

ABSTRACT

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This thesis rethinks how schools adapt to change, by exploring themes of flexibility and adaptability. *Flexibility* in the short term allows learning spaces to be a platform for changing pedagogy or technology. In addition, *adaptability* in the long term allows for the architecture to absorb changes in enrollment. Education facilities around the world are constantly fluctuating between being over-crowded and under utilized. This thesis explores opportunities for the architecture of the school, from the master planning and organization of program to the construction methods of the building, to adapt to this change. A systematic approach is established where a pre-fabricated kit of parts is defined and utilized to create learning communities, which incrementally expand or contract from the core of the school. This thesis proposes this system of adaptable design as a solution to optimizing space utilization in public schools, grades pre-kindergarten through eight, in Washington D.C.

RETHINKING SCHOOLS: A SYSTEM OF ADAPTABLE DESIGN

By

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Preface

“The difficulty of accurately predicting enrollment at particular facilities *necessitates a flexible and iterative facilities planning process*. We will need to reassess school-level trends on a regular basis and adjust facilities plans accordingly, including entertaining *new and creative ways of utilizing space*.”

-DCPS Master Facilities Plan 2008¹

How to use the space in schools, with constantly changing enrollment size has been a struggle for both educators and designers. In addition, the constant social, cultural, economic, and technological changes creates an environment where new ideas of what and how to teach generate new ideas of how the space should be used. This thesis explores themes of flexibility and adaptability in architecture to create a system that allows schools to adapt to the constantly changing future.

In 1998, the average age of school buildings was 42 years with most public schools built between 1950-1970.² During this time, the focus was to creating enough space to fit the baby boomer generation by building large and fast. As a result, standardized school buildings were massed produced, leading to a lack of individuality and experimentation. In more recent history, there has been a similar outlook on the disposable nature and unimportance of school buildings, even though about a quarter of the U.S. population

¹ DCPS Master Facilities Plan 2008, Data and Demographics, pg. 1

² www.ncef.org, Data and Statistics

spends their time in K-12 schools.³ In 2006, about 300,000 portable classrooms were in use by the United States public school system.⁴ Even though these do not make ideal learning environments, these temporary additions are used universally because their assembly is quick and inexpensive. This is the current solution for how schools can quickly expand and contract as the enrollment changes.

A major problem in school planning is that enrollment is hard to predict from year to year. During the 2007-2008 school year, 2,120 schools were closed nationwide and 1,927 were opened with planning for 460 more.⁵ There is an issue of under enrollment in some schools, causing these schools to close and the students to consolidate. In D.C. alone, twenty-three schools were closed before the 2008-2009 school year.⁶ In addition, the general lack of satisfaction with the state of existing schools leads to new construction. The distribution of school age children is not a problem that can be solved by architecture, but it presents the opportunity to rethink how schools can adapt to the inevitable, yet unpredictable, conditions of varying enrollment.

The complexity of the changes that affect schools is not limited to enrollment size. Although the way educators teach and what they teach has changed, the educational spaces have remained largely the same. In order for the school to be relevant as our culture continually progresses, the school

³ <http://www.usgbc.org> LEED for Educational Facilities

⁴ www.ncef.org; Data and Statistics

⁵ www.ncef.org. Data and Statistics

⁶ DCPS Master Facilities Plan 2010

must adapt to changes in technology and pedagogy, but be simultaneously independent from any specific form of either.

Although the thesis will be tested using two case studies, this research is intended to be broadly applicable to the national problem of over-crowded and under-utilized educational facilities. The thesis will propose design principles and diagrams, which should be considered by designers facing this problem in the future. These principles will not denote a style or form of the building, but will be a broadly applicable set of diagrams that should consider the specifics of the site, city, school, and other contextual opportunities.

In Chapter 5, a systematic approach is established where a pre-fabricated kit of parts is defined and utilized to create learning communities, which incrementally expand or contract from the core of the school. In order to test these ideas, the thesis will show how this concept can be applied to two case studies. The first case study look at an open site where the entire school is designed using the system. The second case study tests how an existing school can expand using the system. Both schools are pre-kindergarten through eighth grade education campuses in Washington D.C. The goal of the case studies is to illustrate how the system of incremental expansion can be adapted to site and context, to give schools a way to expand or contract without sacrificing their individuality.

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Chapter 1: Utilization of Space in Schools

“... a thing exclusively made for one purpose, suppresses the individual because it tells him exactly how it is to be used. If the object provokes a person to determine in what way he wants to use it, it will strengthen his self-identity. Merely the act of discovery elicits greater awareness. Therefore a form must be interpretable—in the sense it must be conditioned to play a changing role.”⁷

- Herman Hertzberger

1.1: Effect of Changing Enrollment

In the public education system, it is hard to limit, promote, or predict enrollment from year to year.⁸ Between 2007-2010, decreased enrollment and economic turmoil has forced cities to evaluate their inventory of schools and utilization of space. As a result, schools have been closed in every major U.S. city to consolidate and reallocate funding and resources. Specifically in Washington D.C., many schools with under 51% enrollment have closed in the last four years. Meanwhile, looking to the future, the NCEF (National Clearinghouse for Educational Facilities) projects public schools, grades kindergarten through eight, will see a 12% increase.⁹

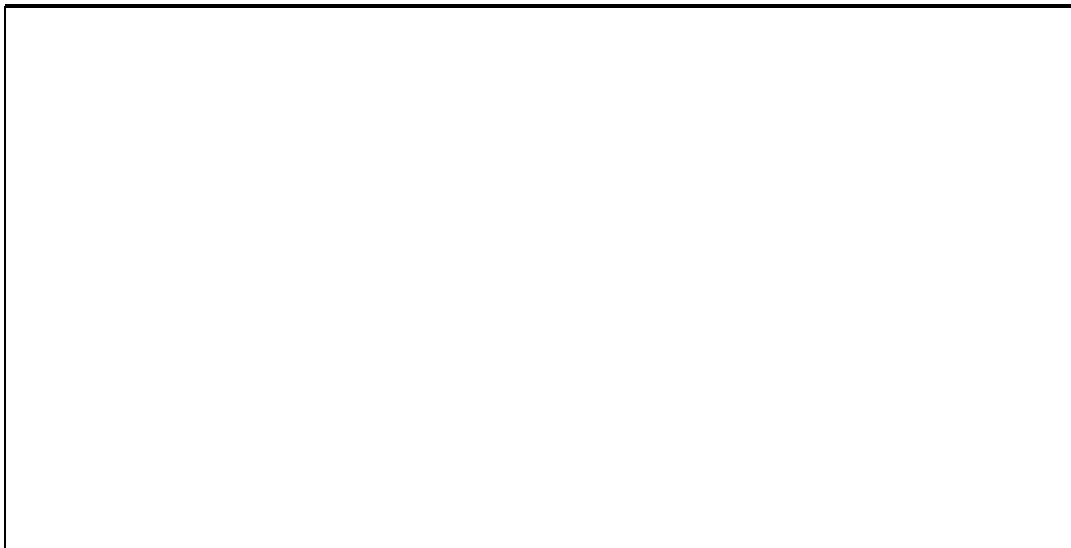
⁷ Dudek, Mark. *Architecture of Schools: The New Learning Environments*. 5

⁸ DCPS Master Facilities Plan 2008, Data and Demographics, 1

⁹ www.ncef.org, data and statistics



*Figure 1: Graph of School Age Children Population Change
Image is located in the DCPS Master Facilities Plan for 2008*



*Figure 2: Early Exit Statistics
Image is located in the DCPS Master Facilities Plan for 2008*

Even though the population is increasing, many other factors contribute to the unpredictability of enrollment. Specifically in Washington D.C., about 14% of students exit early from their school. Sixty-seven percent

of those students transfer within the public school system.¹⁰ This is caused by the parents desire to send their children to the best school in the system, and the “No Child Left Behind” act provides this opportunity. Whether there is a problem of over or under-enrollment, this inconsistency and inability to predict changes from year to year puts stress on the system. When the enrollment is above or below the intended size, the spaces in schools are not optimized, often leading to undesirable learning and teaching conditions, as well as an inefficient use of resources.

The goal of this thesis is to find a way to alleviate the stress of fluctuating enrollment on the students and community by creating a school that can support these constant changes.

1.1.1 Over-enrollment

When the enrollment is higher than the school’s capacity, there is a need for the building to expand. Permanent additions are often added, requiring design, planning, and construction, where construction is limited to times when school is not in session. From design to completion, these projects often take up to 3 years. Then, if the enrollment changes dramatically, this permanent addition cannot quickly readjust or respond.

¹⁰ DCPS Master Facilities Plan 2008, p. 17

1.1.2 Under-enrollment

When enrollment is below capacity, the building is under-utilized. As a result, schools are closed and demolished or abandoned. In 2008 alone, the District of Columbia closed 23 schools due to under-enrollment. When this occurs, resources are lost and people lose a piece of their neighborhood infrastructure.

“DCPS enrollment has declined significantly over the past 10 years, leaving many buildings seriously underutilized. In 2007, the schools system has an average of 288 square feet per student across 145 schools. Analysis of enrollment decline revealed that 33 elementary schools has less than 272 students and had lost more than 21% of their enrollment in the past five years, leaving many of these buildings more than half-empty. Such inefficiency gradually left its toll on the school facilities as well; dollars spent on heating, cooling, and lighting unused sections of buildings were wasted, while at the same time there was not enough funding to maintain buildings at an adequate level”¹¹

Not only are resources wasted with demolition, construction, or under-utilized schools, but the students and their communities are also affected by these conditions. According to the District of Columbia Public Schools Facilities Plan, over 5,000 students and their families have been affected by school closures within the 2008-2009 school

¹¹ DCPS Master Plan 2008, 17

year.¹² Not only is a school closure potentially damaging for the students who rely on the school for their education and social growth within a specific community, but schools are also a part of the neighborhood's infrastructure and an amenity for the community.

1.2 Permanent Solutions in Recent History

Since this issue of changing student population is not new, it is relevant to recognize how the problem has been dealt with in the past. This section focuses on the past century, since this is the period of time with the most applicable technologies and educational strategies. The following examples focus on infrastructural changes on a national level.

In the Early 20th Century, mass urbanization caused the population of students in urban schools to grow. The concept of the Junior High School was invented to alleviate overcrowding in elementary and high schools.¹³ This involved moving students to new schools once they reached a certain grade.

Post World War II, standardized schools were mass-produced to deal with the issue of over-crowding due to the Baby Boomer generation. An Example of this prototypical school is Crow Island School in Winnekta, IL by Perkins & Will in collaboration with Eero and Eliel Saarinen. This one story school was built in 1940 where each classroom is individually accessed off a

¹² DCPS Master Facilities Plan 2008, 14

¹³ Walden, Rotraut (ed.). Schools for the Future, pg. 24

common corridor, has access to light and air, and is scaled to the needs of a child.

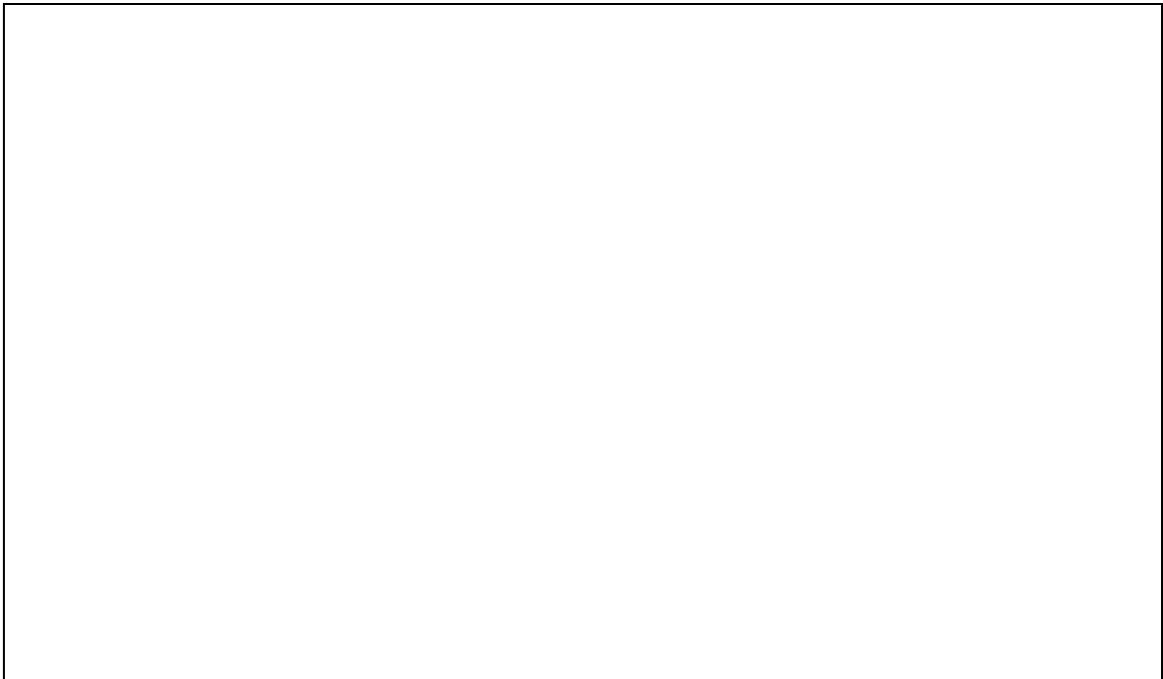


Figure 3 Crow Island School by Perkins & Will partnered with Eiel and Eero Saarinen.

The image was found at <http://rogershepherd.com/WIW/solution5/images/plan>

More recently, in the early 21st Century, low enrollment and budget cuts caused mass consolidation of students in under-utilized schools filling some schools and leaving others to be demolished or reused.

The previously listed changes have been widely controlled by the government and policy, but individual public schools have also enacted strategies to deal with the issue of space utilization. For over-enrollment, the following strategies have been tested:

1. Lease space in another building

2. Create an additional class at a certain grade (limited to a bulk of students in one grade and having the space to house this new class)
3. Build an addition which may take three years to complete
4. Limit enrollment by allowing students to attend other schools out of their zone or by only allowing neighborhood students to attend.

For under-enrollment, the following strategies have been tested:

1. Close certain classrooms or wings of a building
2. Close and consolidate entire schools to increase building utilization and move those students to other schools in the system. These buildings may either be demolished or adaptively reused.
3. Rent un-utilized space in building to a different or similar user (must consider security)

These solutions are used to re-structure the schools to allow them to adapt to an increase or decrease in students. Section 1.3 will address solutions that use pre-fabrication to allow for the building size to rapidly increase or decrease.

1.3 Prefabricated Solutions in Recent History

The use of portable trailers is an inexpensive, fast, and popular way to expand schools. In 2006, over 300,000 portable classrooms were used by public school districts in the United States.¹⁴ These trailers are shipped to the

¹⁴ www.ncef.org; data and statistics

site, so they are restricted by their size. By putting two or three trailers together, larger classrooms or multi-purpose spaces can be achieved. Due to the maximum height for shipping, twelve feet, the design is limited. Aside from the height, the trailers must be rigid for shipping, which often limits the amount of openings and where they are located. This limits how the trailers can address the climatic needs related to different exposures.

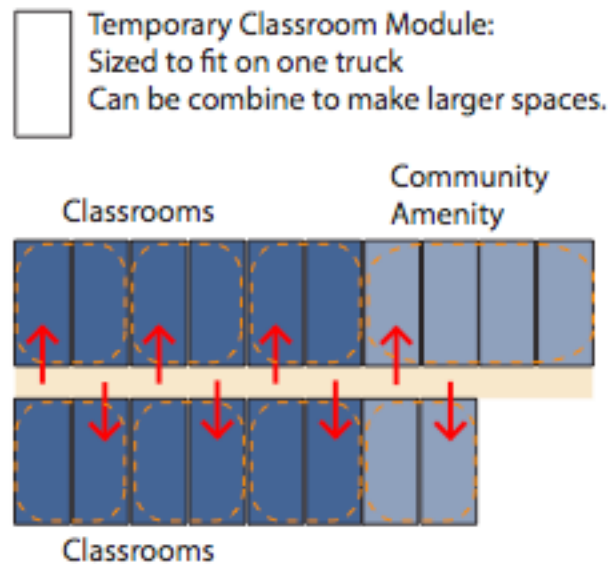


Figure 4: Temporary Classroom Modules

Portable trailers are often added to buildings that were not designed for expansion. As a result, the site planning is often unthoughtful and the circulation is usually exposed to the outdoors. Although it is nice for children to have access to the outdoors, the circulation between classes should be sheltered from the weather conditions. Since the cost of transporting a portable trailer is not cheap, these trailers often stay at the school rather than provide a temporary solution. Aesthetics become a major deterrent in making

these portable trailers permanent because they all look the same and have no architectural interest.

Chapter 2: Exploring Opportunities of Prefabrication

“Prefabrication: some form of assembly occurs in one location because of some advantage or efficiency before being moved into its final location.”¹⁵

This chapter explores the benefits of combining off-site fabrication and on-site fabrication to achieve a more optimal system than the modular portable classroom. Anderson and Anderson flush out the benefits of different pre-fabrication methods in their book *Prefab Prototypes*. The general conclusion is that a panelized system is the easiest prefabrication method to integrate into construction and fabrication.¹⁶ In this thesis, the idea behind a panelized system is that by creating a kit of parts, there can be much more variety in the product.

General benefits of a pre-fabricated kit of parts

1. rapid construction
2. Reduces excessive overages of materials from 10% to 2-5%
3. The panels can be recycled or reused
4. Uses less embodied energy than on-site fabrication

¹⁵ Anderson, Mark and Peter. *Prefab Prototypes*, 23

¹⁶ *ibid* p 24

There are many benefits to a prefabricated kit of parts solution over a modular, shippable classroom.

1. Reduces the thermal envelope
2. Using shippable modules to create a learning community (like those designed in this thesis) would take 14-15 trailers. This would require intense seaming and water proofing
3. Using a panelized system would allow for each facade to be treated differently to respond to the exposure

Chapter 3: Pedagogy, Technology, and Architecture of Schools

There have been significant changes in pedagogy over the past hundred years, but the ways schools are designed has remained relatively constant. This segment of research focuses on the United States over the past century because this is the most applicable to the thesis. The goal of this section is to analyze the complex social, cultural, scientific, and technological advances in the past hundred years to better understand how this has influenced teaching methods. Then, the types of the spaces needed to support a constantly changing educational model will be compared to the types of spaces in use today. Ultimately, a designer cannot predict changes that will occur and plan for them, but a flexible spatial arrangement that supports a variety of teaching modalities can more successfully absorb the changes.

3.1 Changes in Technology

The computer is the main technological change that has occurred in recent history. Since then, computer labs have been proposed for every school. As computer technology continues to change, it is becoming more popular for students to have their own laptop. Obviously this is not the case among all demographics, but even if the students do not have their own

computers, many schools are finding that laptops can assist teachers and students in each classroom. As a result, computer labs may become less important. This thesis proposes it is important for learning space to be independent of any specific technology. Instead, the spaces should be thought of as a platform where the technology can be constantly changing.

Along with computers comes the Internet. Information is more readily available through the Internet causing the library or media center unable to keep up-to-date books. The idea that the library is the only place for information is already outdated, and it is possible that a database can supply the same information to all public schools through the Internet. There may be a need for a media center now, but if it is thought of as a flexible space, then it can be converted to another use. Another effect of the Internet is social media as an increasing form of networking and interaction. This can be both positive and negative for young children. It is important that students always have places to encourage social interaction.

3.2 Changes in Educational Theory

Traditionally, learning happened in a linear way, from teacher to student. Further research on how students learn and how to prepare children for today's world has led to advances in educational theory. Here is a quick overview of some of the pedagogical changes that *should* affect the way learning spaces are designed.

3.2.1 Lecture Based Learning

This traditional method of teaching involves the linear transfer of knowledge from teacher to student. Students need to be facing the teacher, who is most often in the front of the room. This method has been manifest in the modern school design discussed in section 3.3.1.

3.2.2 Project Based Learning

This method of teaching gives students the opportunity to work together in groups to complete projects. The idea is that the student learns through the process of making or creating. This usually requires more space with movable furniture.

3.3.3 Student Directed Learning

Theorists like Reggio Emilia or Maria Montessori theorized this method of teaching where the student becomes the facilitator. In some cases, each student requires their own desk.

3.3 Changes in the Architecture of Schools

“The Information Age has seen new innovations in educational architecture, although many school boards continue to miss opportunities to create better school facilities as they struggle to cope with ever increasing enrollments”¹⁷

¹⁷ Walden, 25

This section will discuss architectural solutions to the previous teaching methods. Some strategies are more limiting in how the space can be used and the learning modalities it supports. These strategies are not necessarily in chronological order, as they did not happen in a linear fashion.

3.3.1 The Modern School

The Modern School¹⁸ is usually associated with traditional classrooms located off a corridor. This configuration is referred to as “cells and bells” because there is a strict schedule that is necessary to make these spaces function. It is also referred to as the “ford model” alluding to the treatment of students along an educational assembly line. The cellular arrangement of rooms made for efficient, inexpensive buildings. Since the classrooms are all separate, and usually designed with lecture based learning in mind, there is less flexibility. In addition, space for chance social encounters is not emphasized.

¹⁸ Walden, 25

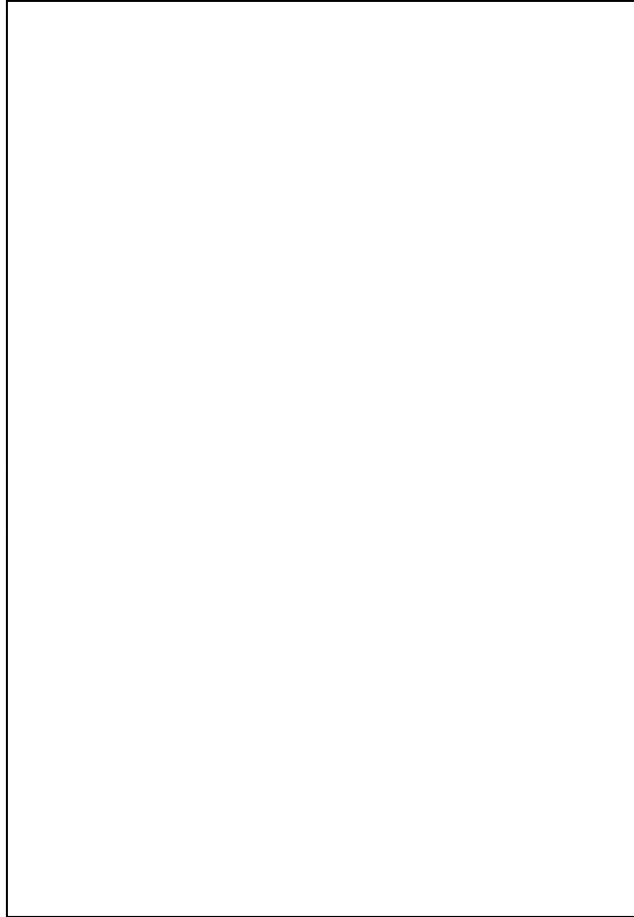


Figure 5: The Factory Model

Located in Taylor, Anne. Linking Architecture and Education: Sustainable Design of Learning Environments. University of New Mexico Press, Albuquerque, NM; 2009, pg 10

3.3.2 The Montessori School

This often consisted of open classrooms to support a variety of different learning modalities. Students are often more self-directed and independent since there is less structure to the schedule.

3.3.3 Learning Communities

Learning communities are often also referred to as “houses.” Grouping 100-120 students into a “house” creates a sense of community within

the larger school. Most everything the student needs is within their “house”. Research has been done to prove the success of smaller schools in the development of children.¹⁹ In terms of accommodating students, learning communities would allow for a change of twenty or so students to go relatively unnoticed.



Figure 6: Small Learning Community

Found in Nair, Prakash, Randall Fielding, Jeffery Lackney. The Language of School Design: Design Patterns for 21st Century Schools. Revised Edition. National Clearinghouse for Educational Facilities, 2009, pg 34

¹⁹ Nathan, Joe and Sheena Thao. Smaller, Safer, Saner, Successful Schools. National Clearinghouse for Educational Facilities, Washington DC; 2007, pg 11 <http://www.ncef.org/pubs/saneschools.pdf>

3.3.4 The Virtual School

The virtual schools gives students the ability to access a large variety of information from where ever they are. This allows for students to have access to the best sources of information from anywhere. An example of this is The School of One, which was implemented in New York City for a summer program. Allowing each student to have their individualized lesson plan for each day, students can work in groups at same level or on their own at their own pace.

When studying these experimentations and standardizations over the past century, it is evident there is a struggle to define how the school supports learning. Should the school be a rigidly ordered place of discipline and control or a place that encourages individual creativity? As a result of this duality, the architectural development of schools is not a linear progression and has not universally improved over time. This thesis looks to find ways that space can be designed to support a variety of learning modalities, absorb new uses, and foster discipline. This utilization of space is widely missing from school design today.

When considering what makes a desirable school, it is worth noting that schools built one hundred years ago are more often kept than schools built fifty years ago. The older buildings were designed without ventilation and cooling technology and therefore have tall windows to maximize light and air.

However, these buildings are usually organized with classrooms on either side of a double loaded corridor. This strategy rarely creates communal spaces for gathering, besides in the corridors, but rather reinforces a factory method of learning and is limited in the opportunities for new methods of teaching to be tested. Mid century, the same organizational strategies are used, but the windows are smaller because views to the outdoors was thought to be a distraction to students and the need for natural ventilation was negated by air conditioning. Studies have since reported that direct sunlight improves the productivity of students.²⁰ Designers often find opportunities to reuse older, early twentieth century buildings, but find the mid-century buildings to be spatially and experientially undesirable. Existing buildings should be analyzed to determine whether or not they should be kept.

There are many contemporary schools that experiment with ways to create spaces that support a variety of learning modalities. This is desirable to educators because they are no longer limited to a linear, lecture based learning method, but can more creatively utilize the learning spaces. The spaces that allow for this to occur while avoiding completely open plans, with no delineation of space, are desirable when thinking about flexible spaces. The thesis explores how flexible spaces within learning communities absorb small changes in enrollment size and allow for a variety of ways they can be used.

²⁰ Daylight, View, and School and Office Work Performance. Lawrence Berkeley National Laboratory, Berkeley, CA; 2009
<http://www.iaqscience.lbl.gov/performance-daylight.html>

Chapter 4: The Role of the Community

“Today, the need to provide school buildings no longer revolves purely around school-age population growth and decline; to be viable community facilities, schools must be designed and built to tie directly into the needs and desires of the communities that they serve, both programmatically and physically, in their scale and their symbolic potential to give identity and purpose to the surrounding community.”²¹

Since the school is a place of interaction between students, parents, and teachers, it has a specific role within the community. The level of involvement between a school and the community is more important to some cities than others. Although the goal of the thesis is not to prove or disprove the importance of community involvement, the discussion is important when thinking about the school as a community center, which is discussed later in the document.

Ideally, urban schools should be central to a neighborhood or district for the convenience of the attending students, though this is not always the case. This allows any community amenities housed in the school to also be centrally located and accessible. Not only are the students attending classes during the day, there are often after school recreational activities, PTA meetings, and other activities that activate the school after hours.

²¹ Haar, Sharon. Mark Robbins, Mayors’ Institute on City Design. *Schools for Cities: Urban Strategies*. Princeton Architectural Press, New York, New York; 2002. Pg. 7-8

Communities often look to schools as places that can support such activities, making them integral to the infrastructure within a community. School buildings are where students are educated, become social beings, and begin form a community of their own.

As previously stated, many schools across the country are being closed and consolidated. Students from these schools are forced to switch to a new school, potentially in a different neighborhood within another community. This removes a child from their community inside and outside the school walls, which has supported their social growth. In addition, when a school is closed, this takes away the amenities and infrastructure from the community. If the school is seen as a community asset, which it is in Washington D.C.,²² closing a school has repercussions, in the community.

The school community also benefits greatly from the community in which it exists. Community involvement offers many opportunities to improve and enhance the education of the students. By overlapping student and community learning both spatially and temporally, there is a constant exchange between the school and outside community. As society and culture change, the knowledge and technologies within the community will permeate the school, and vice versa. The school is directly involved in the community rather than a microcosm of it.

The needs of the community, as well as those of the school, should be taken into consideration when programming a school. For the school to be

²² DCPS Master Facilities Plan 2010. Priorities, Objectives, and Defining Modernization, 5-6

culturally sustainable and relevant in the future, it must have amenities that stimulate the growth and wellbeing of the community in which it exists. In the first case study, there will be a further analysis of what a community in D.C. needs and whether or not it is reasonable for the school to house this amenity.

Chapter 5: A Systematic Approach

DCPS uses the term “right sizing” as their strategy for tackling the issue of space utilization in schools. This thesis presents a solution where the architecture can adapt to create a school that can quickly become the “right size.” To achieve this, adaptability and flexibility are critical throughout the design.

5.1 The Core and Academic Expansion

This approach uses the rapid construction of a pre-fabricated kit of parts and the value of a more permanent piece of community infrastructure to create a school that can withstand the test of time. The first diagram shows learning communities that are incrementally added to the core to expand the school. This is the method that is tested in Chapter 7.

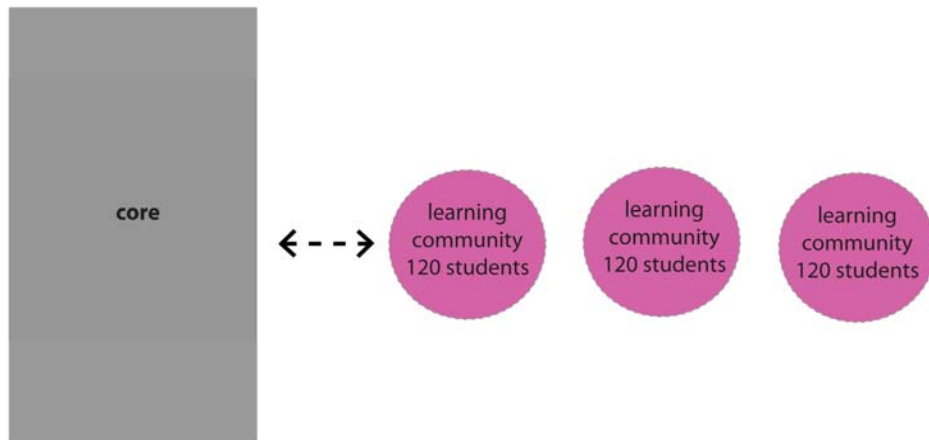


Figure 7: Incremental Growth in Clusters

The second diagram shows how the same idea of a learning community can expand in a linear bar. This method is tested in Chapter 8.

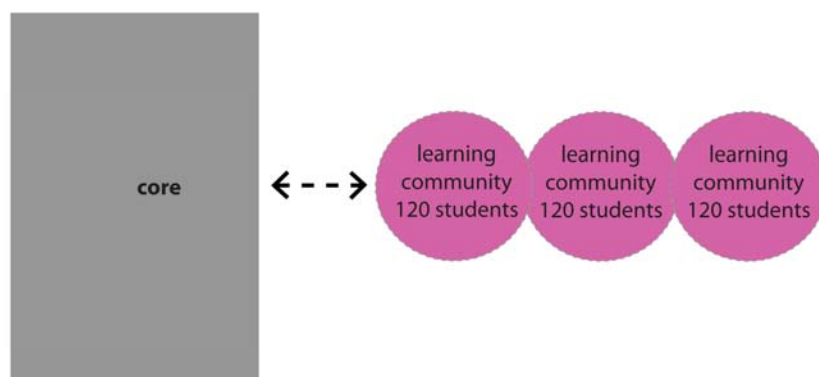


Figure 8: Incremental Expansion in a Linear Bar

5.2 The Core

The “core” refers to the more permanent school building. The building can either be an existing building or new construction. If it is an existing building, the site analysis will provide opportunities for how this building can be systematically expanded. The thesis is tested on an existing school in Chapter 8. Given an open site, which is tested in Chapter 7, the core should be thought of as a community center in terms of its programming and public presence. A designer is commissioned to design the core building in a manner that prepares to apply the pre-determined system of academic expansion. The following section explains how the core should be conceived of given an open site.

The design of the core building should address both the needs of the school, and the needs of a community building. As discussed in Chapter 1, when a school reaches a low enough enrollment size, it is often demolished or left abandoned. By creating a permanent civic building, the building can function with or without an academic component. The following list identifies design principals that any designer of the core building should follow.

A. The structure should be designed to allow for flexibility and adaptability in the future. If the walls are independent from the structural grid, spaces can be redefined if needed. Below is a diagram that shows how the grid is consistent, but there are hierarchal long-span spaces can create larger spaces.

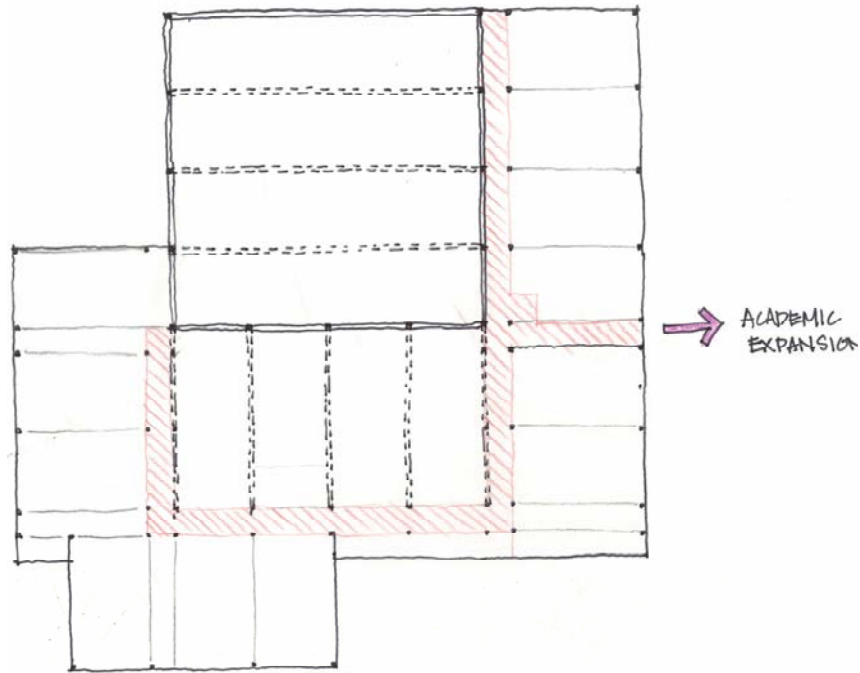


Figure 9: Sketch of Core Structural Concept

B. For a successful school or community center, there needs to be a hierarchal main space that can serve as the heart of the building.

C. The architectural definition of the exterior must have a public presence so the building becomes meaningful and valuable to the people in the community.

D. The building must function as a community center, independent from the academic program. The designer must consider security as the primary reason why schools are not normally open to the public.

5.3 The System of Incremental Expansion

Although the core varies from project to project, the pre-fabricated system of academic expansion is clearly defined. With that said, the variation within the system provides opportunities to allow for different spatial configurations, treat the envelope differently depending on the exposure, and provide a variety of cladding options. These variations are established in the “kit of parts” defined in the next section. First, it is important to explain some of the design principles that guide the use of this kit of parts.

A. The system is used to create learning communities. This allows for the school to incrementally expand by clusters of learning spaces, accommodating up to 120 students, rather than by one classroom. The programmatic suggestions for these learning communities are discussed in Chapter 6.

B. Each learning community is structurally and mechanically independent from the core. This allows for the rapid construction and deconstruction of learning communities.

C. The structure should tread lightly on the earth. Foundations should be considered that are not permanent.

D. The character of the learning communities can and should be strategic and the cladding should be chosen to represent each school. The intention is not to have all the learning communities at one school be different, but rather, each school should be cohesive in its entirety.

5.3.1 Kit of Parts

The following image shows the kit of parts product list. By working within the system, each school should be able to customize their learning communities to meet the needs of their school while still respecting the aforementioned design intentions.

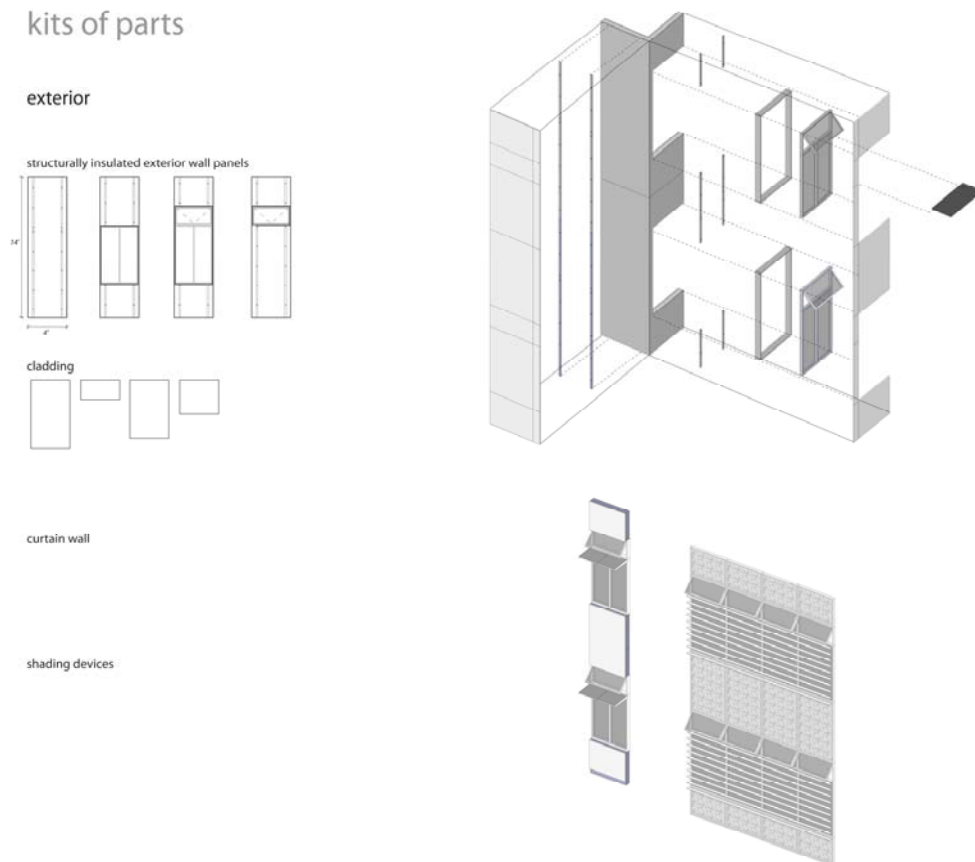


Figure 10: Kit of Parts

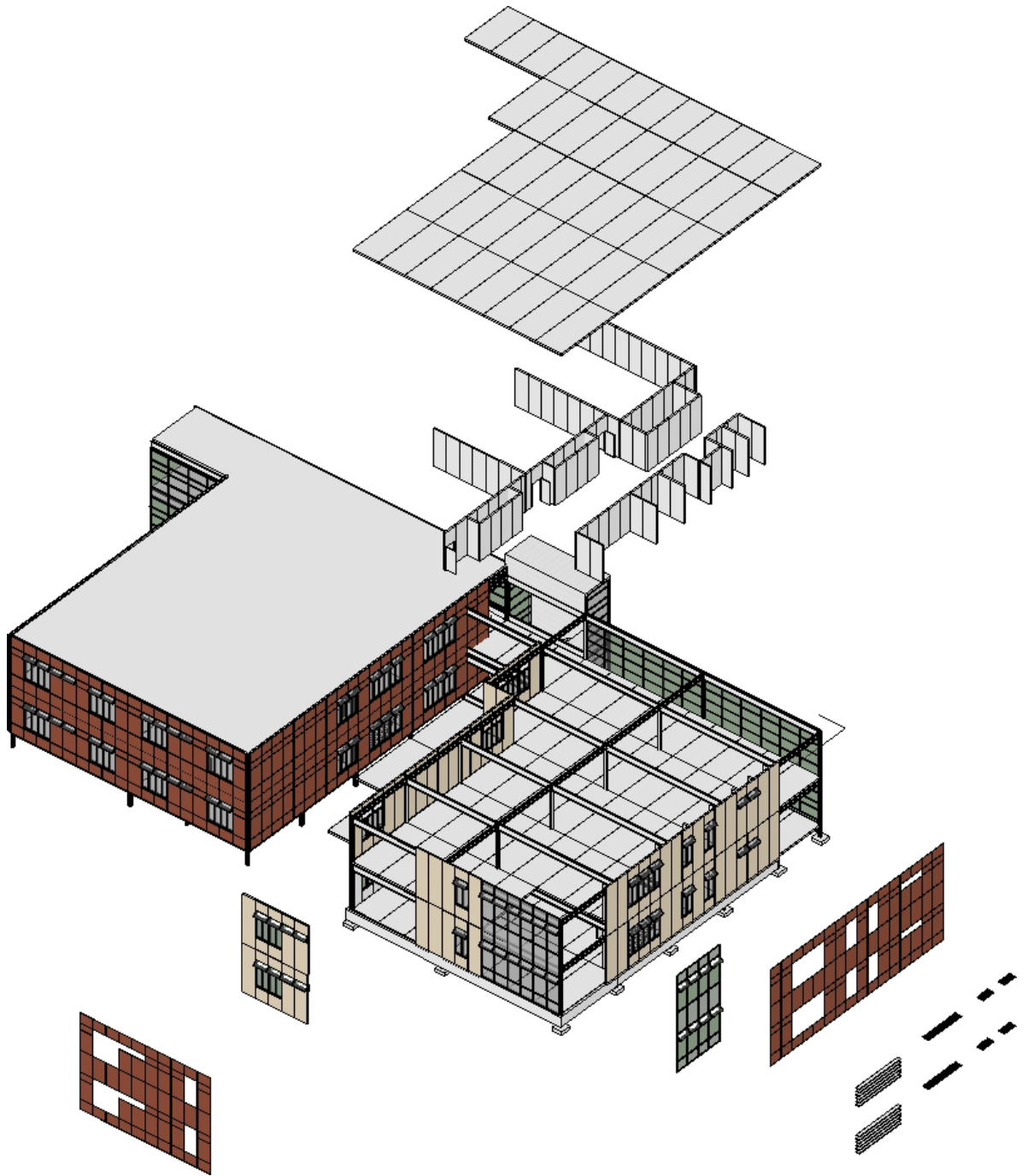


Figure 11: Pre-fabricated Learning Communities

Chapter 6: Reinterpreting the Functional Requirements

“Architects must learn how to invent flexibly scaled teaching and learning spaces to respond to needs for collaborative, team, and individual study areas for children of different ages and levels of learning”²³

6.1 Typical Education Specifications

By analyzing these specifications, there will be many opportunities to rethink the ways these spaces can support flexibility. Through the analysis the thesis will show that the current educational specifications do not allow for flexibility that will support the aforementioned changes in pedagogy, technology, economy, society, etc and therefore should be rethought. While generally working within the parameters of the specifications, a new program will be derived to support the thesis.

The programmatic information analyzed below is taken from the 2009 Bruce-Monroe PK-8 School Educational Specifications.

This is a program for approximately 600 students in grades PK-8.

Building Program: ²⁴

Core Academic/Special Education Area: 37,125 sf

²³ “Something from ‘Nothing’: Information Infrastructure in School Design, Haar p. 50

²⁴ Educational Specification for Bruce Monroe PK-8 School, Drafts, September 2009

Pre-K : 4 Classrooms @ 1,175 sf each, includes WC and
storage

Kindergarten: 3 Classrooms @ 1,175 sf each, includes WC and
stor.

Grades 1-5 : 3 classrooms per grade @ 900sf each

Grade 6-8 : 7 classrooms @ 850 sf each

Science Lab (Middle) : 2 @ 1300 sf each w/ prep areas

Resource Room (Elem) : 2 @ 400sf each

Resource Room (Middle) : 1 @ 800 sf

Student Services Offices : 4 @ 150sf each

Speech Room : 1 @ 300 s.f.

Special Needs Classroom : 2 @ 900 sf each

Special Education Suite :

Offices : 1 @ 150 sf

Small Group Area : 1 @ 200 sf

Occupational Therapy / Physical Therapy_ 1 @ 400 sf

ESOL / Bilingual Education : 2 @ 900 sf w/ support space

Storage : 3 @ 400 sf

Workroom / Teacher Office : 2 @ 400sf

Media Center: 3,600 sf

Visual Art and Music: 3,400sf

Physical Education/ Gym: 10,400 sf

Administration: 3,915sf

Student Dining & Food Service: 5,425sf

Maintenance & Custodial Services: 800sf

Mechanical, Electrical, Toilets, Custodial Closets: 24, 466 sf

Total Net Square Footage: 89,131 sf

Total Gross Square Footage: 96,975 sf

Exterior Spaces:

Multipurpose Grassy Play Field- soccer / softball—may be off-site

Structured Play Area For Primary Grades

Structured Play Area for Intermediate Grades

Protected Pre-School Play Area

Outdoor Paved Play Area [full basketball court, with markings for games]

Faculty, Staff, and Visitor Parking

Other potential additions to the building program that would be community assets:

Student-based health clinic

Adult and Post Secondary Learning Facilities

Day Care Facilities

6.2 Permanent and Variable Program

Figure 12: Program Analysis of Brightwood Educational Specification

6.3 The Core as a Community Center

In order for the core to act as a community center, the permanent program, as defined in the educational specifications, will need to be reworked.

Library

The library can be thought of as a information commons (a place where people go to exchange information), a support room (could be stacks now, but also wired to support computers if need as computer room or platform for new technology), and small group rooms (for students to work more quietly or meeting to occur).

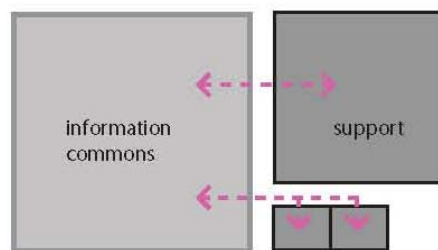


Figure 13: Library Program Diagram

Dining Area

The dining area does not need to be an enclosed room, although it could be. Either way, it should be thought of as a multipurpose room that can be

serviced directly by the kitchen. There is an opportunity for the dining area to become a more centralized space that is programmed for dining, but can become a larger gathering space for the public.

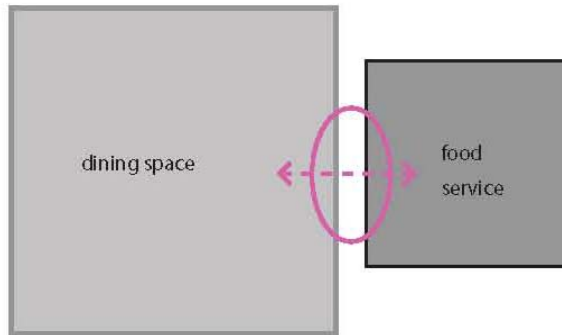


Figure 14: Dining Program Diagram

Administration

The welcome center component should be readily accessible from the entrance, and should ideal have a visual connection to the academic component. The administrative offices should be placed at the joint between the community center and the academic expansion with visibility to both.

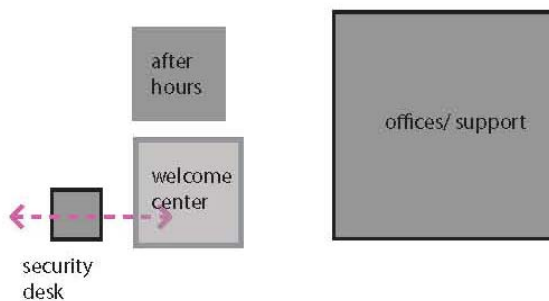


Figure 15: Administration Program Diagram

Student Health

The student health clinic is a place where students can go during the day if they do not feel well at school. It should be accessible from the academic spaces as well as the administration, gym, and public health center.

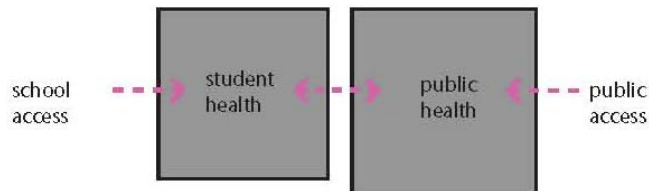


Figure 16: Health Program Diagram

Public Health

The public health is an added program, not included in a typical educational specification. This piece is added as an extension of the student health component and provides another service to the community. Many families of public school children may not have the best access to quality health care, and this could be a way to serve the families of the children, thereby providing the children with a healthy home life.

Gymnasium / Music

The music room / stage is considered permanent because there will always be a need for this program. There are many after-school programs that integrate music and it should be accessible for the public. The stage should be directly linked to either the dining/ multipurpose area or the gym to allow for that space to double as an auditorium.

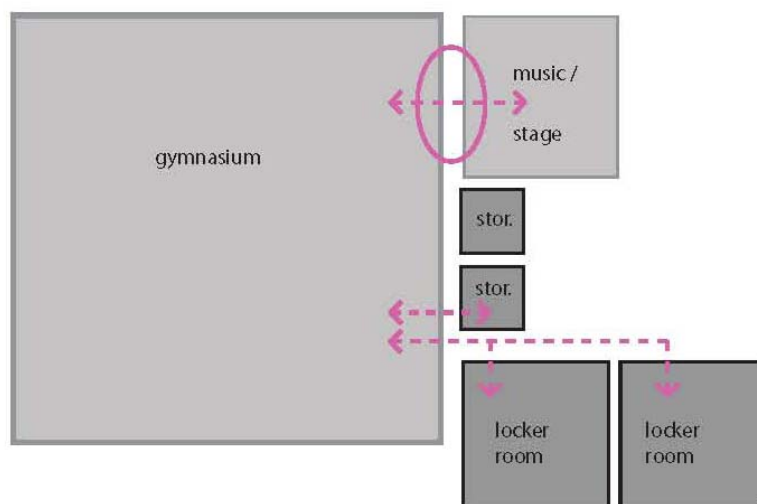


Figure 17: Gym / Music Program Diagram

Pre-kindergarten Classrooms

These classrooms are not grouped with the other academic functions. This is mainly because there is usually a need for day-care in a community center, so these classrooms can be considered permanent.

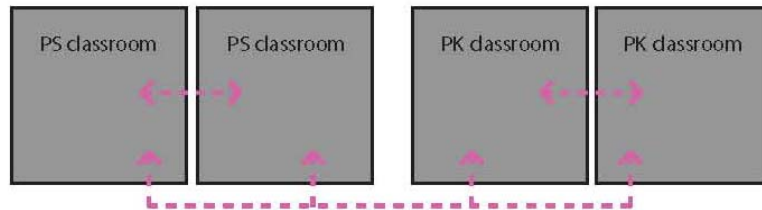


Figure 18: Daycare Program Diagram

When testing the thesis on an open site, the community center building incorporates these ideas.

6.4 Academic Expansion

The variable program is housed in academic expansion. The strategy is unlike the current portable trailers, because the school will not expand in modules of one classroom. Instead, the learning communities will each house 120 students and will be created using the kit of parts. In chapter three, the success of these learning communities was discussed.

Since PK-8 students are at all levels of development, there are some functional considerations that vary between the younger children and the oldest.

6.4.1 Early Learning Communities

Students in pre-kindergarten until first grade would attend these learning communities. Since the students are more dependent, they spend most of their day in one classroom, including mealtime. The students may also occasionally come together to eat in the common space. Since the meals occur within the community, there is a need for a warming kitchen. This would be serviced by the main kitchen, but would allow for the lunches to be prepared in the learning community. The common space should provide students with a physical and visual connection outdoors. The classrooms are large (1,175 square feet) and each has their own restroom and storage closet. A few small group rooms that are accessible from the commons provide spaces where teachers can meet with students or other teachers in private.

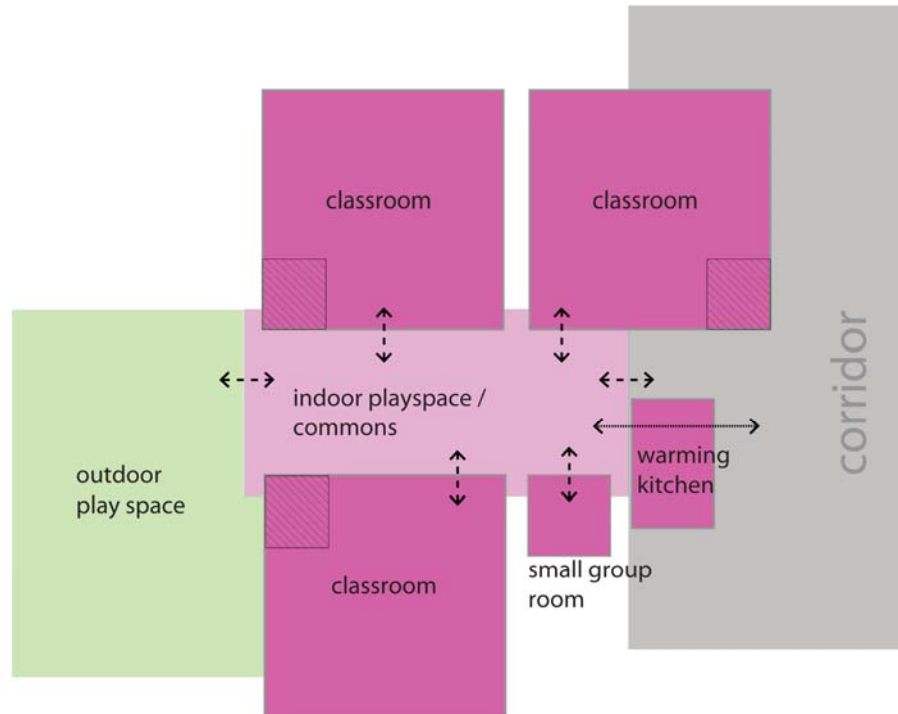


Figure 19 Early Learning Community Diagram

6.4.2 Elementary Learning Communities

Students in first through fifth grades would be attending these learning communities. The students are more independent, and most likely have a schedule that requires them to visit different classrooms, including labs or art rooms. There is still need for constant supervision. Since the students may have a rotating schedule, it is likely that the teachers will as well. As a result, there is a need for a faculty collaboration room within the community where the teachers can keep their belongings and have a desk. This should have a visual connection to the common space so the students can be watched even during their free time.

The common space will start to be used as a project area or larger gathering space. Students could also eat in this space if needed, but their primary space for meals is the all-school dining area. As a result, there is not a need for the warming kitchen. The common space should provide students with a physical and visual connection outdoors. A few small group rooms that are accessible from the commons provide spaces where teachers can meet with students one-on-one and small group work between students can occur.

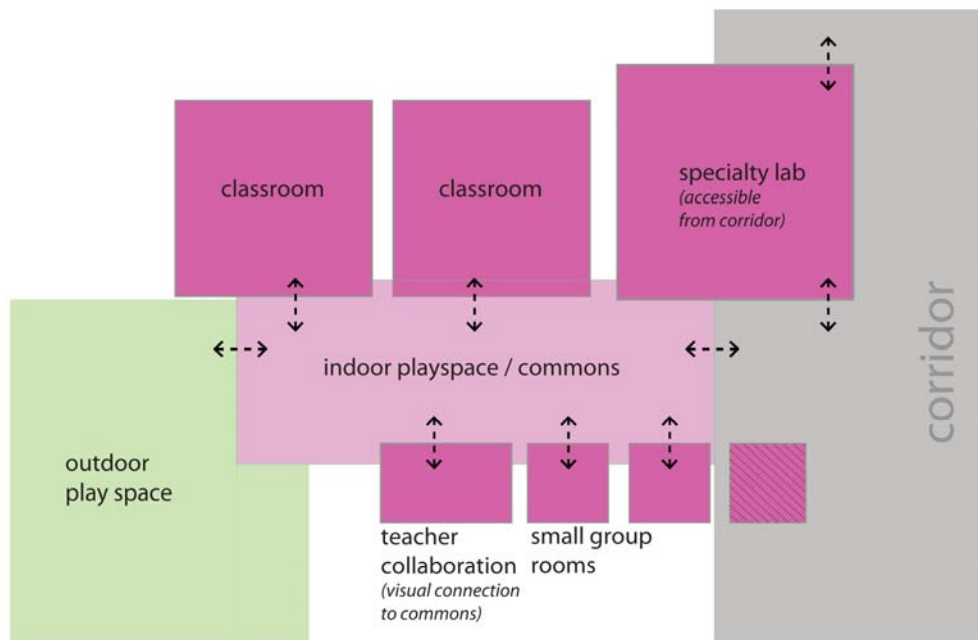


Figure 20: Elementary / Middle Learning Community Diagram

6.4.3 Middle Learning Communities

The spatial configuration of the middle learning community is the same as the elementary learning community. That said, there are some

differences in the way they use the space. The oldest children may use the commons as a place to do independent work or project based work. Study carrels or other furniture can start to provide places where students can look up something online for a research paper while his/her classmates are working on a group project at the next table.

The goal for the academic expansion is to create learning communities using the kit of parts discussed in Chapter 5: A Systematic Approach.

Chapter 7: Case Study One_An Open Site

The following case study will test the thesis on the now open site of West Education Campus.

7.1 Enrollment at West Education Campus

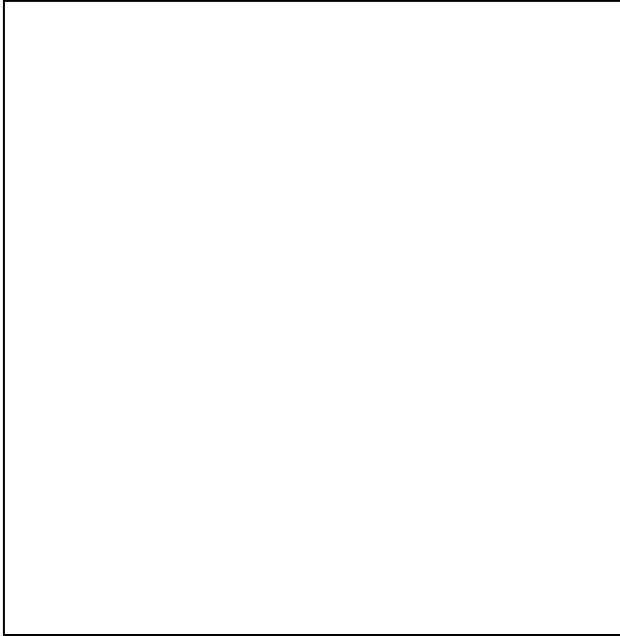
The following chart examines enrollment variation. The maximum enrollment capacity at West is now 280 students and is projected to increase to 450 students after pending modernization in 2011.

Year	'02-'03	'07-'08	'09-'10
Enrollment	309 students	190 students	265 students
Building Enrollment	110%	68%	95%

The enrollment at West has fluctuated over the past eight years, leading to the building utilization ranging from 68% to 110% of its capacity. West is located in the center of its residential neighborhood, but only fifty-one percent of students are coming from within boundaries.

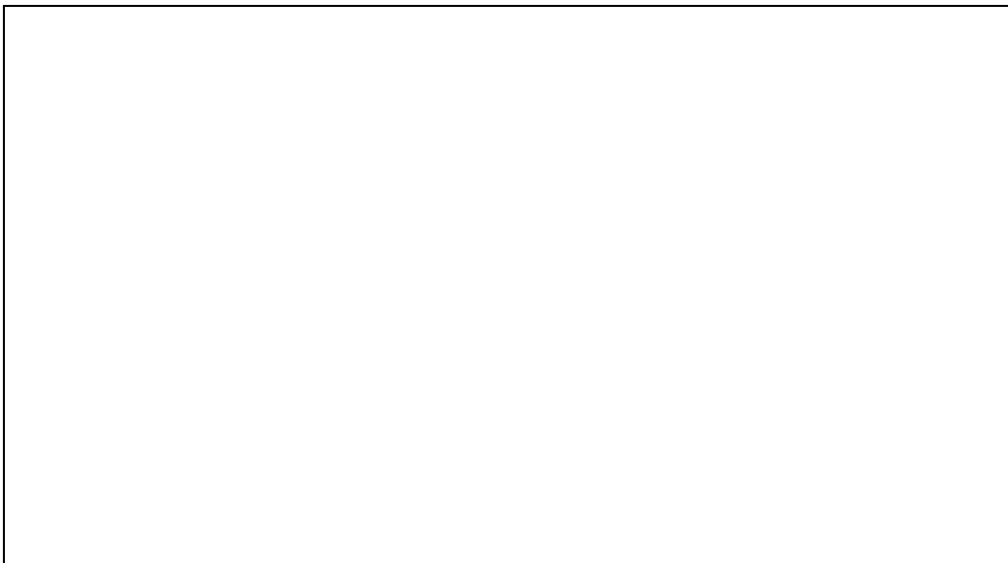
7.2 Climatic Considerations for Washington D.C.

The following diagrams show the climatic considerations in Washington D.C. and are relevant to both sites.



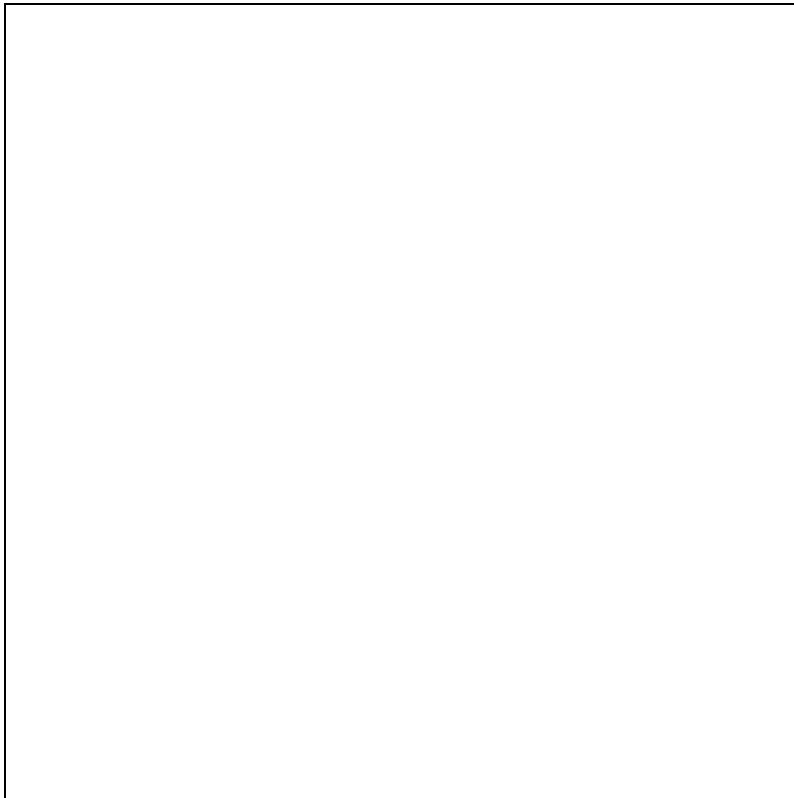
*Figure 21 Average Temperature for Washington D.C.
Data found on www.weather.com*

The averages over the year vary significantly causing temperatures to range from below freezing to the high eighties. The seasons cause uncomfortable weather for most months of the year, making natural ventilation a secondary means of airflow.



*Figure 22: Average Rainfall for Washington D.C.
Data found on www.weather.com*

The rainfall over the year is consistent. There is potential to collect and recycle rainwater.



*Figure 23: Path of Sun for Washington D.C.
Image found on
<http://www.gaisma.com/en/location/washington-district-of-columbia>*

The sun angle is greater in the summer causing less sun to enter the building. During the winter, the building can use sunshades or louvers to block light or allow it into the building. The western light is severe and direct exposure should be avoided. As previously cited, studies have shown that children perform better when exposed to natural daylight.

7.3 Site Analysis

Currently, there is an existing school on the site, but this thesis assumes it needs to be rebuilt. The site is located in a residential neighborhood in northwest Washington D.C. It is central to its neighborhood (see figure 24: the red region shows West), so students will be entering the site from all directions. It is between Fourteenth Street and Georgia Ave, both of which are commercial thoroughways connecting the neighborhood to downtown Washington.

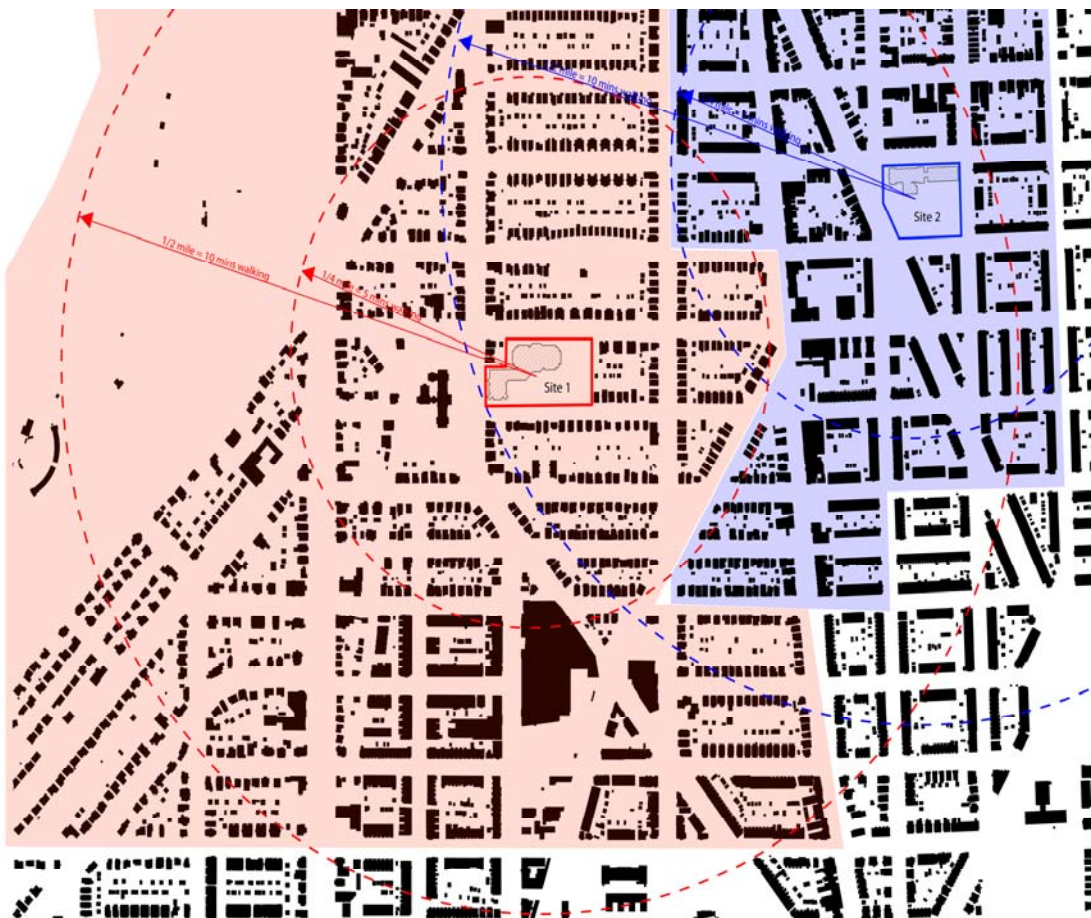


Figure 24: Neighborhood Catchment Area for West Education Campus

The topography on the site is severe with a 20-foot drop from the northwest to the southeast corner. This provides the opportunity to test how the pre-fabricated expansion can be site specific and address a change in grade as an opportunity, rather than leveling the earth and making the site flat.



Figure 25: Existing West Site Plan and Section

There are no major community centers in the area, so this is a prime example of using the school as a way to connect the neighborhood. There is a private school across the street, as well as a few churches nearby, but the site is primarily residential (*see photographs below*).



Figure 26: Photographs of West Education Campus



Figure 27: Photographs of Neighborhood

7.4 Site Strategy

In designing the site and landscape of the school, it is important to consider where the expansion will occur. As discussed in Chapter 1, the current portable trailers are placed anywhere on a site with no enclosed circulation. Knowing where the school will expand presents opportunities in the site planning. The diagram below shows the site at capacity with five learning communities, accommodating up to 640 schools. This number is the maximum amount because community center amenities are designed for a 600-student school and this is above the D.C. average. Below the full site plan is a series of diagrams that show how the school expands. The amount of students each phase is able to accommodate is written below the diagram. The intention is for the site to accommodate anywhere between zero and five learning communities with little affect on the landscape.

site plan_ west education campus



incremental expansion of learning pods



Figure 28: West Education Campus Site Plan

Although this configuration proved to be the most successful on the site, the following sketches show a variety ways the learning communities can aggregate on the site.



Figure 29: Double-loaded "corridor"

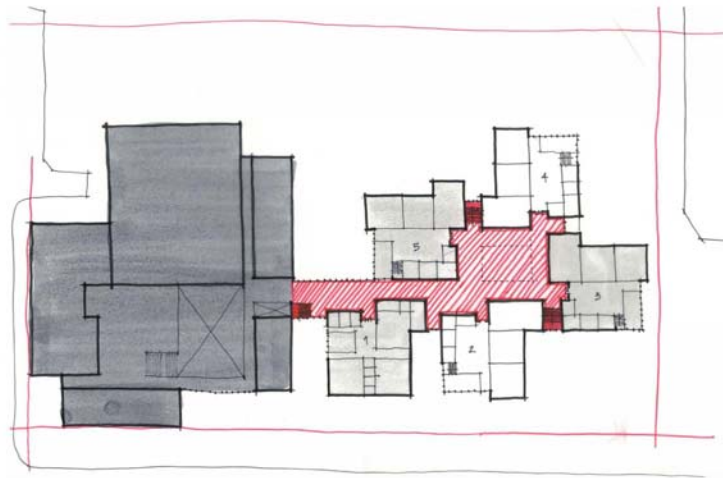


Figure 30: Interior Courtyard

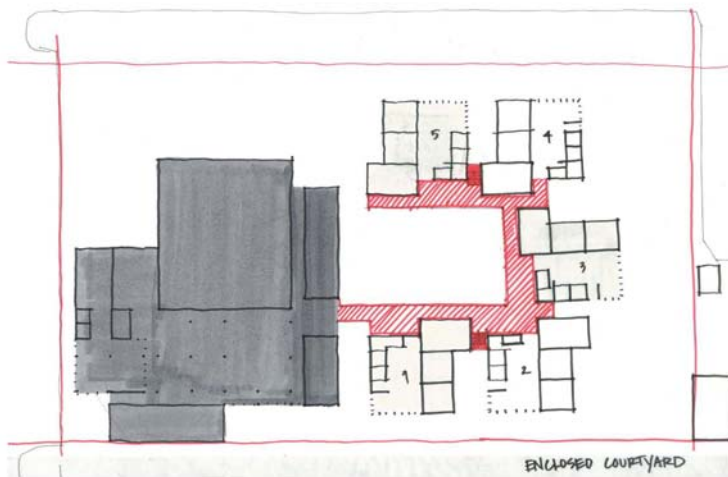


Figure 31: Enclosed Courtyard

The following diagram shows how the kit of parts is used to create these learning communities on the site.

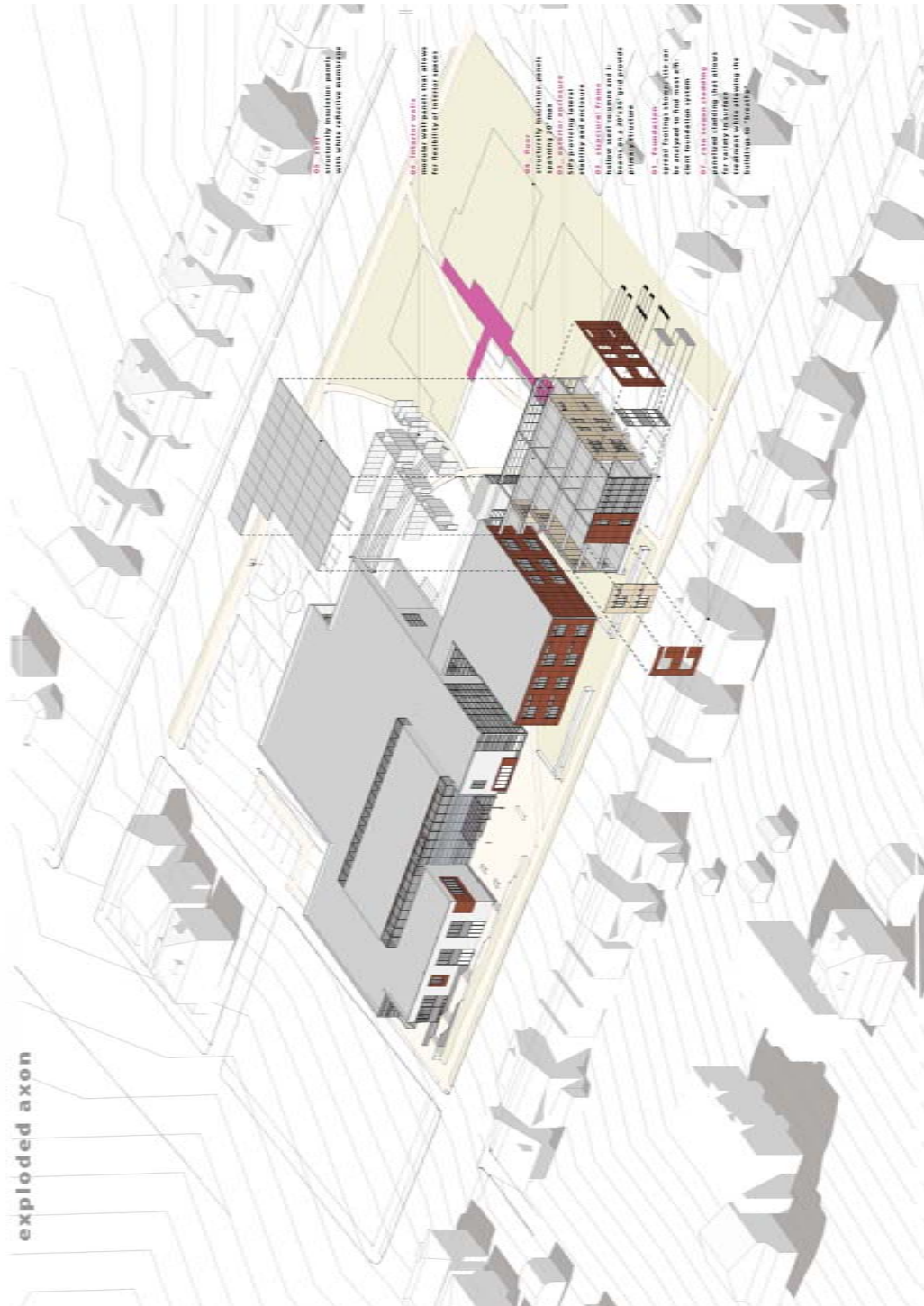


Figure 32: Exploded Axon

7.5 The Core as a Community Center

Given the open site, the core is designed to act as a community center independent from the academic functions. Refer to Chapters 1, 5, and 6 to better understand the intention behind this idea.

The Core building is dropped below the level of Fourteenth Street to allow for the public to enter off the quieter Farragut Street. The program is arranged with the gym, welcome center, music / stage, pre-kindergarten, and student health on the ground floor, all accessible from the main central space. On the second floor is the dining area, library, administration, public health clinic, and several public classrooms. Lowering the building below grade allowed the public health clinic to have a private entrance from the West. In the plans below, the shades of gray represent the permanent program.



Figure 33: Proposed West Education Campus Plans



Figure 34: Section Perspective through community center

The above section shows the entrance, main central space and the gym. On entry, the visitor has a visual connection to the gym and quickly understands the building.

In order to the core to act as a community center, it needs to have a civic presence.



Figure 35: Exterior Perspective of Main Entrance

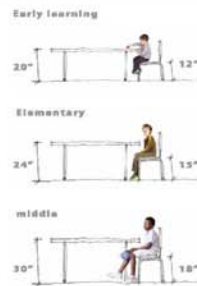
7.6 Learning Communities

The learning communities are made using the kit of parts defined in Chapter 5. The intention is for the students to spend most of their days in the learning community. As they get older they have more independence within the community and the rest of the school. The learning communities have differing requirements depending on the age of the students inside (as outline

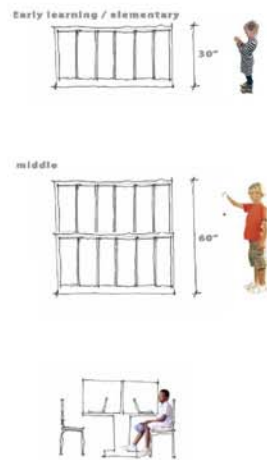
in Chapter 6). Since this can vary depending on the amount of students in the school, this customization is mainly addressed in furniture.



entrance to community



classroom



commons

Figure 36: Customization of Learning Communities

This is an example of an early learning community.



Figure 37: Early learning community

This is an example of an elementary learning community.



Figure 38: Elementary learning community

7.7 Adaptable Permanence

The relationship between the permanent building and the academic expansion can be addressed in a few ways. To a certain extent, the construction of the two has similarities. In this example, the permanent building is articulated as more solid, using masonry cladding and a heavy base, with concrete protrusions giving a playful variation to the façade. The learning communities are a terra cotta rainscreen that varies in its texture to give verticality to an otherwise horizontal composition.



Figure 39: Perspective of early learning outdoor terrace



south elevation
scale 1/8" = 1'-0"



s-n section perspective
scale 1/8" = 1'-0"



e-w section
scale 1/8" = 1'-0"

Figure 40: Sections and South Elevation

Chapter 8: Case Study Two_An Existing School

The following case study will test the thesis on the site of Truesdell Education Campus.

8.1 Enrollment at Truesdell Education Campus

The following chart examines enrollment variation. The maximum enrollment capacity is now 471 students and is projected in decrease to 450 students after pending modernization.

	'02-'03	'07-'08	'09-'10
Enrollment	477 students	286 students	423 students
Building Utilization	101%	60%	90%

As seen, the enrollment at Truesdell has fluctuated over the past eight years, leading to the building utilization ranging from 60% to 101% of its capacity. Truesdell is located in the center of a residential neighborhood where seventy-nine percent of students are coming from within these boundaries.

8.2 Climatic Considerations for Washington D.C.

Same data as section 6.1.

8.3 Site Analysis

The 69,600 square foot school is comprised of two buildings. The first was built in 1908, and the second was added in 1967. The only way to get

from one building to the other is at the ground floor, causing disconnect between the upper levels. The buildings are scheduled for “modernization” in 2010. These adjustments are mostly interior, but also change the entrance and look to connect the two buildings on multiple floors. In this plan, both building are to be kept.



Figure 41: 1908 Building



Figure 42: 1969 Addition



Figure 43: Playground behind school

The thesis assumes that the existing school on the site needs to be expanded. The site is located in a residential neighborhood in northwest Washington D.C. a few blocks from West Education Campus. Like West, it is central to its neighborhood (see figure 42: the blue region shows Truesdell), so students will be entering the site from all directions.



Figure 44: Neighborhood Catchment Area of Truesdell

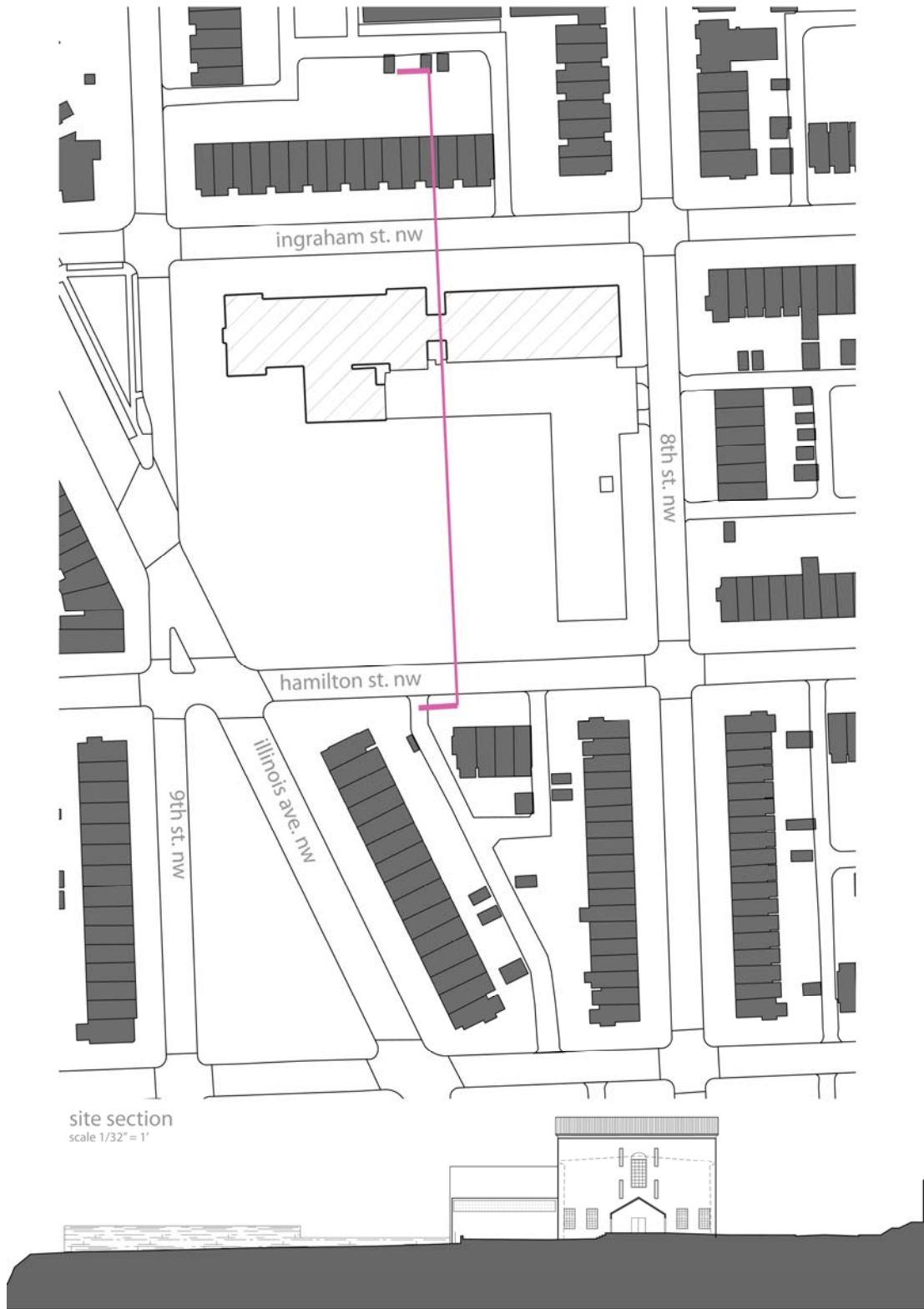


Figure 45 Truesdell Existing Site Plan and Section

The topography on the site is severe as there is a 20-foot drop from the north to the south. The existing school has level mostly leveled this topography change. The main goal is to see how the learning communities can be added to an existing school and adapt to the height of its floor and the topography on the site.

8.4 Site Strategy

The strategy is to use the same system proposed in the thesis to expand from an existing school. Instead of expanding in the same way, the case study illustrates how the kit of parts can be used to expand linearly. The same principles of a learning community remain true, but the spaces are configured in a bar rather than clusters.



truesdell site plan
scale 1/32" = 1'-0"

Figure 46: Truesdell Proposed Site Plan

Although this site strategy was used, many other configurations were explored. The following sketches show a variety of ways the school could expand.

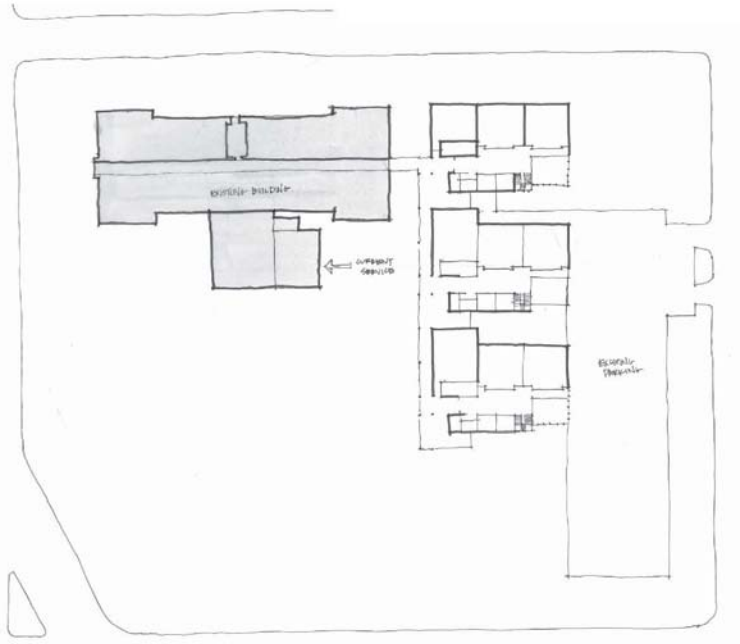


Figure 47: Replace 1969 building with learning communities

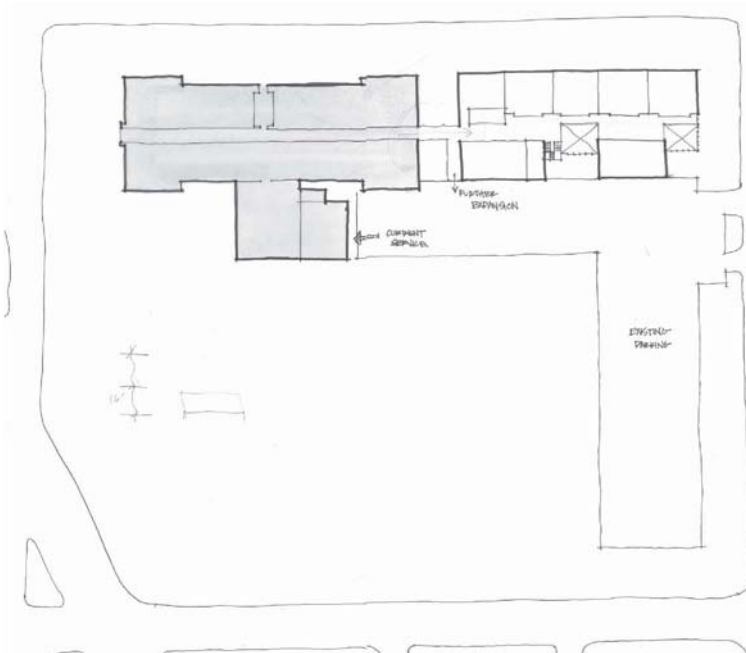


Figure 48: Replace 1969 building with linear learning community

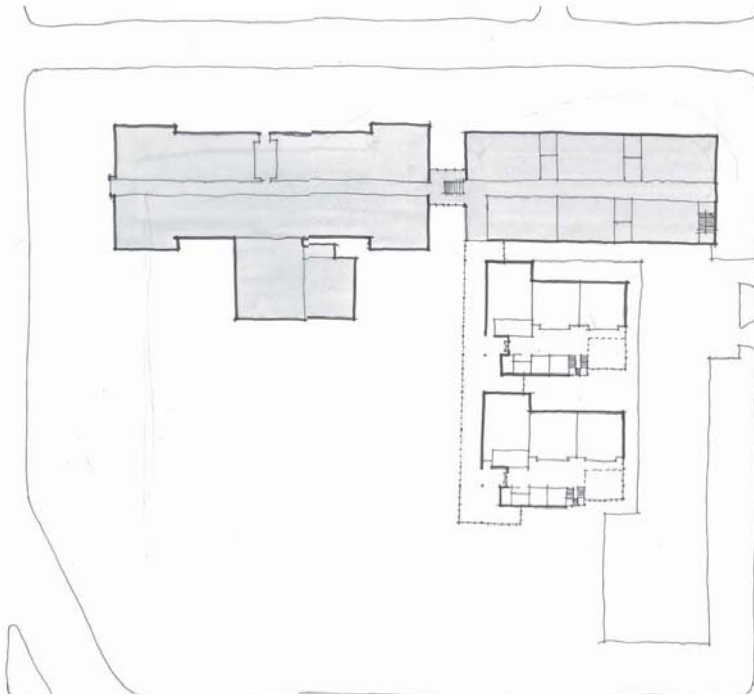


Figure 49: Keep both school buildings and add learning communities

The joint between the two existing buildings is one story, but further examination is needed to show how the levels between all three buildings could be mediated in this joint.

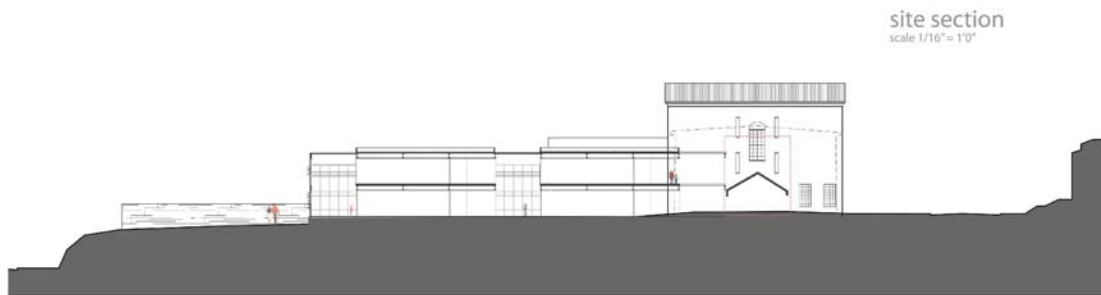


Figure 50: Proposed Site Section



Figure 51: Perspective showing expansion

Note the difference in cladding between this expansion and the expansion at West Education Campus. The next chapter will explore these variations in more detail.

Chapter 9: Applying the Kit of Parts

Chapters 7 and 8 have explored ways to use the kit of parts can be used to make learning communities that can be added to a new or existing school.

This chapter explores how the system works in greater detail.

9.1 Adjusting to Slope

The following sketches show how the corridor can be designed to include a ramp and allow the learning communities to step down or up with the existing topography. The ramp occurs next to a longer wall, and therefore it limited to a 30" drop per learning community.

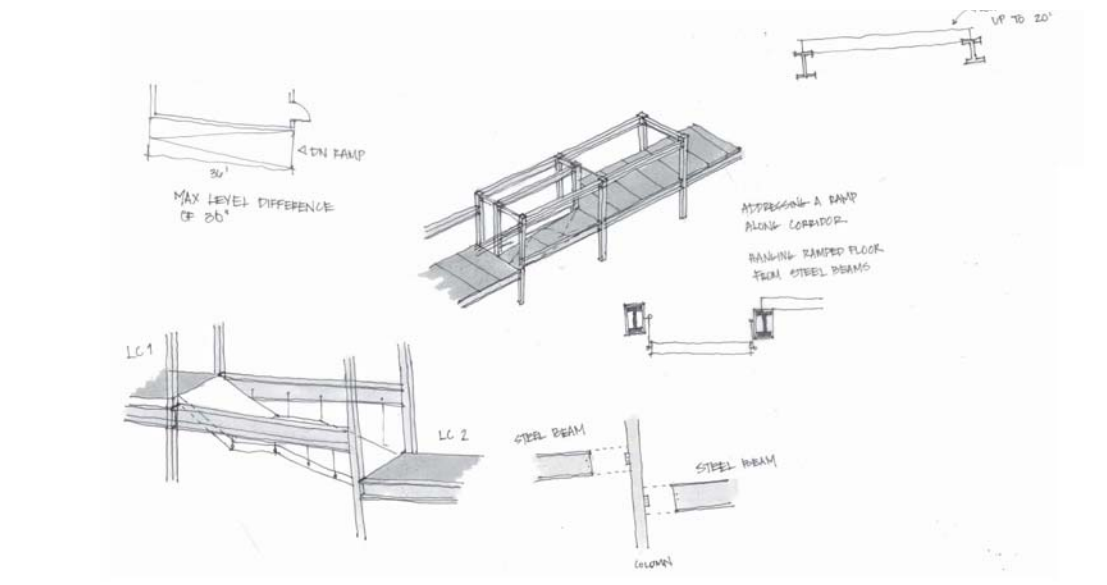


Figure 52: Detail Sketches

9.2 Variations of Exterior

One major issue with modular construction is that each module is often the same. One of the advantages of the kit of parts method of pre-fabricated construction is the ability to customize. This means that the amount of openings on the façade can vary depending on the exposure. These diagrams should show how the same façade can be creatively altered to have more or less exposure to light.

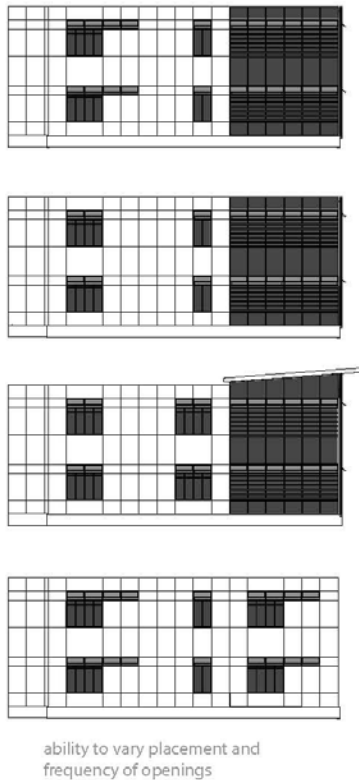


Figure 53 Elevation Diagrams

Additionally, the cladding can vary as well. As seen in the two case studies, the cladding, and therefore character, of the learning communities was

different on each site. The intention of the thesis is not to make all the learning communities look the same and be recognizable around the city. Instead, it provides a way that schools can quickly expand, but still keep their own identity or create a new image for themselves.

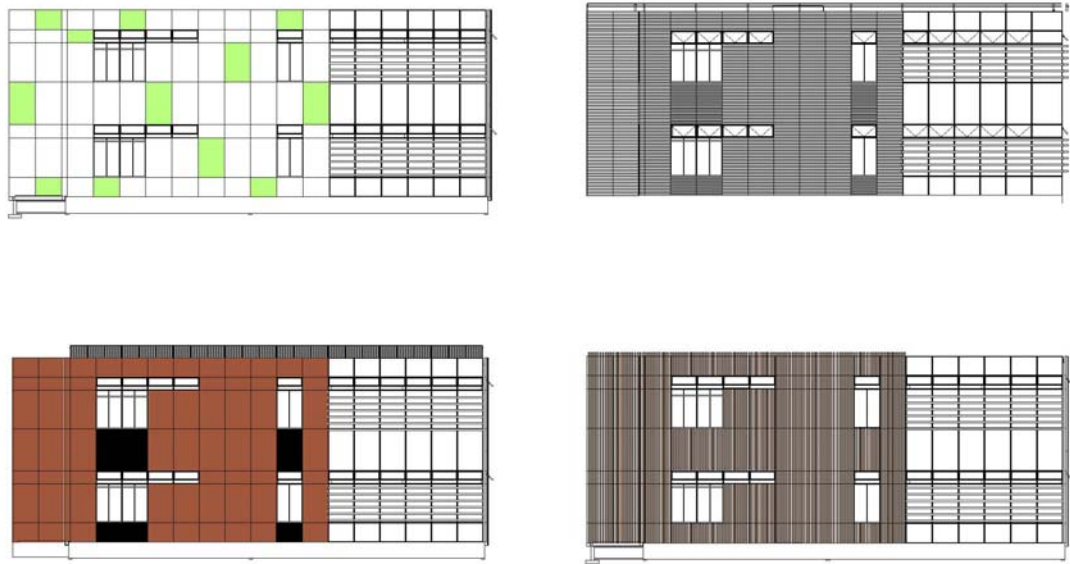


Figure 54: Elevations showing Cladding Options

9.3 Contraction

The idea of expansion was explored in great detail, but the idea of contraction is also important to this thesis. The project started with the premise that these learning communities could expand and contract depending on the enrollment. When the learning communities are taken away, the community center building is able to independently contribute to the neighborhood and city.

The research generally found that even portable classrooms, which are thought to be the easiest structure to remove from a site, are often left at

schools for longer than expected. Although the likelihood that these learning communities would be deconstructed instead of left unoccupied is unlikely, there are still qualities of the system that make it possible. First, each learning community is structurally and mechanically independent. In addition, all the pieces are pre-fabricated and panelized, and then added to a steel frame. In theory, these pieces could be deconstructed, almost as easy as they were constructed, and recycled or reused. If the decision is made to leave a learning community unoccupied, the mechanical systems can be shut off so no resources are wasted.

Chapter 10: Conclusion

The public review of the work was held on Dec 1, 2010 at the School of Architecture, Planning, and Preservation.

The following sections address the comments that were made.

10.1 Articulation of Permanent vs. Temporary Architecture

Should this be expressed in the façade of the building? Two opposite approaches come to mind. One option is for the core and the incremental expansion to have a similar language. Even though the methods of construction are different, there can still be a similar palette used in each. The other approach is to contrast the two and accentuate the differences between the methods of construction. I did not fully commit to one or the other. In the end, the buildings were meant to match in language/color but not in the material. There may be an issue with how the different materials show their age.

10.2 Scale of Learning Communities

The pre-fabricated nature of the project makes it more difficult to have more formal variety. When developing the kit of parts further, the integration of a truss might help to give more options for the roof.

10.3 The Civic Presence of the Core Building

The exterior of the building should be civic, so that it can stand alone as a community center, and represent the institution of school. There were comments on how the building did not seem civic, but it did seem institutional. The question of what makes a building civic has been a constant discussion throughout the whole thesis. Some ideas of how to make the building civic are:

- a. Grand and welcoming architectural definition of entrance—
including signage
- b. Entry plaza that creates a place for people to gather outside the
building
- c. Large transparent area that allows a visitor to view the interior
space from the exterior
- d. Accentuate how the building meets the ground and sky

At the same time, I wanted the building to read as a school so the façade is more playful and whimsy than a “civic” building.

10.4 Figural Quality of Common Spaces

“There is a lack of figural space that makes the common spaces seem residual” – Frank Durken

“I think it’s less residual and more organic” – Coke Florence

The following diagrams show how these spaces can be broken into activity zones that allow for a variety of different learning modalities to take place. One concern is that there are not as many “nook and crannies” where students can work individually. Since there are small group rooms, there would be places for teachers to pull aside one or two students or for students to work independently.

The main goal of the thesis was to find a way to create a school that is both adaptable and flexible. At one point this meant the school was a permanent building where this flexibility occurs within the walls and another it was a completely pre-fabricated solution. In the end came a hybrid, a school that could both adapt or change size and have a permanent presence in the city. The outcome was a community center where academic functions can be systematically added or subtracted. Exploring architecture as simultaneously permanent and variable is an issue that designers face in a rapidly changing world.

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