. was the lowest in recorded history. How did we get here? Let’s start by taking a quick look at the beginning; how schools came to be. Louis Kahn defined the beginning of school by stating, “Schools began with a man under a tree who did not know he was a teacher, sharing his realization with a few others who did not know they were students. The students reflected on what was exchanged and how good it was to be in the presence of this man. They aspired that their sons also listen to such a man. Soon spaces were erected and the first schools became.” Education was once for the elite and intellectual, an option for the intellectually curious. After World War II, schools quickly transformed into a factory-like model—where we began pushing all American children through a series of requirements and forcing them to sit tethered to their desks.

School buildings and their learning environments have remained relatively static over time. According to Louis Kahn, architect, “The rooms required by our institutions of learning are stereotypical and uninspiring. The Institute's required uniform classrooms, the locker-lined corridors and other so-called functional areas and devices, are certainly arranged in neat packages by the architect who follows closely the areas and budgetary limits as required by the school authorities. The schools... are shallow in architecture because they do not reflect the spirit of the man under the tree.”

The majority of our schools are decades old, and have not undergone a major redesign since they were originally built. These classrooms were built for traditional, “chalk-n-talk” modalities and passive learning. They are not prepared for today's more active learning approaches. The United States has over $2 trillion invested in its school buildings, the majority of which were designed as "cells and bells." Cells are the classrooms students inhabit until the bell rings, at which point they

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7 Steelcase. Active Learning Spaces: insights, applications & solutions.
8 Nair, Prakash. "Blueprint for Tomorrow: Redesigning Schools for Student-Centered Learning."
move on to another cell. This model for schools has been prevalent for over a century, finding its roots in the Industrial Revolution and large-scale manufacturing ideals. This school model is considered "teacher-centered," because it is designed around an educator who delivers content to a passive audience of listeners.9

* * *

Teacher-centered education is the pedagogical model found in the majority of our schools today. It is based on the crude idea that children must be continuously engaged with a teacher in order to learn, and that a school's primary purpose is to teach students a specific quantity of information. Student-centered learning, however, is a wholly different philosophy of education. In this model, the teacher becomes a facilitator rather than a lecturer. Students take charge of their own education, developing skills and knowledge for applied learning. Student-centered learning encompasses many modalities, including project-based learning, personalized, competency-based, and other new pedagogical models. John Dewey and Maria Montessori are two familiar educational theorists who influenced the student-centered learning approach through the twentieth century.10

Student-centered education has gained momentum recently, in part due to the rise of technology. One-to-one devices allow students to work at their own pace, on a personalized content area. Technology also affords the ability to better keep track of individual student progress. Computer programs exist now that let teachers watch each student's personalized curriculum, their progress on problems designed for their skill level, and give real-time feedback. Student-centered education gets students more actively engaged in their learning, which has been proven time and again to help them learn better.11 In addition, the knowledge and competencies required in today's 21st-century economy are vastly different from those required even one generation ago. Schools have been failing to keep up with teaching these technology-driven skills.12 Student-centered learning allows students to explore and integrate with technology that will prepare them for their future careers.

* * *

9 Kohn, "The Schools Our Children Deserve."
11 Gerver, Richard, "Creating Tomorrow's Schools Today: Education--Our Children--Their Futures."
Architect Trung Le explained the need to rethink school design at a TED Talk in June, 2013.

“The way that we’ve been designing schools or placing kids in an environment over the last one hundred years, we’ve completely forgotten about ‘do no harm’. We have been placing our children in rigid furniture, in straight rows, looking at the front wall and asking them not to move or talk—unnatural to the way humans and living systems work. We need to move from do no harm to do good only. If we’re able to make that shift, we can begin a new era of how we can design learning environments. We must focus on how children want to learn.”

* * *

Innovative schools are beginning to adopt new curriculum and teaching strategies that align with current research being done on student learning outcomes. We are at a point in history where technology is advancing rapidly and becoming widely available for classroom use and application. The two modalities of blended learning and competency-based learning are gaining momentum in terms of classroom adoption, but their spatial requirements are different from traditional classrooms. **Blended learning** is the idea of incorporating technology into classrooms as a teaching tool, blending technology and in-person time for students. **Competency-based learning** is the idea of “transitioning away from seat time, in favor of a structure that creates flexibility, allows students to progress as they demonstrate mastery of academic content, regardless of time, place, or pace of learning.” In competency-based systems, schools get rid of credit hour requirements and move toward self-paced modules based on mastery of material rather than seat-time.

How can physical environments accommodate these new learning models, and continue to inspire students? School developers and designers are beginning to rethink school design to create “breakthrough environments”: ones where their new teaching models can thrive and where students can be more engaged in their learning. Assuming students will continue to spend less

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14 Competency-Based Learning or Personalized Learning. U.S. Department of Education.  
seat time in traditional classrooms, new school designs are built to foster learning anytime and everywhere.16 The main idea behind Cannon Design's *The Third Teacher*17 book and project is that learning happens when students interact with a teacher, they learn both content and social concepts from fellow students, and immense learning comes from the environment itself.

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16 Jodi Lewis. E3 Civic High School. Next Gen Tools
**CONTEXT**

“And when they look around and see that no one has lifted a finger to fix their school since the 19th century; when they are pushed out the door at the sound of the last bell... is it any wonder they don’t think their education is important?”
- Barack Obama, president of the United States

The Rochester City School District (RCSD) serves approximately 33,000 students pre-kindergarten through grade 12. As of 2010, RCSD owned and maintained 51 school buildings, six non-school facilities, and leased four facilities. The average age of the district’s school buildings is now 70 years. Over forty percent (22 buildings) have some portion of the building that is more than 85 years old. Approximately twenty-five percent (25%) are at least 75 years old. More than fifty percent (50%) are over 60 years of age. Even the most recent schools were built in the mid- to late-1990s and are now nearing 20 years of age. These buildings are not built for current teaching and learning practices, are not energy efficient, and at the time of their design, the infrastructure for today’s technology needs did not exist.18

The Rochester City School District was ranked 672nd out of 673 New York State school districts, beating out just one district on Long Island for students meeting standards on state tests.19 Nathaniel Hawthorne School #25 is an elementary school serving 327 students in the RCSD Northeast zone, and covers 35,911 square feet on 3.37 acres. The building was built in 1914, making it just over 100 years old. While the school is not officially listed on the historic registry of New York, the community has expressed pride and an affinity for the historic style of the building façade.

Nathaniel Hawthorne School #25 is ranked 1,994th of 2,307 elementary schools in New York State (NYS), which equates to performing worse than 86.4% of schools in NYS. From 2013-2015, on average thirty-one percent (31%) of third graders in NYS met the math and reading standards on the standardized tests. However, in Nathaniel Hawthorne School #25, just 4-5% of students met the standards.20 This struggling elementary school is just one of 37 in Rochester that would benefit from some design intervention.

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18 Comprehensive School Facilities Modernization Plan for Rochester City Schools
19 Http://www.schooldigger.com/go/NY/schools/2475003398/school.aspx
20 Http://www.schooldigger.com/go/NY/schools/2475003398/school.aspx
In Rochester, New York, an initiative called the Rochester Schools Modernization Program (RSMP) has secured $325 million from New York State for Phase I of an effort to redesign, renovate and update 12 existing schools. Later phases will address the remaining schools in Rochester. This initiative is based on the idea that we need to adapt Rochester’s existing school buildings to accommodate 21st-century learning. It is time-consuming and expensive to build new schools, but how can we use the ones we already have and redesign the spaces to be better for students and teachers?

This thesis combines research on how students learn, environmental factors that affect and enhance learning, and explores the benefits of sustainable schools into a schematic redesign of Nathaniel Hawthorne School #25. This redesign will then serve as a model for the Rochester School Modernization Project (RSMP), offering insights and researched ideas that will support the project as a whole.

By transforming the physical learning environment of Nathaniel Hawthorne School #25, learning has the potential to be transformed for students. We can recapture existing school buildings in Rochester and create new spaces that inspire learning, are more sustainable, and are adaptable to the changing educational landscape.

Figure 1: NY State Assessments Test Scores for School 25 vs. NYS Average
1: THE NEED FOR SCHOOL REDESIGN
PART 1: THE NEED FOR SCHOOL REDESIGN

“If we teach today as we taught yesterday, we rob our children of tomorrow.”
- John Dewey

BASIC NEEDS OF SCHOOLS

According to Maria Montessori, the thought leader behind Montessori Schools, and Reggio Emilia approach founder Loris Malaguzzi, “everything that is material affects the child’s temperament and development. In a conducive environment, a child can learn many things without being taught in traditional ways.”21 School can no longer be a series of classrooms connected by a locker-lined hallway. Instead, they need to be designed with students’ learning in mind.

“Children learn best when they interact in a rich environment with other people.”22 It is generally understood that humans have several basic needs for learning. First, we need to feel safe and secure—environments need to be nurturing, inspiring and supportive. Second, we need to feel personally connected and engaged—passion and motivation allow innovation and creativity.23

After those environmental prerequisites are met, the environment has the ability to either simply conform and perform at a baseline level, or truly inspire students to take charge of their learning. “Anywhere, anytime learning” is the idea that learning is not confined to classroom walls. Instead, students are learning from one another and their environments, between classes and after school. A school building can be designed to foster interactions among students outside of classrooms by allowing various types of congregation spaces, varying hallway widths to allow students to gather, and plenty of varied seating opportunities.

Salman Khan, founder of the Khan Academy, imagines future learning spaces to be drastically different from what we see today. He envisions “schools in the cloud” as glass pods filled with computers and a single large screen to allow moderators to video-call in, in order to play a role in the students’ education.24 Salman Khan asks, “do we have to separate classrooms anymore?”

According to the Next Gen Learning organization, the best learning environments should include the following types of spaces and features:25

21 Muller, Dr. Thomas, CEO, VS Furniture. The Third Teacher, pg. 18
25 Http://nextgenlearning.org/blog/can-physical-spaces-inspire-innovation
• Walls: glass walls, movable partitions, and floor-to-ceiling whiteboard surfaces
• Main staircase: a traveling path and a gathering space
• Learning Studios: clustered around a “Village Commons”
• Tech: students connect their 1:1 laptops to media screens throughout the school
• Furniture: movable chairs and tables
• Nooks: informal spaces for working alone or in small groups

The Academy of Neuroscience for Architecture in San Diego, a collaboration of neuroscientists and architects, claims that there is evidence that certain types of spaces promote the growth of new neurons in humans. Their research looks at how architects could, with the use of color, lighting, and layout, design spaces that improve brain responses and increase learning. A 2007 study by Joan Meyers-Levey shows how architecture can influence brain process. In it, she demonstrated that a lower ceiling height promotes greater attention to detail, while higher ceilings promote greater abstract and creative thinking.26

The age of school buildings themselves can also have a significant effect on student performance. This has been attributed to newer buildings being equipped with better lighting, better thermal comfort and air quality, and more advanced laboratories and libraries.27 One study found that eighth-graders scored consistently higher on standardized tests in new or modernized buildings.28 Another study found significant gains in math scores when students were housed in improved school facilities.29

In addition to the general building design requirements, the specific spatial qualities of a school building have been heavily researched and show significant effects on student performance. The four fundamental categories for spatial quality research for this thesis include daylight, temperature and control, acoustics, and indoor air quality. In addition, sustainability and learning outcomes is also addressed.

DAYLIGHT AND LEARNING OUTCOMES

Research has proven that the quality of educational facilities affects learning outcomes. Until the 1950s, daylight was the predominant source of light in classrooms. But, as electricity costs declined, so did the use of natural light in buildings. In a study comparing daylight in classrooms and holding other factors constant, student performance in the classrooms with the most daylight increased by twenty-one percent (21%) when compared to the least. This particular study covered over 2,000 classrooms in three districts, offering a relatively large sample size upon which to base these findings. Another report, published in the National Clearinghouse for Educational Facilities, states that “students with limited classroom daylight were outperformed by those with the most natural light by twenty percent (20%) in math and twenty-six percent (26%) on reading tests.”

Natural light has proven to be a significant factor in happiness and performance in the workplace and at home, and we need to begin bringing daylight back into schools.

Increasing daylight while eliminating glare has been a goal in green building, as the positive impacts of daylight in buildings are well understood. A 2004 study on green building productivity issues found that "workers in offices without glare outperformed workers in offices with glare by 15% or more." While daylight is hugely beneficial, glare can have unintended consequences of eye strain and temporary blinding. Balancing the amount of light coming into a building is important so that natural light is prevalent without causing these adverse effects.

*   *   *

"Children are growing, their organs are developing, and they breathe more air relative to their body size than adults, and as a result sustain greater health problems and risks than adults from toxics and pollutants common in schools."  

Asthma is the leading cause of absenteeism in schools, responsible for more than 20 million missed school days in the U.S. per year. To prove the effect clean air has on students, one study simply installed an electromagnetic air cleaner in classrooms — absenteeism then dropped from 8.3% to 3.7%. After the air purifier was removed, the rate jumped back up to 7.9%. Another study across 1,100 schools in Canada yielded similar results showing a link between environmental quality and student commitment and morale, teacher commitment, disruption in class by students, and teacher expectations of students.

The link between air quality and performance is believed to be logical: poorer air quality causes sick teachers and students, and sick people don't perform as well as healthy people in school. The indoor air quality (IAQ) symptoms often seen in schools include irritated eyes, nose and throat, upper respiratory infections, nausea, dizziness, headaches and fatigue, and general drowsiness. These are often collectively referred to as “sick building syndrome.” The Occupational Safety and Health Administration (OSHA) recommends a minimum air refresh rate of between fifteen and twenty (15-20) cubic feet of air, per minute, per person. This standard came into effect in the late twentieth century, after many school buildings were already in use. Therefore, many older buildings do not meet this minimum requirement.

*   *   *

38 EPA. Indoor air quality and student performance.
THERMAL COMFORT AND LEARNING OUTCOMES

Temperature and humidity affect IAQ in many ways, perhaps most significantly because their levels can promote or inhibit the presence of bacteria and mold. For example, a study of Florida classrooms with relative humidity levels greater than seventy-two percent (72%) found visible mold growth on the ceilings and complaints of allergy symptoms associated with sick building syndrome.40

A 1970 study done in Saskatoon, Saskatchewan, Canada, found absenteeism was reduced in schools by twenty percent (20%) as relative humidity in the facilities was increased from twenty-two (22) to thirty-five percent (35%).41 Another study found that office workers are most comfortable in the low end of temperature and humidity comfort zones.42 These findings support the idea that students will perform mental tasks best in rooms kept at moderate humidity levels (between forty percent (40%) and seventy percent (70%)) and in temperatures ranging from 68 to 74 degrees Fahrenheit (20 to 23.3 degrees Celsius).43

The chart on the following page shows the results of 14 studies done at Carnegie Mellon University, compiled in 2005, on the impact of temperature control and productivity. The y-axis represents the percentage improvement in productivity as a function of individual temperature control. The studies included in the meta-analysis range from 1992 to 2002. All of these studies show a positive correlation with temperature control and productivity, up to 15%, and with an average improvement of 3.6%.

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Figure 2: Productivity Gains From Improved Temperature Controls

Productivity Gains From Improved Temperature Controls

<table>
<thead>
<tr>
<th>Study Type</th>
<th>% Improvement in Productivity</th>
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<tr>
<td>Desktop Temperature</td>
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</tr>
<tr>
<td>Control</td>
<td>2.7%</td>
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<tr>
<td>Individual Temperature</td>
<td>0.2%</td>
</tr>
<tr>
<td>Control</td>
<td>15.0%</td>
</tr>
<tr>
<td></td>
<td>7.0%</td>
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<td>4.9%</td>
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<td>2.3%</td>
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<td></td>
<td>1.9%</td>
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<td></td>
<td>0.8%</td>
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<tr>
<td></td>
<td>0.7%</td>
</tr>
<tr>
<td></td>
<td>0.6%</td>
</tr>
<tr>
<td>Average</td>
<td>3.6%</td>
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Source: Carnegie Mellon University Center for Building Performance, 2005
ACOUSTICS AND LEARNING OUTCOMES

Many classrooms feature a speech intelligibility rating of 75% or less. That equates to listeners with normal hearing only understanding 75% of words being said.44 “Studies of speech recognition confirm that an adult listener hearing words in the context of a sentence can fill in words or syllables that are not heard clearly. Since children have smaller vocabularies, they are less able to fill in the words not heard clearly.”45 Some recommendations for good classroom acoustics include:46

- Ceiling: Acoustical ceiling tile with a noise reduction coefficient (NRC) of 0.7 or higher
- Side Walls: Surface-mounted panels with sound-absorbent or sound-diffusive cores
- Front Wall: Hard surface to reflect sound to rear of classroom
- Rear Wall: Surface-mounted fabric-wrapped panels with sound-absorbent cores
- Floor: Sound-absorbing materials, ie. carpeting
- Furniture: Soft furnishings help absorb sound

In 2002, the U.S. Architectural and Transportation Barriers Compliance Board wrote of the importance of acoustics in classrooms: “Research indicates that high levels of background noise, much of it from heating and cooling systems, adversely affects learning environments, particularly for young children, who require optimal conditions for hearing and comprehension... In 1999, the Board partnered with the Acoustical Society of America (ASA) on the development of a new standard for acoustics in classrooms... The standard, completed in 2002, has been approved as ANSI/ASA S12.60-2002, Acoustical Performance Criteria, Design Requirements and Guidelines for Schools. It sets specific criteria for maximum background noise (thirty-five decibels) and reverberation (0.6 to 0.7 seconds for unoccupied classrooms). These and other specifications are consistent with longstanding recommendations for good practice in acoustical design.”47

Designing for good acoustics does not need to be complicated. To help meet the ANSI/AIA requirements for schools, simply adding sound-absorbing ceiling clouds and wall panels, area rugs, and soft furnishings can have a dramatic effect on the acoustical design of a classroom.

44 Waldecker, Mark. “Creating Positive, High Performance Learning Environments.” American School & University
45 “Strategies for Enhancing Wanted Sounds” Cannon Design: The Third Teacher
46 Wetherill, Ewart A. “Classroom Design for Good Hearing”
SUSTAINABILITY AND LEARNING OUTCOMES

“All education is environmental education. By what is included or excluded we teach students that they are part of or apart from the natural world.”

- David Orr, Environmental Educator

School buildings represent the largest construction sector in the U.S., totaling $80 billion between 2006 and 2008. We also know that all buildings are responsible for thirty-eight percent (38%) of CO2 emissions in the country. Redesigning school buildings to be more sustainable presents a huge opportunity, both in terms of energy and cost savings, as well as health and performance of students. “Greening school design provides an extraordinarily cost-effective way to enhance student learning,” says Gregory Kats, Managing Principal of Capital E.

According to a 2006 review of 30 green schools, sustainable schools do cost on average ~2% more than conventional school construction, which equates to about $3/square foot (sf). These green schools, however, provide financial long-term benefits that are much greater. In many cases, green schools achieve indirect savings of nearly $70/sf. According to a report co-authored by the American Institute of Architects (AIA) and the U.S. Green Building Council (USGBC), about $12/sf goes back to the school directly in the way of energy savings, lowered water costs, improved teacher retention and lowered health costs. For the average school, these savings would equate to being able to hire an additional full-time teacher. The National Renewable Energy Laboratory (NREL) released a similar research paper, titled "High-Performance Schools: Affordable Green Design for K-12 Schools." In it, they found even greater economic impacts for sustainable school design. They state that on average, green schools save $100,000 annually, which equates to hiring two additional full-time teachers, purchasing 200 computers every year, or acquiring 5,000 new textbooks annually.

The average cost for construction of new schools nationally is $150/sf. Building a green school often has slightly higher costs up-front, due to higher quality materials, more efficient mechanical systems, and the extra time taken to model and optimize the building during the

48 USGBC, “Benefits of Green Schools”
49 Kats, Gregory. “Greening America’s Schools: Costs and Benefits.”
preliminary design process.

A 2005/2006 report of school energy usage found the average cost to be $1.15/sf. Electricity accounted for sixty-three percent (63%) of this total, and natural gas thirty-four percent (34%). See Figure 3 below for a breakdown of Electric and Natural Gas uses in schools, according to Energy Star. Note that lighting alone accounts for twenty-six percent (26%) of electricity demands on average.\(^{52}\) However, one survey of thirty green schools found the average energy reduction to be thirty-three percent (33%), or $0.38/sf per year. In 2003, a study of costs and benefits of green buildings for forty state agencies found that the operations and maintenance (O&M) benefits of greening California public buildings provide savings worth $8/sf over a twenty-year period.\(^{53}\)

Figure 3: School Building Average Energy Consumption

![Figure 3: School Building Average Energy Consumption](image)

Maintenance costs of green schools are inherently lower, due to the increased efficiency. Twenty-first century schools, in particular, are often less expensive to build and operate than traditional schools. They tend to be more efficient with space, using up to fifteen percent (15%) more floor area for teaching and learning, and less for circulation and utilities.\(^{54}\)

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52 [https://www.energystar.gov/ia/business/EPA_BUM_CH10_Schools.pdf](https://www.energystar.gov/ia/business/EPA_BUM_CH10_Schools.pdf)
54 Nair, Prakash. "Blueprint for Tomorrow: Redesigning Schools for Student-Centered Learning."
Benefits of green schools extend beyond the physiological and economic. High performance schools provide hands-on educational opportunities that conventional schools do not. For example, on-site renewable energy generation, water conservation features and other green technologies provide valuable opportunities for hands-on learning.

In a survey of 665 organization executives by Turner Construction, seventy percent (70%) of those in green schools reported reduced student absenteeism and improved student performance. A 2005 study of the cost and benefits of green schools in Washington State estimated a fifteen percent (15%) reduction in absenteeism and a five percent (5%) increase in student test scores.

The Third Creek Elementary School in Statesville, North Carolina provides a good case study on the benefits of a green building on students. This school is our country’s first LEED gold K-12 school, and was completed in 2002. Terry Holiday, the Superintendent of the district, reports, “Third Creek Elementary School replaced ADR and Wayside Elementary Schools, schools that were two of the district’s lowest performing school in regards to test scores and teacher retention/absence. This same group of students and teachers improved from less than sixty percent (60%) of students on grade level in reading and math to eighty percent (80%) of students on grade level in reading and math since moving into the new Third Creek Elementary School. Third Creek had the most gains in academic performance of any of the 32 schools in the school system. We feel that the sustainable approach to this project has had very positive results.” Attributing an over twenty percent increase in student performance to being in a new, sustainable building is an incredible testament to the power of the environment on students and teachers.

David Suzuki, an award-winning scientist, environmentalist, and broadcaster, talks of one noteworthy school north of Toronto. "...they were treating all of their sewage right on site and it was going to plastic pipes that were transparent--you would see this raw stuff going through. I think that's really intriguing. I think that school ought to be a place where you see the world as it really is. To me the most important lesson you learn is that there isn’t the environment out there and me in here. The environment is all around us; it’s in us.”

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58 Cannon Design. “The Third Teacher.” pg. 142
Revealing the way buildings and systems work, by making school infrastructure literally transparent, provides a unique and interesting educational opportunity for students. They could learn the consequences of their actions, watch water and waste flowing to and from the building, and even learn more about how energy and electricity work.

The Collaborative for High-Performance Schools (CHPS) outlines three priority outcomes for green schools: Maximize the health and performance of students and staff; Conserve energy, water and other resources in order to save precious operating dollars; and Minimize material waste, pollution and environmental degradation created by a school.59

59 “National Core Criteria.” Collaborative for High-Performance Schools.
2: THE PROBLEM
PART 2: THE PROBLEM

SCHOOL 25 EXISTING CONDITIONS

The following observations of Nathaniel Hawthorne School #25 help to give context to this design project, by identifying problem areas for the redesign to address:

Existing Site Plan // Nathaniel Hawthorne School #25

The existing school sits on a corner lot in Rochester’s northeast North Marketview Heights neighborhood. The L-shaped building surrounds a central parking lot, used primarily by teachers and staff. On the north side of the building, a small playground sits, hidden from view. The portable building adjacent to the playground currently houses the school’s pre-K students, as the main school building ran out of space for them. A small auxiliary parking lot sits on the north side of the lot as well. The central parking lot is cramped, and may further exacerbate the security concerns of the building.
Observations // Nathaniel Hawthorne School #25

The school is located in an underserved neighborhood of Rochester, NY. Before visiting the school, I was nervous as to what I would find there. But, when I visited the school and met the principal and some outgoing students and teachers, I was taken aback by the overwhelming school pride, and just how well-behaved and attentive all the students were. The school was quiet, and full of students excited to be there and learning. However, the school simply wasn’t meeting their needs. I witnessed a music class taking place in the hallway, one-on-one teaching happening in the nook by the wheelchair lift, and the stage in the auditorium gym converted into a classroom space. The school was severely short on space, and that theme kept popping up throughout the building tour with the principal.

Music class has been relegated to the hallway, as classroom spaces are all spoken for.

The nook by this wheelchair lift is used for one-on-one student meetings with teachers, signifying the lack of private spaces outside of classrooms.

The stage area behind the curtain in the auditorium/gym has been converted into a semi-permanent classroom, again a function of much-needed space.
Lack of variety

The existing school layout is simple and predictable. It is arranged with evenly-sized classrooms off a single, central corridor. For contrast, picture a children's museum and how vastly different it is in design, taking advantage of various sizes and shapes of spaces to inspire and cater to every learning style.

Lack of informal learning areas

Informal learning happens when students interact socially, help one another, or learn to work independently. This school is lacking any spaces outside of the classrooms themselves for students to meet and learn from one another. There needs to be ample space for eating and drinking, reading, studying and relaxing either in the company of other students or alone -- outside of the classroom. Agile spaces will allow students to feel more relaxed.
Classrooms and Hallways model

The current setup is intended for teacher-centered learning models. Hallways take up a significant amount of interior space that is used for only a small percentage of the day. Hallways could be evolved into space for teaching and learning, and in so doing would add nearly 20% more space to the learning environment. Eliminating the rigid separation between hallway and classroom will take back extra space to be used for learning, allowing more flexibility within the classrooms themselves. Nathaniel Hawthorne School #25 is severely lacking space for all its students and activities, so reclaiming the hallways for usable space would make a huge improvement.

Technology

Is technology available outside of classrooms as well as within? At Nathaniel Hawthorne School #25, the central library has a section with desktop computer stations. Technology can and should be better integrated into each individual space, allowing for more personalization of learning. The library shouldn't be the only place where investigation happens, whether formal or informal.
Entry

The experience of entering a building influences how a person feels inside. How and where do students enter their school? Do they feel welcomed and positive? Do those arriving by bus, car and foot feel equally refreshed when entering the school building? At Nathaniel Hawthorne School #25, most students enter through a door in the corner of the "L" of the building, rather than through the visible main entrance. This entry leads directly to two hallways, without creating a feeling of arrival and transition from outside to in.

Daylight

In its original design from 1914, this school building featured large triangular monitors that would have lit the corridors and classrooms from above. It is unclear when those were removed, however what is important is that the original design intent to bring in natural light has been lost. The interior is now entirely lit by overhead fluorescent lights. Each classroom has at least one window, but these are often covered and shielded, for privacy and security reasons in the neighborhood. The analysis on the following page shows the potential for daylighting given the current window configuration. At times, just 16% of the building currently receives enough natural light to avoid artificial lighting, but even that small amount of daylight is kept out by window blinds.

Based on what we know about daylight and its positive impacts on student performance, the redesign needs to bring natural light back into the school. This would have the added benefit of helping to reduce usage of overhead fluorescents, and thereby lowering the energy bill. According to the research, daylight has the ability to improve student performance up to 20-26%. Improving the quality of interior daylight in the building, therefore, is a huge design priority.
Air Quality + Temperature

The existing HVAC system in Nathaniel Hawthorne School #25 is predominantly designed for heating. Given the Rochester climate, for the vast majority of the school year the temperature outside is cooler than the ideal interior environment. The school currently utilizes a steam boiler which is housed in a large HVAC room off the back of the school. The boiler requires a large amount of water, which is converted to steam and heat is forced into the classrooms. With this type of boiler system, the heat for the building is either turned on or off, with little ability to control for individual rooms.

Another drawback of the boiler system is the lack of fresh air. This system does not work to meet the OSHA minimum of 15-20 cubic feet of fresh air per minute, per person. Instead, air turns stale and is kept for longer periods in the classrooms, causing drowsiness and making it more difficult to concentrate.

Existing HVAC room containing the large boiler equipment.

Radiators are seen along exterior walls of the existing classrooms.
Acoustics

Nathaniel Hawthorne School #25 contains many hard surfaces, aside from the acoustic tile ceiling present in classrooms and hallways. The majority of classroom walls are lined with painted gypsum board, floors are hardwood, and the furniture is metal. These hard surfaces create an environment of surfaces that reflect sound. Young children, especially, require very good classroom acoustics in order to learn. Their smaller vocabularies make it more difficult to fill in missing words, and they can be easily distracted by random noises and loud background sounds.

In addition, the existing classrooms at School #25 are incredibly large, and students often huddle up in a corner to form a tight learning circle with their teacher. This small group tactic is a solution to the current acoustical issues with such an expansive space, though there is significant wasted floor area within each classroom.
Addressing these learning environment factors will help to build a stronger academic environment for the students of Nathaniel Hawthorne School #25. Increasing the variety of spaces, creating informal learning areas, reconfiguring hallways, adding better accessibility to technology, and addressing the school's entry will all improve the students' learning by providing more flexible opportunities. In addition to these factors, addressing the environmental factors of daylight, air quality, acoustics and temperature will increase student performance -- based on the compelling research discussed earlier in this paper.

In addition to the environmental factors on the interior, the main building entrance and façade has remained essentially untouched from its original 1914 design. Although the building is not officially listed on the New York State historic building registry, the school community has expressed a deep pride in their historic school building. The redesign will need to preserve this building's exterior identity, respecting the original design intent, while making both exterior and interior improvements.

* * *
3: CASE STUDIES
PART 3: CASE STUDIES

“I think of school as an environment of spaces where it is good to learn.”
- Louis Kahn, architect

The following innovative school design projects are school buildings that were completed in recent years. Each one is a new building that was designed with 21st-century learning in mind. These projects all aim to create learning spaces that don’t conform to traditional ideas of a classroom.

**Concord Elementary Schools, Concord, NH // HMFH Architects // 2013**

Three new school buildings have been built to replace undersized and aging elementary schools in Concord, New Hampshire. The design centered around three main ideas: 1) spaces should support collaborative learning; 2) these spaces should be easily accessible by faculty and students to fully integrate them into the day-to-day learning experience; and 3) spaces should house a range of flexible environments to support a range of learning activities. The design was based on research on brain-based science. Project-based learning is integrated into the daily curriculum, and students are provided a multitude of spaces for group and individual work. Each of the three buildings has a “multi-use Learning Corridor” which promotes collaboration between students and teachers. The open spaces feature lots of natural light, and the updated HVAC system provides fresh air and temperature controls. Soft flooring and high ceilings with sound-absorbing hanging panels help to create a space designed for good acoustics. However, the incredibly high ceilings feel out of scale with the students that attend the school, dwarfing the students in the hallways.

SOURCE: HMFH Architects, Portfolio: Concord Elementary Schools
E3 Civic High, San Diego, CA // LPA Inc. // 2013

E3 Civic High is a new school that was built on two floors of a public library in downtown San Diego, California. The school is a true 21st century space, designed to support personalized and project-based learning. Flexibility and openness are core to the design. The school is a college and career prep high school, where students explore potential career interests through internships with local partners. Locating the school within a library offers a myriad of opportunities, as both organizations support the ideals of lifelong learning and literacy. More than 75% of spaces have access to daylight and views to the outside, which significantly affects student performance.
VITTRA school system, Sweden // Rosan Bosch // 2012

VITTRA is a unique school attempting to ensure learning takes place everywhere on campus, by eliminating classrooms altogether. Telefonplan, an elementary school, opened in 2012 and has no interior walls (aside from restroom and storage areas for privacy). The design of this school is intended to stimulate children's curiosity and creativity, and offer them opportunities for both collaborative and independent time. They are focusing on the ways children like to learn, and the environment becomes the physical manifestation of those ideas. Multifunctional learning spaces, colorful interiors and small niches for concentration and contemplation help to achieve these goals. While this school contains no interior walls, the acoustics of the space are kept at a level that allows students to focus on working independently or in small groups. The soft furnishings, ceiling clouds and absorptive panels throughout the school help to achieve these ideal acoustical levels.

The Redding School of the Arts serves as a teaching tool for the arts as well as sustainability through its cheerful environment. The California climate allows 50% of classrooms to use outdoor spaces as a part of the regular classroom environments. All classrooms are designed to receive northern light, significantly reducing the reliance on electricity for artificial lighting. The school was designed to be transparent, showcasing the internal working and energy consumption as a way to teach students about its sustainable systems.
Roots Elementary School, Denver, CO // 2014

Roots literally knocked down the walls of a traditional school, designing its learning environment with a big open space at its center.61 Called the Grove, this is where personalized learning comes to life and students move from activity to activity every 15 minutes based on their own needs and interests. Roots began when the administrators started seeing the patterns—both great and challenging—that emerged at the most successful charter schools. One in particular was especially compelling: Everyone knew that grouping students by age, in cohorts of 25, and trying to teach them in a way that met each student where they were was difficult, if not impossible. Knocking down the walls and providing an open, collaborative space for all students to personalize their own learning became the effective solution.

In this model, each student’s experience is unique. Students at Roots are not constrained to one classroom with students their age. Instead, students work independently or in small groups on projects aligned to their personal learning plans. Several times throughout the day, teachers pull flexible groups of students into small meeting spaces to receive targeted skill instruction.

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61 Http://rootselementary.org/take-a-sneak-peek/the-grove/
This learning environment is a school designed for students, not for adults – a school that appreciates its students as young people with innate curiosity and a wide range of interests, strengths and gaps.

The following spaces make up "The Grove":

1. Small meeting rooms allow one teacher to meet with five students who are at the same reading level, even if they are not all the same age.
2. Coaching rooms allow one student and her coach to review her academic progress and portfolio of work. Together, they can discuss what her goals should be for the next two weeks.
3. This writing area allows a student to write quietly and independently.
4. Comfortable seating options make for a cozy reading space.
5. A Teacher is present to help students when they are stuck and asks comprehension questions.
6. The computer area allows students to work independently through math problems, while a teacher oversees this area to provide support and answer questions.
7. The tablet area is similar to the reading area, but provides power for the devices. This allows students to listen to their books and read at the same time, a system that helps students through challenging books.
8. The flex/group work station allows for various activities. Two students might measure the length of various objects using nonstandard units. A math teacher is observing students’ work and pushing their thinking.
9. The maker space allows for crafts to be completed. Volunteers encourage the young makers and suggest improvements.
10. This small classroom allows a larger group of students to gather and have a class discussion.
4: (RE)DESIGN GOALS
PART 4: (RE)DESIGN GOALS

“To design is much more than simply assemble, to order, or even to edit; it is to add value and meaning, to illuminate, to simplify, to clarify, to modify, to dignify, to dramatize, to persuade, and perhaps even to amuse.”
- Paul Rand, artist and architect

David Thornburg, an educator, futurist and PBS commentator, describes four overarching learning modes that a well-designed school allows: campfire (learning from an expert), watering hole (learning from peers), cave (learning from introspection), and life (learning by doing).62 The current school design relies heavily on the campfire mode, with traditional classrooms for teaching and little space outside of those for other types of learning.

![Figure 7: Four Primordial Learning Metaphors](source: "Blueprint for Tomorrow" by Prakash Nair)

After talking with a retired teacher from School #25 who is a believer in the power of student-centered school design, it became clear that the needs for teachers in these types of learning environments could be easily met with just a few simple measures. She noted that teachers need a space to congregate, either before or after school, in order to plan as a group. In addition, they would need secure storage areas for their belongings as well as any materials needed for the day. Once those basic needs are met, teachers should be comfortable and prepared to succeed in student-centered environments.

62 Nair, Prakash. “Blueprint for Tomorrow”
(RE)DESIGN SPATIAL & ENVIRONMENTAL GOALS

In addition to accommodating these four learning metaphors, the new design will need to address the problems in spatial organization outlined in the previous section. These eight design goals are outlined below:

Increase the variety of spaces to inspire learning anytime, anywhere

Create informal learning spaces outside of classrooms

Integrate technology access throughout the building

Eliminate the rigid separation between classrooms and hallways, and recapture unused space

Redesign the entry to be welcoming and provide better transition

Improve the daylighting potential and reincorporate daylight as a primary means of lighting the space

Upgrade the HVAC system for improved temperature control, fresh air, and space

Improve acoustics by providing more soft furnishings, ceiling and wall treatments
PRIORITIZING THE (RE)DESIGN GOALS

Each of the first five design goals can be easily achieved through a retrofit of the building’s interior, reorganizing spaces and creating nodes for various types of learning. The three environmental goals are a little less straightforward, although looking at previous studies helps to provide a baseline for the priorities of this project.

After reviewing the research on environmental factors and student performance, it is clear that optimizing daylight in the building holds the biggest potential for increasing student performance. According to the research, students showed gains of between 20-26% in well daylit schools when compared to the least.\(^1\) School #25 is an example of a school with minimal daylight currently, so the potential for increasing student performance is especially great.

Updating the HVAC system would add measurable benefits as well. Research shows that individual temperature control and performance are positively correlated, and the current HVAC system at School #25 does not have that functionality. However, the potential gains for adding temperature control hover around 3.6%, based on previous studies compiled by Carnegie Mellon University. Updating the HVAC would also improve air quality, which is proven to reduce absenteeism, as asthma is the leading cause in US schools. While updating the HVAC system for more individualized controls and better fresh air certainly yields a positive result, daylighting holds a larger potential for improving student performance.

Acoustics is more difficult to provide metrics for, however, it is clear from looking at the existing building that acoustics could be significantly improved from the current condition. Providing smaller spaces with soft furnishings and more acoustic treatment on the walls, floor and ceiling is a secondary goal for the redesign. However useful, full-blown acoustical studies are not necessary to understand the impact of acoustical design, as evidenced by the best practices approach used in the Vittra Telefonplan, Roots Elementary, and Concord Elementary Schools case studies.

According to the research, sustainable school buildings have an effect on student performance as well. However, calling this out as its own design goal was not done explicitly in this case, because the concepts of sustainable buildings are captured by the other goals. Lighting

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is responsible for on average 26% of building electricity usage,\(^2\) according to a report done by Energy Star. By prioritizing daylighting in the redesign, electricity usage will significantly decrease. The sustainability goals outlined by the Collaborative for High-Performance Schools (CHPS) overlap directly with the goals of this building redesign: Their first goal, 'Maximize the health and performance of students and staff,' is the overall goal of this school redesign project, addressing sustainability's social aspect. 'Conserve energy, water and other resources in order to save precious operating dollars' will be taken care of through reducing energy demands by daylighting and upgrading the HVAC. Finally, CHPS' last goal is to 'minimize material waste, pollution and environmental degradation created by a school.'\(^3\) Reusing an existing building as the base for a redesigned 21st-century school learning environment is a perfect example of minimizing waste and environmental degradation.

In summary, the first five design goals will be met through a broad reconfiguring of interior spaces. Because daylight holds the highest potential for gains in student performance, reduction in electricity costs, and teacher retention, optimizing the building for natural light is the first environmental priority in the redesign. Designing for better acoustics is a secondary goal, along with the update to the HVAC system to increase efficiency and provide more control.

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\(^2\) [https://www.energystar.gov/ia/business/EPA_BUM_CH10_Schools.pdf](https://www.energystar.gov/ia/business/EPA_BUM_CH10_Schools.pdf)

\(^3\) “National Core Criteria.” Collaborative for High-Performance Schools.
5: THE (RE)DESIGN
PART 5: THE (RE)DESIGN

Accounting for the spatial requirements of Nathaniel Hawthorne School #25, as well as the environmental factors affecting student performance, the following pages illustrate and communicate the building redesign.

Proposed Schematic Site Plan
Proposed Schematic Floor Plans
Select Details
Daylight Solution
Air Quality and Temperature Control Solution
Acoustics Solution
Renderings
A Day in the Life at the Redesigned Nathaniel Hawthorne School #25
In the proposed redesign, the parking lot and playground areas are flipped. The central courtyard space becomes a welcoming place for students to arrive to the school, a play area, and outdoor classroom space. The building entrance remains in the elbow, but the access to it is made much more open and grand. Leading up to the corner entrance are squared arches at slightly varied angles, the right half of which are sized for smaller students. This simple tactic tells students that this is their building, that it was designed specifically for children right from the start. The usable recess area is expanded here to include the entire courtyard, rather than just the physical playground. The same number of parking spaces are achieved by expanding the north auxiliary lot, and the preschool is incorporated into the main school building.

A bus and car drop-off loop is added to the site plan, with temporary parking for parents dropping off their kids. Sidewalks connect the exterior exits and entrances, with a central triangular paved area housing a symbolic Hawthorn tree. Vegetation areas form a barrier between the street and the school’s site at the edges, making a safe, open zone for students near the school.
Site Plan
Not to a specific scale
N ▶
The new courtyard forms a transition zone for students arriving to school, informing them that this is a fun place to learn. That idea is continued into the new plans right from the start. An additional main entrance is added to the new curtain wall, sized just for small children at three and a half feet tall. The entry corner also receives an expanded entry zone, which maintains the original building's fireplace and creates various casual seating areas. This entry area would house student work on the walls, and a place for school announcements on the wall facing the entrance.

A direct connection between exterior learning studios and interior spaces is enforced by opening up the building façade at those connection points. The curtain walls reveal walls that appear to continue directly from inside to form the outside edge of these exterior platforms. These two areas feature pergolas overhead where plants could grow, creating a cozy outdoor space. The outdoor spaces could be used for at least half the year, if not more. Students are expected to go outside for recess on all but the most brutal winter days, so kids are always prepared for the weather.

The proposed schematic plan eliminates classrooms in the traditional sense, and creates different spaces for various types of learning. In the north wing, spaces were designed for Pre-K, kindergarten and first graders. These spaces adhere to the primordial learning metaphors from Prakish Nair: Campfire, Watering Hole, Cave and Life. A balance of types of spaces allows increased flexibility, and keeps students more engaged for longer periods of time. The structure of the existing building makes this sort of renovation relatively easy, as nearly all interior partitions are simple stud walls, and a simple linear structural grid. The columns remain in place in the redesign, some exposed and others fall within new walls.

The central gymnasium and auditorium remains unchanged, but importantly can be used exclusively for those intended activities in the proposed design. By eliminating wasted corridor space and using the building more strategically, enough learning spaces are created to accommodate all students in the learning studios.

The longer N-S wing provides space for grades 2-6, which also contain new spaces to support the primordial learning metaphors. Enclosed spaces create the environment for lectures or student
presentations (campfires), while open computer stations allow easy access to technology throughout the day (caves). Soft seating areas provide cozy spaces for reading (caves), and small group stations can be utilized by teachers meeting with one or more students privately, or for group work (watering holes). A multi-use stair and stage becomes a combination of lecture or performance space (watering hole and campfire). Finally, combination art/science labs and a rooftop garden provide test beds for experiments and hands-on learning (life).

Nathaniel Hawthorne School 25 is currently home to 327 students, and the new design has space for 519 students to be engaged in various activities. In addition, there is an 80-student food station in the existing cafeteria space. Although the space can accommodate more students than the school currently serves, those extra seats should not necessarily be filled. The available space simply proves that the proposed design could easily fit all current students, including the pre-k. Flexibility and freedom of movement are tenets of student-centered education, so designing these concepts into the school was a must.

The second floor spaces currently house speech therapy and other small group developmental needs. These types of spaces are integrated into the first floor of the proposed design, through a mix of small group work areas. These allow those students to be closer to their classmates while they receive extra help, rather than being escorted to another area of the school. In their place, the second floor has been converted into science labs and a hands-on learning studio to be used by all students.

The second floor science lab has direct access to a converted rooftop area, where linear gardens allow students to learn about growing vegetables and flowers firsthand. Linear gardens are placed between rows of pyramidal monitors, which bring ample amounts of daylight into interior learning spaces. Nathaniel Hawthorne School #25 had large monitors on the roof in its original design from 1914. However, those have since been removed, and the interior has been lit primarily by overhead fluorescent lights. Each classroom has at least one window, but those are often blocked by shades, presumably for privacy from the surrounding neighborhood. Bringing back overhead daylighting would help to increase student performance, as well as conform to the privacy and security needs of the school. These new monitors are organized on a diagonal grid, and allow
beautiful northern light into the rooms below. The southern panels are solid, to help mitigate glare on the interior.

A large diagonal mural encloses the rooftop area so the students only have access to the safe area. This mural could be designed and painted by students as an ongoing art project. The roof will be covered in a light stone gravel to enable safe access and a sturdy walking surface.

See the floor plans on the following pages for a closer look at these features.

* * *
First Floor Plan

Not to a specific scale
Second Floor Plan

Not to a specific scale
Second Floor Space Diagram
Not to a specific scale

Campfire
Cave
Watering Hole
Life
The details outlined on these pages begin to illustrate the design intent. Zooming in on a portion of a learning studio provides some additional context as to what these different types of spaces afford.

1. This stage area provides a flexible space that can be used for seating while students work independently, a stadium seating area where a teacher can address all the students while standing at the front, or a stage that can be used for student presentations or performances. Smaller steps for climbing to the top are embedded into larger steps, which double as seats.

2. This seating area provides a cozy space for independent reading. Traditional armchairs and couches are combined with a serpentine sofa to provide different options for students.

3. Another "cave" area is provided in a central computer station, where students can work
independently on personalized applications to help them learn. There is space for a teacher to stand at the desk portion to the right, where he can oversee students working and be available to answer questions in case they get stuck.

4. Table and chair groupings throughout the school provide breakout spaces for activities such as book club, snack time, or teacher-directed learning for small groups.

5. This private "campfire" space with a conference table provides a place for direct instruction by a teacher to a larger group of students. This space is also ideal for student discussions, and would be used before or after school for teacher meetings to discuss planning goals.

6. This "life" space provides an area for both science and art projects. The area is provided with plentiful counter space and storage areas, as well as a durable floor to handle messy projects. A sink allows for easy clean-up, and students work in groups at the designated tables.

* * *

One goal of the redesign is to redesign the entry to be welcoming and provide a better transition from outside to in. As noted on the floor plans, the entry corner was expanded with a diagonal wall connecting to the two wings of the existing building. This new, expanded entry area is designed to provide good visibility between outside and in, reinforcing the openness of the new school design. The sketch below shows this new curtain wall and the new entry doors, with the smaller "kids only" door off to the right of the main entrance. The main doors are embedded in a

Sketch of Redesigned Building Entry, from Exterior
brick wall, which matches the existing building's main exterior material. Window walls on either side of this central entry connect the new entry arrival space to the school's courtyard.

Leading up to this new central entrance, as noted on the site plan, are squared arches in a playful pattern. The right side of these arches are sized just for kids, letting them know that this building was designed with children in mind. This simple addition communicates a strong message to the students about their importance in the school's design and layout.

Sketch of Squared Arches, Relative Sizes
(RE)DESIGN ENVIRONMENTAL FACTORS

Daylight Solution // Nathaniel Hawthorne School #25

The new rooftop monitors provide a good quality of daylight, without glare, to the usable spaces on both floors. The ideal daylight values range between 300-3,000 lux. Up to 85% of interior spaces receive this quality of daylight, surpassing the LEED criteria of 75%. This solution not only could significantly affect student performance, but can help the school to reduce their operating expenses by reducing the reliance on electric lights.

With the addition of new monitors onto the roof, both celebrating the original design of this historic school and looking to the future, up to 85% of the school's interior could be lit almost entirely by the sun. According to LEED v4, at least 75% of spaces need to have daylight to earn the credit, so this new configuration would meet LEED standards. The proposal is for new monitors that

Existing Daylight Capacity

Fig 8: Monitor design daylight analysis, 9/16 at 3pm 85% of interior spaces get access to daylight. (First Floor)

Fig 9: Monitor design daylight analysis, 9/16 at 3pm 85% of interior spaces get access to daylight. (Second Floor)
would have a pyramidal shape that gestures to the historic version in geometry, but offers a new form. These new daylighting pyramids have solid panels on the southern-facing sides to help mitigate glare, but would still provide plenty of interior light. They would also conform to the building's security needs by keeping windows off the ground level, and pulling in light without compromising privacy.
To reach the goals of better air quality and increased temperature controls in Nathaniel Hawthorne School #25, an update to the existing HVAC system is required. The existing system is inflexible and inefficient. Updating to a more modern heating system would allow more individualized control at the classroom level, and would require significantly less floor space for mechanical equipment. This newly-claimed space could instead be used for school services such as the nurse, additional offices, and private classrooms for students who need extra help. Temperature control is important to student and teacher performance, as noted earlier in this paper. The research shows that individual temperature controls have an average impact of 3.6% on student and teacher performance.

A Central Station Reheat Variable Air Volume (VAV) system would allow the individualized controls, fresh air volume, and energy efficiency this building needs. In this system, reheating is done at the room or zone level, making the system more efficient overall. With this system, one can program a fresh air refresh rate, allowing the ideal rates to be easily achieved. A Variable Air Volume system gives each zone of the buildings its own thermostat, intended to control the amount of conditioned air entering the zone.

Dampers in the ductwork allow for this increased flexibility, shutting off or allowing air to circulate as needed. This system differs from the Constant Air Volume (CAV) system, in which the entire building is controlled by a single thermostat.¹

While there is concern that opening up the floor plan will cause acoustical issues, a few preventive measures will help to ensure the acoustics remain at an optimal level. Acoustical ceiling clouds and area rugs throughout the space will help to absorb unwanted sounds. Angled walls, of which there are many throughout the proposed school design, help to diffuse sounds more than square rooms. Finally, while elementary schools are traditionally thought to be loud and rowdy spaces, this in part can be traced to traditional classroom arrangements not meeting the needs of active youngsters.

Children are not designed to sit still and quiet for hours on end, and will become rambunctious if asked to do so. In the proposed school design, movement is encouraged, and the spaces are specifically designed for different activities. In the open areas, kids will be engaged with their individual work. In enclosed spaces, teachers will have instruction time or students will be doing hands-on learning. By segmenting the uses of the spaces, acoustics is also segmented and therefore optimized. Smaller classrooms with space for intended activities breaks up the school so that a teacher and students aren't taking up a large classroom space and using just a small corner. By providing the right amount of space for certain activities, the right acoustic levels are achieved throughout the building.

Vittra Telefonplan in Sweden, outlined in the case study section, provides a special padded room just for kids to express themselves and let off some steam. They hold dance and movement classes in it, helping the rest of the open interior environment to remain quieter for independent or group work. At Nathaniel Hawthorne School #25, the gym and outdoor areas become this space where it's OK to be a kid and be loud. Allowing students to let off steam when needed is one proven strategy to optimizing school acoustics.

View the renderings on the following pages to get an in-depth look at these proposed features and to get a better idea of the design concepts.
A Day in the Life // Nathaniel Hawthorne School #25

While the redesign might work on a conceptual level, what really matters is how it works for those using the building on a daily basis. What would a typical day look like for students in the new Nathaniel Hawthorne School #25? The diagram below shows what a typical day might look like for two fictional students, Charlie and Kayla, both third graders. This sample schedule has been adapted...
from the ROOTS school in Denver, a new personalized learning elementary school outlined in the Case Study section of this thesis.

Charlie and Kayla have personalized schedules to help them meet their learning goals. The two "Personalized Learning" blocks each day become the time for each of them to work on skill-building or extra practice on areas where they need the help. These blocks provide flexibility so that students are truly getting a unique experience at school that meets their needs.

Content teachers, who teach a specific subject, use daily observations and data to determine where Kayla and Charlie need the most support. For example, if during reading Kayla was soaring at phonics and was ready to push on to deeper literacy skills, her literacy teacher would note that in her online schedule, prioritizing that Kayla spend Personalized Learning time on an advanced reading program.

Coaches are responsible for supporting both the academic journey and social and emotional journey of 50 students, taking what content teachers recommend and their own observations to create a master daily schedule for each student.
To help them keep track of their schedules and move from activity to activity throughout the day, each student is equipped with an iPad. For instance, at the end of Reading time, music sounds throughout the school, signaling it's time to switch activities. Charlie then grabs his iPad and clicks on his "What's Next" app to see it's time for him to head to the central computers for personalized math help. He finds a seat and uses his iPad to scan the QR code on the table, signaling he has checked in.

Charlie gets stuck for a minute on a problem so he raises his hand, and a content teacher comes over and kneels down, helping Charlie with the question. A few seconds later, he's back to his math game, working independently. Third-party applications such as DreamBox provide the personalized content for each student so that content teachers don't have to plan individual activities for each of their 50 students.

In this student-centered school, the delineations between grade levels have been blurred—students instead receive personalized, blended learning to help them grow. Students are grouped throughout the school based on their proficiencies.
6: CONCLUSION
PART 6: THE CONCLUSION

In conclusion, the proposed schematic redesign of Nathaniel Hawthorne School #25 meets the goals outlined previously for the project, aimed at increasing student performance and preparing for student-centered learning modalities. To quickly summarize, the project goals were as follows:

- Increase the variety of spaces to inspire learning anytime, anywhere
- Create informal learning spaces outside of classrooms
- Integrate technology access throughout the building
- Eliminate the rigid separation between classrooms and hallways, and recapture unused space
- Redesign the entry to be welcoming and provide better transition
- Improve the daylighting potential and reincorporate daylight as a primary means of lighting the space
- Upgrade the HVAC system for improved temperature control, fresh air, and space
- Improve acoustics by providing more soft furnishings, ceiling and wall treatments
The variety of spaces was increased in the interior's redesign, as well as in the central courtyard addition. Informal learning areas were added throughout the school, and in some outdoor areas. Technology has been integrated throughout the school in more accessible ways, and soft seating areas promote the use of mobile technology, such as tablets and laptops. Classrooms and hallways were eliminated in the traditional sense, recapturing the unused space and creating different zones for learning. The entry was entirely redesigned to create a welcoming environment and a better transition zone from outside to in. Monitors were brought back to the roof so that the interior can be nearly 100% lit by the sun. The HVAC system can be upgraded to be healthier, provide more controls, and be more efficient. Angled walls, soft furnishings, ceiling clouds, and segmentation of spaces help the space to be designed for good acoustics.

Student performance could significantly improve due to an updated, optimized learning environment. In these ways, the school building at Nathaniel Hawthorne School #25 has been redesigned, and in return, learning has the potential to be transformed for its students.

Note on design budget and future implications of this thesis:

Being a conceptual project regarding updating schools for student-centered learning and increasing student performance, a project budget was not used as a constraint. This solution provides an idealized design response to a complicated problem. While real-life school designs will always be constrained by tight budgets, the hope is that this design project will provide some inspiration for how schools can change for the future. Increasing daylight, providing spaces for different learning modalities, and beginning to blur the lines of a traditional "classroom" are ideas that can be explored and accomplished on any budget.

The concepts and solutions discussed in this project can be translated to middle and high schools, libraries and even some colleges. While this design thesis focused on an elementary school in particular, the research and design goals can apply to anywhere that learning is a goal.
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