The 21st Century Learning Environment:

Education in the Digital Era

James Moehring

A thesis submitted in partial fulfillment of the requirements for the degree of:

Master of Architecture

University of Washington

2012

Committee:

Joel Loveland, Chair

Chris Meek

Dave Miller

Program authorized to offer degree:

Department of Architecture

Acknowledgements:

I'd like to the my advisors Joel Loveland, Chris Meek, and Dave Miller for their effort through the entire year of 2012 to help me in the process and production of the final thesis presentation and document. Their knowledge and expertise has shaped my thesis and understanding of education in a more comprehensive way than I could have imagined.

I would also like to thank my coworkers from Bassetti Architects for allowing me use them as a resource for my relevant thesis. The have shown great intrest and support through out my time in Seattle.

Finally, I owe my parents many thanks for their love and support through my six and a half years in architecture school.

Table of Contents

List of Figures

Introduction

"The average high school graduate has spent about 13,000 hours within the walls of a public school building. These 13,000 hours are potentially the most valuable hours of his life..." – William G. Carr Executive Secretary of the National Education Association[1]

"The world of learning is changing, in no small measure due to the challenges of the global knowledge society, where students need to be able to master such 21st century skills as critical thinking, problem solving, innovation, digital and media literacy, and collaboration, as well such cross disciplinary content areas as civic literacy, global awareness, and environmental literacy." – Partnership for the 21st Century Skills[2]

"We 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 CEO of KnowledgeWorks Foundation[3]

School age is an important stage in life that shapes each student over time into a unique adult. The experience and habits that an individual forms during childhood will deeply affect their development, health, and personality throughout their life. The majority of the school day is spent learning from a teacher and curriculum, but social interaction and experiences that happen in schools are also a large part of learning and becoming an adult. School is a place where learning goes beyond the teacher at the front of the classroom; it is also shaped by other students and the physical space. The physical learning environment has a significant impact on students and how they learn. The environment that shapes the school equally shapes the student. Spaces that encourage collaboration, health, development, and inspiration give students a place that

1 Burke, Catherine, and Ian Grosvenor. *School*. London: Reaktion Books, 2008. 1. Print.

2 "The Partnership for 21st Century Skills." *The Partnership for 21st Century Skills*. Web. 24 Feb. 2012. <http://www.p21.org/>

3 *The Third Teacher: 79 Ways You Can Use Design to Transform Teaching & Learning*. New York: Abrams, 2010. 1. Print. Pg. 1

encourages success.

The way students learn has evolved over time, but the classroom has "changed relatively little in the last 150 years."[4] It is hard to believe that the school system has not changed over this period of time in correlation to the magnitude of changes in information and communication technology outside the classroom. Information and communication technology is used today in traditional classroom settings, but the learning environment has not been shaped to accommodate for the different learning techniques and educational programs of the twenty-first century school. In the next fifty years, technology will start to play a much larger role in the education of our youth. Our current classrooms will not suffice for success because they are not prepared for the changes in technology and the pedagogical response to those changes. It is important though to see that technology is a tool, not a means to an end. "Asking 'How can technology make a better student?' is the same as asking 'How can the refrigerator make me a better cook?'"[5] Reliance on technology alone cannot guide the future school. Congruent changes in the educational program and physical environment are also need to change to create the future school.

Building technology has changed throughout time, and sustainable technology over time has layered into current school designs because of the realization of the importance in health and education of children. Programs such as LEED for Schools and C.H.P.S. are becoming standard benchmarks for healthy schools. Children learn from their environment. By making that environment a tool for learning, children will be able to better understand how their surroundings function. Providing a healthy and daylit learning environment for future generations gives children and teachers the expectations for a sustainable environment instead of becoming more insensitive "to

4 McGregor, Jane. "Space, Power and the Classroom."*Forum: for Promoting 3-19 Comprehensive Education*. 46.1 (2004): 15. Print.

5 The New York Times Company. "Schools For Tomorrow: Bringing Technology into the Classroom." *The New York Times SFTM White Paper* (2011). Print.

brutish conditions of environments designed for maximum efficiency."[6] Sustainable technology and communication and information technology are the tools influencing the change of design for the twenty-first century school.

6 Benedikt, Michael. "Environmental Stoicism and Place Machismo." *Harvard Design Magazine* Winter/Spring.16 (2002): 2. Print.

Thesis Statement

The design of future schools and learning environments will be influenced by advances in information and communication technology and the pedagogical responses to the freedoms that it provides. Understanding the physical environment connection to the future roles of teachers and students in the digital age is an important relationship that will shape the classroom. It is important to create learning spaces in which the physical environment will have as much of an impact on learning as digital technology has on new learning typologies. Creating a healthy and sustainable environment that is integrated with future school design will give teachers and children a better environment in which to teach and learn. This thesis proposes a learning structure and the subsequent physical changes that will take place in redefining the learning environment in a twenty first century urban school. It will facilitate the advancements in future learning methods and digital devices while addressing issues that come along with the decision of locating a school in the densifying urban neighborhood of South Lake Union, Seattle.

Literature Review

Section 1: History of Education Reform and School Architecture

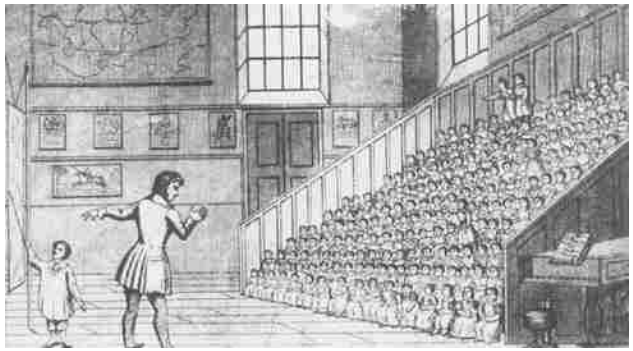


Figure 1.1 S. Wilderspin, *System for the Education of the Young.*

Figure 1.2 Colonie d'Avernes, France 1920.

To understand the future of school design, it is important to take a look at the history of schools and recognize the teaching methods and designs that have shaped schools to the present day. At the start of the 19th century the United States' and Europe's first public schools began to form in conjunction with the rise of the industrial revolution (Fig. 1.1, 1.2). Grammar schools in the United States taught six years of basic skills sometimes referred to as the "3 R's", reading, writing, and arithmetic.[7] The grammar school was essentially an extension of the home, hence the name the "school house." Schools during the late 19th century in the United States were viewed as "a solution to a host of social problems, and as a tool of economic and political development."[8] The "common-school" reform developed by Horace Mann identified that all children should have an equal opportunity to learn. Rather than all the students being taught in a single room, the reform based on Prussian teaching methods that physically separated students into grades. These small school buildings were numerous across the nation because of the need to be within walking distance. The conditions of these many schools fluctuated greatly. The environments in which students learned varied between schools and regions. "Health and safety conditions related to sanitation, hygiene, and the danger of fire were less than ideal and varied location to location, with little in the way of consistent regulatory oversight. As a result, the quality of schools varied considerably, depending for the most part on the experience and knowledge of the architect."[9]

---

7 "The Partnership for 21st Century Skills." *The Partnership for 21st Century Skills*. Web. 24 Feb. 2012. <http://www.p21.org/>

8 Rury, John L. *Education and Social Change: Themes in the History of American Schooling*. Mahwah, N.J: L. Erlbaum Associates, 2005. 75. Print.

9 Hille, R T. *Modern Schools: A Century of Design for Education*. Hoboken, N.J: John Wiley and Sons, 2011. Print.

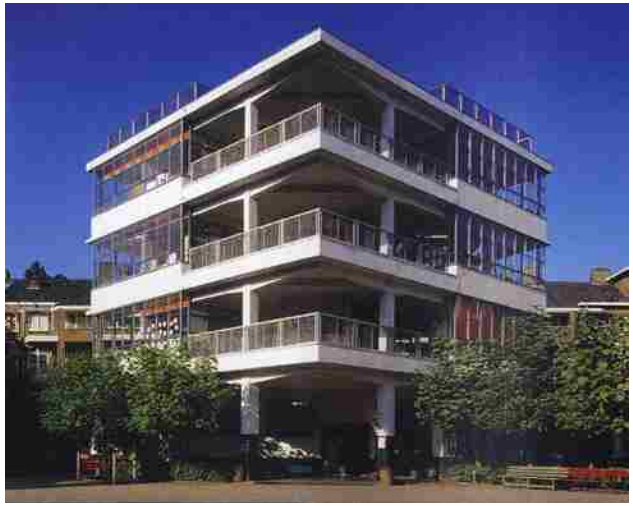


Figure 1.3 Exterior view of the Open Air School in Amsterdam.

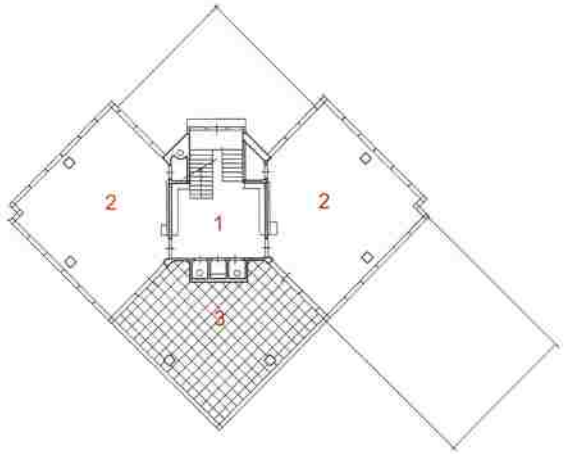


Figure 1.4 Plan of the Open Air School in Amsterdam.

In the early 20th century, industrialization and urbanization defined the Progressive Era of education.[10] Health and safety in schools became such a large concern that standards were made to improve the quality of the classroom. For many schools, windows were the main source of light and ventilation into the room. The room layout and dimensions were heavily influenced by the properties of light and ventilation, and if the architect did not understand these parameters the classroom would not be effectively ventilated or adequately daylit.[11] Standards such as minimum ceiling heights of 12 feet along with large tall operable windows allowed light to fill the room and also ventilated the space more efficiently. These traditional schools typically lined children in rows of desks bolted to the floor and the teacher would stand at the front of the room with the chalk board. Typically the class would face forward with the windows on the left-hand side because students were required to be right handed.[12] Double loaded corridors were used to have the most efficient circulation, structure, materials, and distribution of mechanical systems. Schools were usually one or two stories depending on the density of the site.

Due to previous poor health conditions, education reform sparked innovation in school design. The now iconic modern school called "The First Open Air School for Sick Children" by Johannes Duiker and Bernard Bijvoet (Fig. 1.3, 1.4) opened in Amsterdam in 1929. The functional architecture of the school directly addressed health and hygiene by integrating it in to the educational program. The design showed the desire for light and ventilation in school. The transparency of the building let light in, but it also linked the school to the context and life outside. This manifestation of hygiene and pedagogy in built form set a visionary example of education reform.

While public schools were being construction across the nation, theories of

10 Rury, John L. *Education and Social Change: Themes in the History of American Schooling*. Mahwah, N.J: L. Erlbaum Associates, 2005. 182. Print.

11 Burke, Catherine, and Ian Grosvenor. *School*. London: Reaktion Books, 2008. 58. Print.

12 Burke, Catherine, and Ian Grosvenor. *School*. London: Reaktion Books, 2008. 53. Print.

Figure 1.5 Maria Montessori.

education and teaching methods began to change the way schools were designed. Theories questioned traditional teaching methods and the traditional layout of the classroom.

> *"If we put before the mind's eye the ordinary schoolroom, with its rows of ugly desks placed in geometrical order, crowded together so that there shall be as little moving room as possible, desks almost all the same size, with just space enough to hold books, pencils, and paper, and add a table, some chairs the bare walls, and possibly a few pictures, we can reconstruct the only emotional activity that can possibly go on in such a place. It is all made 'for listening' – because simply studying lessons out of a book is only another kind of listening; it marks the dependency of one mind upon another…" – John Dewey, American Philosopher of education 1900* [13]

Education reform stated that the traditional style of teaching creates passive students rather than students who are active in the learning process. Teaching philosophies believed that the traditional methods were unresponsive to the needs of the individual child, or *The Whole Child*.[14] The *Whole Child* concept believes that every child is unique and that the education system and teaching methods should adapt to each special need.

Maria Montessori (Fig. 1.5), an Italian physician and teacher, believed that children will always learn best by teaching themselves and their peers. Children are independent and self-discover their way through school. This idea thus changed the idea and role of the teacher. She believed that the teacher could only assist in what she considered to be a natural discovery and realization of one's self. Richard Neutra also said, "Individualities must unfold and not be impaired, but they must be harmonized

13 Burke, Catherine, and Ian Grosvenor. *School*. London: Reaktion Books, 2008. 67. Print.

14 Burke, Catherine, and Ian Grosvenor. *School*. London: Reaktion Books, 2008. 73. Print.

Figure 1.6 Crow Island School By Eliel and Eero Saarinen.

Figure 1.7 Crow Island School outdoor classroom.

as well, teamed and tuned together."[15] The belief that children best actively learn by themselves and in groups has led to physical changes from the traditional fixed classroom.

This diversified self-directed education and instruction lead to more creative ways of learning and teaching. Activity based learning encouraged individual and group based activities that were connected to practical applications. Therefore, students were able to grasp the usefulness of learning to something real and tangible.[16] A prime example of this in design is the Crow Island School by Eliel and Eero Saarinen (Fig. 1.6, 1.7). It was "inspired by the laboratory school that emphasizes self-direction in learning and a rejection of classroom citation.[17] Each classroom is home-like and allows for diversified learning. The classroom's intimate environment is a characteristic of the child-centered learning environment. It contains an open room with an adjacent small work area, and each room has a connected outdoor learning space. "The architectural expression strikes a careful balance between seriousness of purpose and common everyday use."[18]

During the Post War Era, an increased birth rate caused a great increase in the number of schools and building technology innovation. Schools needed to be built at a rapid rate to keep up with all the suburban families living the American dream. Schools were expansive one-story buildings that took advantage of their suburban context, connecting the interiors to larger outdoor areas.[19] Functional schools that were easy to build and maintain were very common during this time period. The schools were not

15 Caudill, William Wayne. *Toward Better School Design*. [S.l.]: F.W. Dodge, 1954. XI. Print.

16 Hille, R T. *Modern Schools: A Century of Design for Education*. Hoboken, N.J: John Wiley and Sons, 2011. 16. Print.

17 Burke, Catherine, and Ian Grosvenor. *School*. London: Reaktion Books, 2008. 100. Print.

18 Hille, R T. *Modern Schools: A Century of Design for Education*. Hoboken, N.J: John Wiley and Sons, 2011. 89. Print.

19 Hille, R T. *Modern Schools: A Century of Design for Education*. Hoboken, N.J: John Wiley and Sons, 2011. 91. Print.

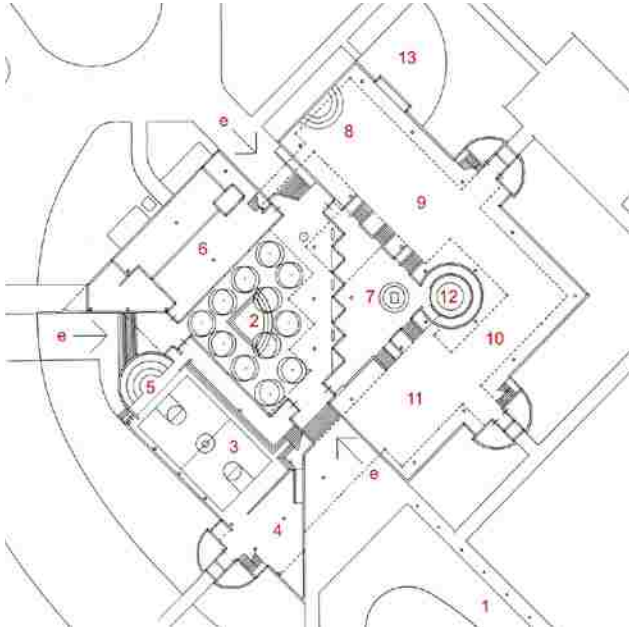


Figure 1.8 Open-plan classrooms at Fodrea Community School in Columbus, IN

built to last very long due to the idea of constant change and growth in the nation.

In the 1960's and 1970's social unrest caused a need for an increase in security and safety in schools. Many architects decided to move away from the modern school movement and started to look at designing the school from the interior. Views to the exterior and connecting to community were considered a security issue and also a distraction to learning. Experimental ideas like the open classroom shaped the interiors while the exterior was a sealed off. Classrooms were viewed as a physical constraint on the creativity of the children. Doors and walls that separated classrooms were removed in design to create open plan classroom.[20] Interiors were designed to be flexible and adaptable. The rigid exterior contrasted the interior spaces that mixed and strayed into each other (Fig. 1.8). This removal of separation went in conjunction with the idea of learning between grades, also called vertical learning. In the years 1965-1967, half of the schools built in the United States and Europe were open plan schools.[21] These open classrooms ended up being more of a nuance than a revolutionary change in education. Many teachers would erect walls later to fit the needs of their teaching methods and curriculum. The way teachers taught and were trained did not change with the innovative ideas of the architects. Financial constraints and reluctance to tried and tested teaching methods "doomed the open-plan school to failure."[22]

Since the 1990's, new spaces for technology like computers needed to be addressed. Computers and televisions were added to classrooms, and additional spaces like computer labs were added to school programs. "Classrooms, not originally designed with computers in mind, have often become cluttered overheated spaces."[23] These additions caused a need for replacement and renovations of many older school buildings constructed in the 1940's 1950's and 1960's. Also, the adoption of building

20 Burke, Catherine, and Ian Grosvenor. *School*. London: Reaktion Books, 2008. 135. Print.

21 Burke, Catherine, and Ian Grosvenor. *School*. London: Reaktion Books, 2008. 152. Print.

22 Burke, Catherine, and Ian Grosvenor. *School*. London: Reaktion Books, 2008. 152. Print.

23 Burke, Catherine, and Ian Grosvenor. *School*. London: Reaktion Books, 2008. 154. Print.

Figure 1.9 Diamond Ranch High School by Morphosis.

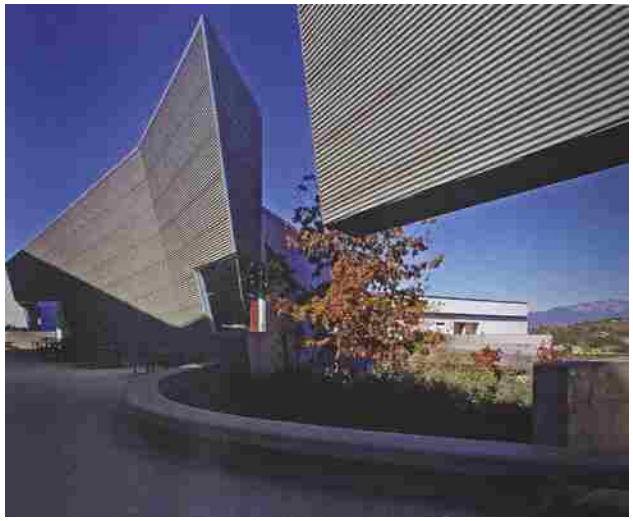


Figure 1.10 Diamond Ranch High School by Morphosis.

codes and restrictions ensured health, safety, security, and structural integrity, but the bureaucratization of schools repelled experimental teaching. Many modern schools today focus on teacher-student interaction and school identity. Architects link schools to their region and context. To become more contextual, schools are reaching out to communities and bring their community in. Sustainable design and technology is another way schools can relate to their context and create a unique identity. Some schools that are considered innovative use architectural form making as a means to address program issues and architectural related themes (Fig. 1.9 - 1.12). While these schools seem complex, their physical response to the classroom is pedagogically traditional.

Schools are complex buildings, and are furthering that complexity by adopting sustainable standards and additional social roles like community centers. Advancements in sustainable technology and computer technology have created opportunities for alternative learning environments, but how do we design a physical space for technology, something that changes extremely rapidly? It is important to note the successes and changes in educational design, but it is more important to understand the reasons for failures of the open plan school that is flexible and adaptable like those in the 1960's and 1970's.

> *"The need for flexible solutions in school design is almost a mantra in the history of education. Despite their poor record of success, designers of learning environments somehow continue to argue the same case. Ultimately, schools are complex organisms of human relationship, and their interconnectivity is opposed to individual innovation. An expanded range of pedagogical possibilities is required of the school building for the twenty-first century. While in past configurations of teachers and*

Figure 1.11 Gymnasium Friedrich II Lorch, Germany by Guenther Bahnish.

Figure 1.12 Interior of Gymnasium Friedrich II.

> *learners in spaces included teacher instruction, individual group work and project-based learning, the impact of new technologies, combined with new theories of learning and intelligences, have extended the list of possibilities to include technology-based learning with mobile computers, distance learning and research via the Internet with wireless routing."*[24]

The finest schools of the twenty-first century will learn draw from the successes and learn from the mistakes of past innovative school designs. . "The tenets guiding twenty-first century learning indicate and support a learner who participates in an active learning environment."[25] It is also evident that technology-based learning will be a part of schools, and future schools will need to address pedagogical changing issues with an innovative change in design. This new design of the physical environment needs to understand what will be added to the traditional learning environment and what will remain based on new technologies, learning typologies, and curriculums. Classrooms and children are connected globally today, and there is a need for a better designed classroom that can guarantee global success with consideration of the new challenges of the twenty first century.

24 Burke, Catherine, and Ian Grosvenor. *School*. London: Reaktion Books, 2008. 171. Print.

25 Lippman, Peter C. *Evidence-based Design of Elementary and Secondary Schools*. Hoboken, NJ: J. Wiley, 2010. 158. Print.

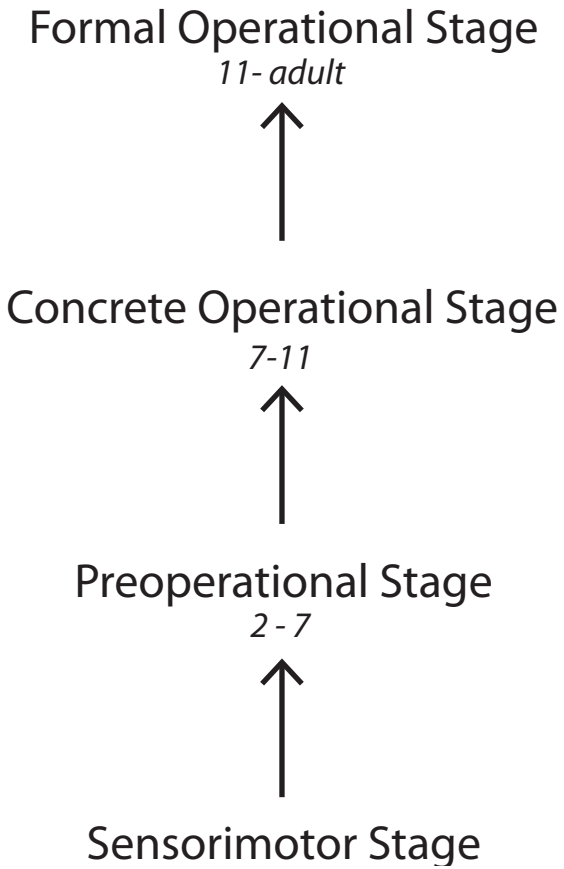


Figure 2.1 Piaget's stages of child development.

Section 2: Child Development, the Teaching Curriculum, and the Physical Environment

Child development is crucial to the physical grouping of grades and the environment in which students learn. The creation of grade levels in the United States, mentioned earlier, was based on a Prussian teaching methods discovered by Horace Mann. The form and separation of today's school system is based on child development. Physical development and the development of the mind offer suggestions on how to group different ages of children. "Development is founded on the child's innate characteristics, unfolds according to maturational timetables, and moves forward through a series of tasks and challenges of increasing complexity that the child must master in order to extend her ability to function within herself and within her environment."[26] The maturation of a child is commonly broken into phases. Jean Piaget, a Swiss psychologist and philosopher created a development stage theory called the theory of cognitive development. The way schools are structure today can be directly related to the theory of Piaget.

Piaget's theory of cognitive development is separated into four different stages (Fig. 2.1). Each stage is closely associated with the age of the child. Within each stage are multiple phases and steps that a child will go through. The first stage, called S*ensorimotor Stage*, starts at birth and ends around the age of two. Children develop basic coordination and understanding of the world. The next stage from two to seven years old is called the *Preoperational Stage*. Children begin this stage around the time they begin to talk. This stage is where playing, pretending, and imagining mostly take place. *Concrete Operational Stage* ranges from seven to eleven. In this stage, a stage equivalent to modern elementary schools is the start of logic. Children have the ability to solve problems of actual objects and events but not to hypothetical problems, thus

26 Davies, Douglas. *Child Development: A Practitioner's Guide*. New York: Guilford Press, 2004. 3. Print.

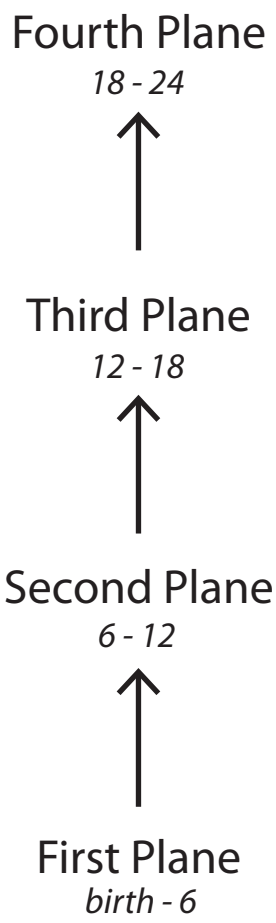


Figure 2.2 Montessori's planes of child development.

the name *Concrete Operational Stage*. The last learning stage is the *Formal Operational Stage*. It starts at eleven years old, or puberty, and continues to adulthood. During this stage, children think abstractly and can solve hypothetical problems.[27]

Physician and educator Maria Montessori likewise divided child development into "planes". Her four planes were divided from birth to six years old, from six to twelve years old, from twelve to eighteen years old, and from eighteen to twenty-four years old (Fig. 2.2). The first plane's characteristics are sensory periods and absorptive minds. The second plane defines children becoming more social and forming "herds". The third plan represents adolescence and the construction of the adult. The fourth plan is the arrival of adulthood and independence.[28]

Author Douglas Davies, like Piaget and Montessori, further demonstrates separations in age based on mental and physical development. His terms follow the common language closer in defining child development stages. The infant stage is considered from birth to the age of one, toddlers range from one to three years old, Preschool is defined from three to six years old, Middle Childhood age ranges from the age of six to eleven or twelve, and adolescence is considered to be around 12, or the start of puberty, and beyond.[29] These age groups can be easily seen in today's school structure.

The physical development of a child also plays a role in the structure of the current education system. Although the previous people categorized the age of eleven or twelve to eighteen as a psychologically similar, the physical difference between the eleven and eighteen year olds is drastic. Younger children in this age group can be greatly intimidated physically by the older ones even though they are considered to be

27 Kohler, Richard. *Jean Piaget*. London: Continuum International Pub. Group, 2008. Print.

28 Montessori, Maria. *The Four Planes of Education*. Amsterdam: Association Montessori Internationale, 1971. Print.

29 Davies, Douglas. *Child Development: A Practitioner's Guide*. New York: Guilford Press, 2004. 3. Print.

in the same development stage. Middle schools act as a divider for this stage because of this physical change. The result of the mental and physical child development is how public schools structure their educational institutions.

Maria Montessori saw the mental development of a child in an active way. She saw traditional schools that forced students to sit and learn quietly similar to slavery. "The principle of slavery still pervades pedagogy, and, therefore, the same principle pervades the school. I need only one proof – the stationary desks and chairs."[30] She believed that forcing a child to sit still during the learning place was counter to the natural way of learning. "[M]ental development must be connected with movement and be dependent on it. It is vital that educational theory and practice should be informed by that idea."[31] It is shown that children lose concentration after five or ten minutes when sitting perfectly still. The increase in movement, the vestibular system and the balance system, "activates special hormones, such as neurotrophin, that have a tremendous effect on brain activity."[32] This shows that the traditional classroom design has a scientific relationship between the surroundings, the activity, and development of a child.

In addition to the school curriculum, teachers must also take in account the developmental (maturational) curriculum and students' personal (individual) curriculum. "For the classroom teacher ... the curriculum presents a problem of balancing and coordinating three sets of priorities."[33] Child development, the school curriculum, and physical environment all go hand in hand. It is important for the teachers' role

---

30 Montessori, Maria, and Anne E. George. *The Montessori Method*. New York: Schocken Books, 1964. Print.

31 *The Third Teacher: 79 Ways You Can Use Design to Transform Teaching & Learning*. New York: Abrams, 2010. 55. Print.

32 *The Third Teacher: 79 Ways You Can Use Design to Transform Teaching & Learning*. New York: Abrams, 2010. 82. Print.

33 Elkind, David. *Child Development and Education: A Piagetian Perspective*. New York: Oxford University Press, 1976. 195. Print.

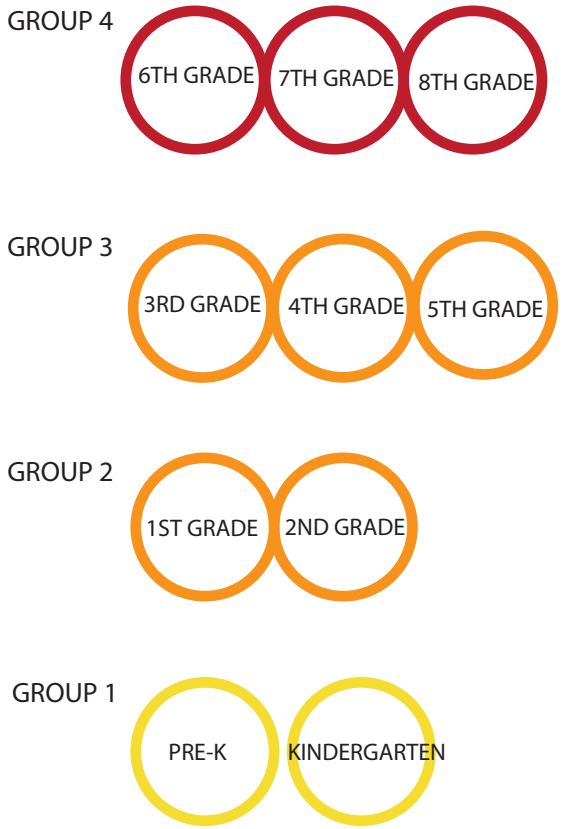


Figure 2.3 Grades broken into development groups.

to match the curriculum and the physical environment. The 1960's and 1970's open plan classrooms and curriculum mismatch justified that the curriculum and physical environment must be considered as one element. The curriculum outweighed the physical environment so the classroom failed and had to be modified.

Each development stage, or sets of grades, has a different curriculum with different learning typologies based on maturation and progression through grades. The learning types effects the classroom environment and vice versa. To fit current standard school bureaucratization, grades are a necessary framework to work within today. Grouping grades into development stages from a programmatic view gives the opportunity to create corresponding learning environments to each particular child development stage. The program should be grouped according to similar curriculums and developmental stages. In accord to this, each group of grades and curriculums should have an environment specially designed to the needs of that stage of child development. Each group has a set of ranges in physical and mental needs. By associating the needs of development and curriculum, a classroom or learning environment can be designed to best fit the needs of the grade group (Fig. 2.3).

In this thesis, preschool and kindergarten can be defined as one group. The need for activity and imagination for children in this development stage defines a certain type of learning environment. The design and scale for this age group is much different from the other groups. The next overall group would be defined as a typical elementary school, six through eleven year olds. Curriculums and environments are more structured than the previous group but there is still a need to be active. In many elementary schools there are addition separations. First and second grade are commonly grouped together, and third, fourth and fifth are a separate group. The last group would be the ages twelve through fourteen, the same as a typical middle school. This age is the start of hypothetical and abstract thinking. The curriculum for this age is more intense and students themselves become structured individuals. This grouping structure addresses

mental and physical development and creates a structure for the layout of the physical environment. This grouping of school design fits into the current education system, leaving the traditional high school out of this thesis program.

Based on this grouping proposed above, each group will have a distinctive curriculum, different learning types, and a corresponding physical environment. This thesis will create a set of learning types based on the separation of age development groups that will address the progress and future changes in technology. The learning types will then influence the shape of each space to accommodate for the future of the learning environment.

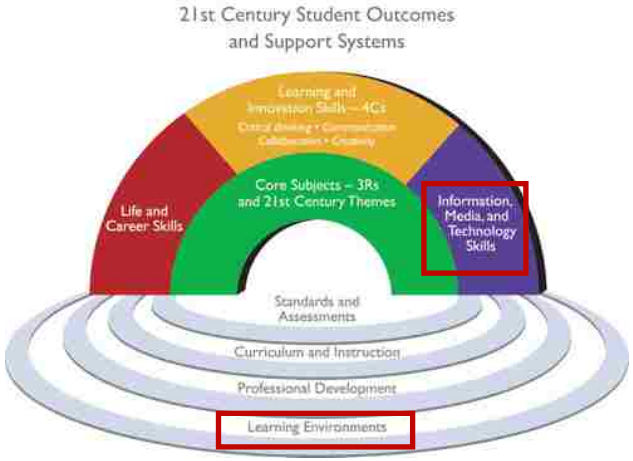


Figure 3.1 Framework for 21st Century Education highlighting the skills of ICT and the enrivnmental support system

Section 3: Information and Computer Technology in School Design

"When even conservative estimates maintain that the classroom of the present where pupils are currently being taught has not changed in decades, is it then likely that the form of today's classroom is appropriate for the tasks it is supposed to fulfill in modern society?"[34]

Information and computer technology (ICT) is being used throughout modern society, and it is changing the way people work and live. People are constantly connected to each other around the world through technology during most of their waking hours. "It insinuates itself into every facet of our social, cultural, psychological, and working environments."[35] The way schools are traditionally structured prohibits this inevitable technology oriented lifestyle. ICT is adapted to the classroom rather than reflecting our dedicated use of it today. Our school designs have not changed physically to adapt to the changes that are currently happening outside the classroom. How do we expect our children to meet the expectations of today and be the leaders of tomorrow when they are learning in traditional environments built for a specific type of pedagogy and curriculum from over a hundred years ago?

The desire for education change in our schools and classrooms is a common view among educators in the United States. They want students to master the multi-dimensional abilities that will be required to compete and lead a global economy. It is seen that if we cannot adapt to these new changes, our children will be left behind. An example of this aspiration is The *Partnership for 21st Century Skills* (Fig. 3.1). Their framework reflects the desires to develop skills including collaboration, innovation and technology skills in conjunction with a supportive curriculum and environment.

---

34 Mäkitalo-Siegl, Kati. *Classroom of the Future: Orchestrating Collaborative Spaces*. Rotterdam: Sense, 2010. 20. Print.

35 Lippman, Peter C. *Evidence-based Design of Elementary and Secondary Schools*. Hoboken, NJ: J. Wiley, 2010. 111. Print.

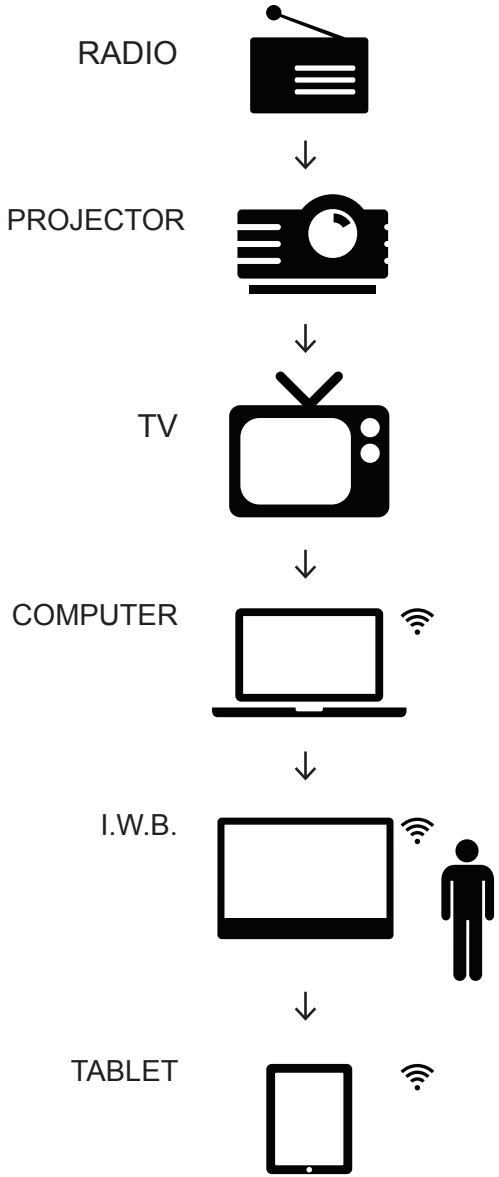


Figure 3.2 Evolution of I.C.T. in the classroom.

Classrooms and schools of this framework should reflect and lead those changes by creating an environment best suited for students to lead in the twenty first century global economy.[36]

The Technology Used in The Past and Today

The traditional classroom environment and its teachers have been trying to adapt to changes in technology for many decades (Fig. 3.2). In the early twentieth century, film and radio were the initial technology additions to the classroom. They were both passive ways of teaching students. Sitting and watching a screen or listening to someone speaking over a radio was no different than having a teacher teaching in the room. In fact, it was worse because there was not an opportunity to interrupt and ask questions, and the transmission may have been difficult to hear or understand.[37] Televisions were the next addition to the classroom and they had many benefits. They enabled students to see past the classroom walls and into the real world, but they teach in the same passive way as the traditional classroom. The invention of the computer created an active environment for one user and could connect users to information, but the additions of computers and televisions to classrooms were used as accessories rather than active tools for learning. Even after the invention of the internet and its establishment in schools, it is difficult find an active and collaborative environment that doesn't directly reflect the traditional and passive ways of teaching.

36 "The Partnership for 21st Century Skills." *The Partnership for 21st Century Skills*. Web. 24 Feb. 2012. <http://www.p21.org/>

37 Lippman, Peter C. *Evidence-based Design of Elementary and Secondary Schools*. Hoboken, NJ: J. Wiley, 2010. 102. Print.

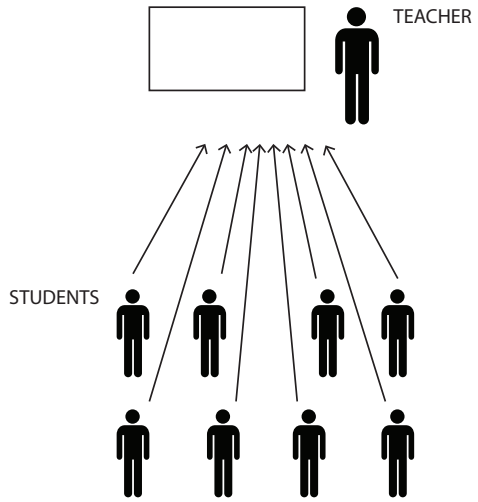


Figure 3.3 Traditional teaching methods

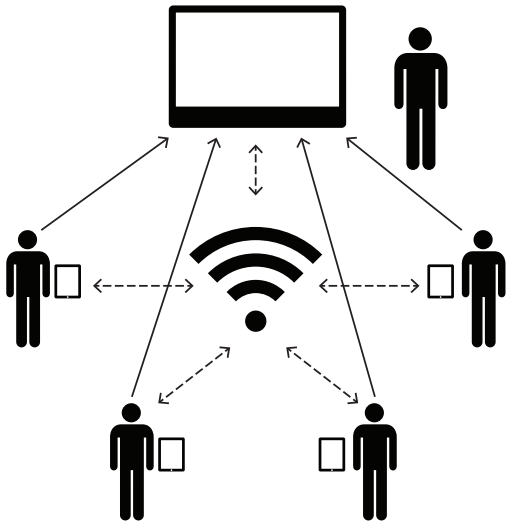


Figure 3.4 Teaching with IWB and tablets (or laptops).

Changing Factors

The reduction of the physical size of electronics, wireless technology, and the ability for collaborative interaction are the changing factors of the twenty first century classroom. They are driving a need for a new classroom design with ICT in schools. Lightweight personal and portable electronics allow each person to have their own device to use and connect to the larger system. The reduction of size and weight of electronics has made technology friendlier and more portable. Electronics have become small and light enough for children to use. In addition to small electronics, wireless internet and connections between devices creates the capability for a more flexible and informal learning environment. Small and portable electronics allow students to use self-guided programs to become more independent learners. Instead of the reliance of physically being connected to the teacher to learn, there is the chance to connect and learn digitally and thus freeing students from the traditional classroom (Fig. 3.3, 3.4). Wireless technology and the internet give classrooms, teachers, and individual students the ability to access all the information on the web in an environment of their choosing. "In the future, classrooms will include a rich technology layer that will help scaffold complex patterns of activities and connect students to rich, collaborative learning experiences."[38] Wireless technology gives classrooms the ability to learn and connect to others from any point in the physical environment. This more flexible environment allows for many different types of learning based on the individual students curriculum. It can allow for a student who may want to learn with the computer at their own pace, or it can allow for groups of students to share and collaborate; each student having the internet at their individual disposal. Being connected digitally decreases the physical dependence of tradition learning, and increases active opportunities for a diverse set physical spaces.

38 Mäkitalo-Siegl, Kati. *Classroom of the Future: Orchestrating Collaborative Spaces*. Rotterdam: Sense, 2010. 239. Print.

Figure 3.5 Interactive whiteboard in the classroom.

Figure 3.6 Tablet technology used in the classroom

Future ICT Devices That Will Change the Classroom Environment

Today ICT has advanced and adapted so that it is used in a more interactive way. Many schools try to use ICT in an active way to excite students to increase involvement and collaboration. Interactive white boards (IWB) are often found in today's classrooms (Fig. 3.5). "Whiteboard technology enables educators to create, customize, and integrate text, images, quizzes, and test, Web, video, and audio content and encourages students to interact with material projected on the white board. The results often are more interactive, engaging, and also have the potential to accommodate different learning styles."[39] The IWB allows students and teachers to connect and engage physically around technology. It can also connect the students digitally to the active environment that the IWB creates. Instead of one student coming up to the black board, each student can connect digitally at the same time. All of this information could then be accessed, organized, and discussed between students and teachers at a later time because of its connection to the internet and other devices. The problem that many classrooms are having is that the teacher is not trained or inventive with the IWB to use it at its full potential. Its capabilities are reduced to the standard blackboard or projector because of the limitations that the teacher has put on the technology. Once teachers are familiar with the device, it opens up new possibilities. Although the IWB is an evolved idea of the blackboard, its ability to connect and display digitally between devices makes it a revolutionary idea that will make it a part of the future learning environment. The physical form and orientation of the IWB may change in the future to entire walls or tables, but the principle that the IWB brings to a classroom will take a large role in the design of the new classroom environment and those spaces that expand beyond it.

The two personal portable electronics that have shown promise in schools today are the laptop computer and the tablet computer (Fig. 3.6). Laptops are similar

[39] Schrum, Lynne, and Barbara B. Levin. *Leading 21st Century Schools: Harnessing Technology for Engagement and Achievement*. Thousand Oaks, Calif: Corwin, 2009. Print.

to the desktop computers and usually require interaction with the device via mouse or keyboard. The student or teacher is able to connect to the internet and other devices through the laptop. The tablet is a lightweight computer device that closely resembles a thin book. It is touch sensitive, unlike laptops, and can be held with one hand. Many tablets come with covers that are also stands so that it can be placed upright like a computer screen. The laptops are more conventional for typing because of the physical keyboard unlike the touch screen keyboard on tablets. Both the laptop and tablet are useful portable devices that can connect to other devices like the IWB. Laptops computers, even at their lightest weight, are more difficult to use in an interactive way. Once a laptop is opened, the student and it are more likely to sit in the same place like a desktop. Most laptops today use the keyboard or mouse for control rather than an interactive touch screen. This technology is harder to create collaborative environments for multiple users.

The tablet is sometimes considered the natural evolution from laptops. The tablet uses your finger or a stylus for interaction, unlike a laptop and a mouse, is has direct connection to the interface that resembles reality. The tablet's form encourages more collaboration because multiple students can work together on one tablet where it is difficult for multiple students to share one laptop. The screen can easily move to angle any individual. The stylus can be passed around, and is easier to use than a mouse from any angle. They lightweight nature and long battery life allow students to move freely and share interactively. During the research of this thesis, Apple© released plans to focus on replacing textbooks with their iPad© in conjunction with major school text book companies (Fig. 3.7). Before this announcement, many schools had already been experimenting with this tablet technology. It is very likely that the tablet design will eventually take over traditional textbooks because of the tablet's constantly updated books, interactive e-books, user made books and content, and low cost in comparison to buying multiple textbooks or buying new editions of books. "Educators laud the iPad's physical attributes, including its large touch screen and flat design, which allows

Figure 3.7 Apple's iPad has established itself as the leader of education with tablets.

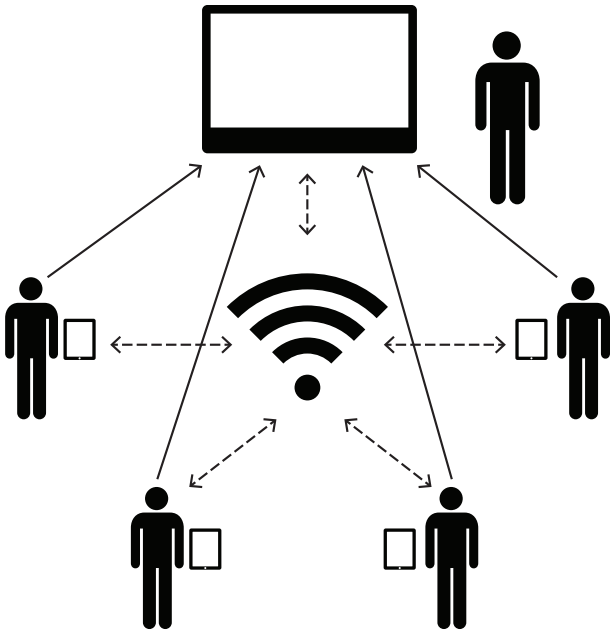


Figure 3.8 Connection and collaboration wirelessly with other students and teacher outside of school

students to maintain eye contact with their teachers. And students like its light weight, which offers a relief from the heavy books that weigh down their backpacks."[40] The exclusivity of the hardware and software for the tablet device is a battle that will be fought between companies. It is significant to observe that whichever corporation is able to monopolize on this opportunity, due incompatible operating systems, will have a significant impact on learning and student's dedication to certain brands. The tablet that works and functions best for learning for the future will yield the best results.

The tablet is not just a marketing scheme to sell these devices. The Obama Administration is pushing to get this technology into schools and replace textbooks. Kimberly Hefling from the Associated Press writes that "Education Secretary Arne Duncan and Federal Communications Commission chairman Julius Genachowski … challenged schools and companies to get digital textbooks in students' hands within five years … Karen Cator, director of the Education Department's office of education technology says 'We're not talking about the print-based textbook now being digital. We're talking about a much more robust and interactive and engaging environment to support learning'."[41] If tablets are the best look into the future technology of the classroom, it is a respectable one because the tablet design and support suggests positive changes in the way teachers and students will interact and learn together (Fig. 3.8). These advances in technology will surely not be the last, but they give a good indication on the direction in which the future classroom is headed. That direction is one that uses tablet technology along with IWBs in a more collaborative and digitally connected way. It allows for many diverse types of learning spaces and situations.

---

40 Hu, Winnie. "Math That Moves: Schools Embrace the IPad." *The New York Times*. The New York Times, 04 Jan. 2011. Web. 20 Feb. 2012. <http://www.nytimes.com/2011/01/05/education/05tablets.html?pagewanted=all>.

41 Hefling, Kimberly. "Challenge to Schools: Embracing Digital Textbooks." *Seattlepi.com*. Associated Press, 1 Feb. 2012. Web. 25 Feb. 2012. <http://www.seattlepi.com/news/article/Challenge-to-schools-Embracing-digital-textbooks-2916164.php>

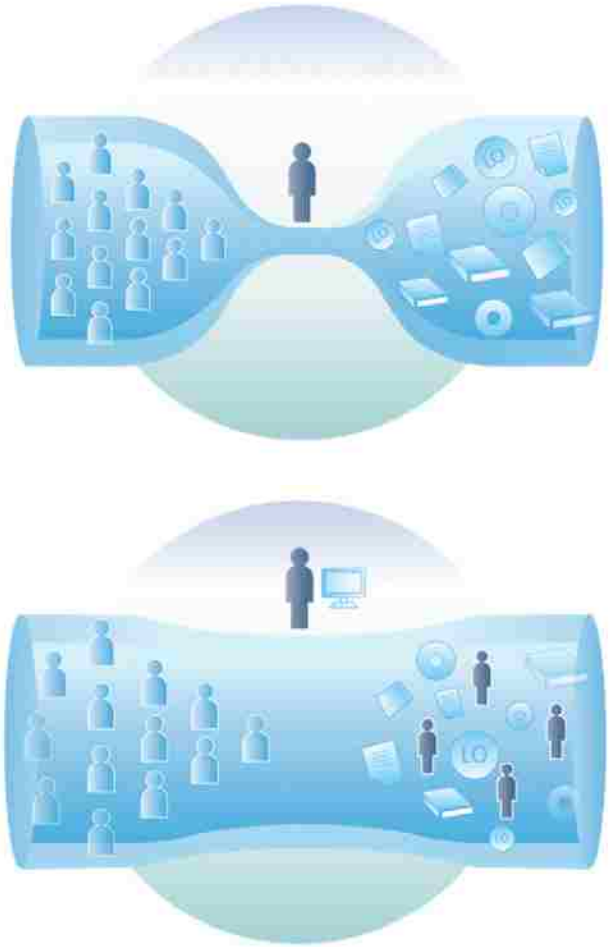


Figure 3.9 School of One traditional classroom and smart design classroom comparision

Case Studies

Interactive white boards and the tablets are examples of hardware advances in technology, but there are also software advances specifically targeting performance in education. *The Khan Academy*, an online educational resource now funded by the Gates Foundation, was started by a Salman Khan who was trying to help tutor his relatives via the internet. He posted videos online to help them and others found them helpful. Now *The Khan Academy* is a well-known teaching and tutoring video provider where students can watch and replay lessons on their computer or wireless device. In addition, the website includes a curricula that can map your progress and suggest videos and problems that you are not proficient in yet. It also has an active community where students can ask and answer questions below videos with links taking them to related videos or assignments.[42]

The School of One is another example of software developed for education (Fig. 3.9 - 3.11). *The School of One* is software, but also a full school structure. In 2009, a pilot study called *The School of One* started and set out to rethink education with technology and improve test scores. The grade range tested was from fourth grade to ninth grade. Learning is done in large group instruction, small group instruction, group collaboration, one on one, virtually, live remote tutoring, and individually. This enables students to learn in a variety of formats and environments. Each student has his or her own laptop. Assignments and lessons are done on laptops in diverse settings. A learning algorithm determines what the student is good in and what needs work. Based on those results, the student will come to school and be assigned certain lessons and assignments for the day. This gives each individual a unique learning schedule to do what best fits their needs. The students and teachers can follow their progress with the “Skill Map”,

42 “Salman Khan: Let’s Use Video to Reinvent Education.” *TED: Ideas worth Spreading*. TED Conferences, LLC, Mar. 2011. Web. 24 Feb. 2012. <http://www.ted.com/talks/salman_khan_let_s_use_video_to_reinvent_education.html>.

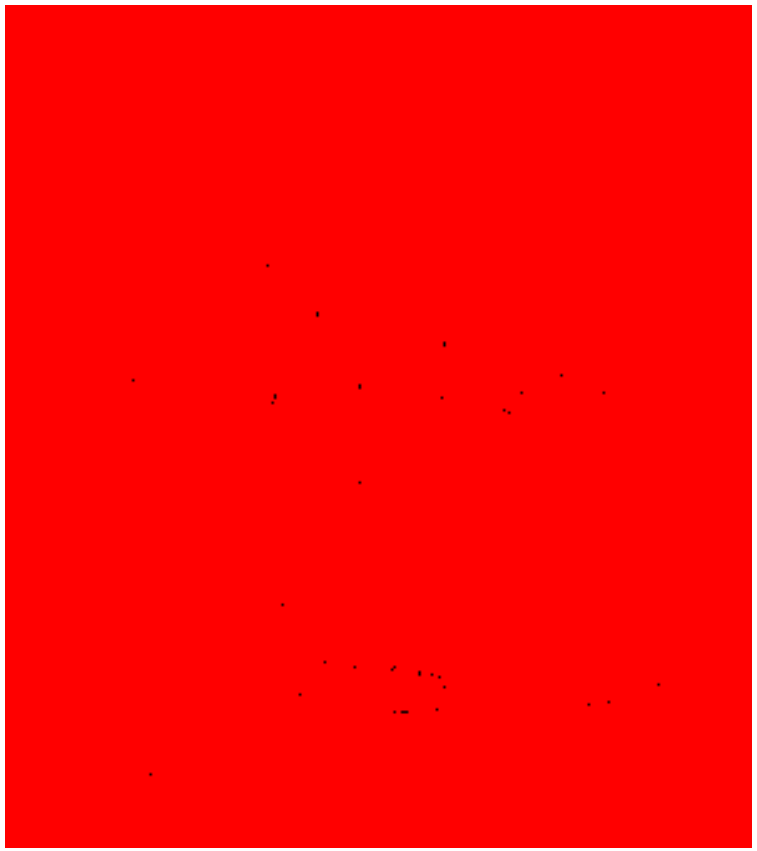


Figure 3.10 School of One diagram by the American Architectural Foundation

Figure 3.11 School of One room layouts

and the student's unique lessons and assignments are called a "Playlist".[43] This is a modern view and solution to the idea that every child is unique. This relates back to the early twentieth century idea of teaching *The Whole Child*, and Maria Montessori's concept that every child is unique.

The School of One pilot program also hired architects to design their learning spaces based on the new curriculum and technologies. It consists of multiple learning spaces that are flexible and fluid, but have the function to separate spaces. It gives students learning, working, and collaborating spaces where they perform best. TV's are also permanently installed around the school to show where students are supposed to go. This setup is not exactly the ideal for the classroom for the strong ideas in curriculum, but it is a step in the right direction.

Learning Types and Development Groups with ICT

As schools begin using information and communication technology like the interactive white board and tablets, the schools are being adapted to support the technology integrated curriculum. Eventually the curriculum will adapt and evolve into something that the traditional classroom may not be able to accommodate. The new curriculum will fit the new capabilities of wireless personal technology devices. In addition to the new curriculum, learning types and environments corresponding to teaching methods and tasks will be designed to effectively use the space and technology. As discussed before, the curriculum for a student is related to the development of a child. A learning space for a first grader will look and function completely differently than a space for a seventh or eighth grader. Based on the development stage and age range, the classroom will match the needs for those students development.

Kindergarten children are hands-on active learners, and they learn through

---

43 "Skill Map and Playlist." *School of One – Concept*. School of One. Web. 25 Feb. 2012. <http://scholofone.org/concept_keyfeatures.html>.

play. Technology will not play as large of a role for them as it will for the older students. Tablets may be used periodically in groups or individually to learn through games or other programs. Interactive white boards maybe used during this stage in conjunction with the tablet. It is somewhat controversial to introduce technology as a main tool at such an early age, but through games, kindergartners can familiarize themselves with the device and have fun and learn at the same time. The classroom space will most likely not change much from a typical kindergarten classroom today.

The early grade school years, first, second, and third will have a different curriculum than the kindergartners. It is still necessary to have a comfortable home-like environment for this age range. Individual students or groups of students will be given a tablet, or a similar personal electronic device, to use at specific times during the day for certain parts of the curriculum. Children can follow along with certain assignments and the teacher will be able to keep track of each student digitally and see how they are doing. Interactive white boards and group learning could be a large part of this stage and the next. While technology in the classroom will be increased during this age range, additional configurations and spaces for the classroom will be needed.

The later grade school years, fourth and fifth grade, will have a similar curriculum to the early grade school years. The difference will be that the students will still to a have a more independent structured learning environment and the ability to start working individually with technology. The physical learning environment will be the same or similar to the early grade school years, but the curriculum will be different and more technology oriented. This age range will prepare students to transfer into the more structured framework of the middle school learning environment.

Middle school students are very different from the grade school children. Traditionally students become more independent and self-organized. This is the stage that Maria Montessori described as the construction of the adult. It is the start of a structured learning environment with clear separations of subjects. Sixth through eighth

Figure 3.12 Students have unique needs

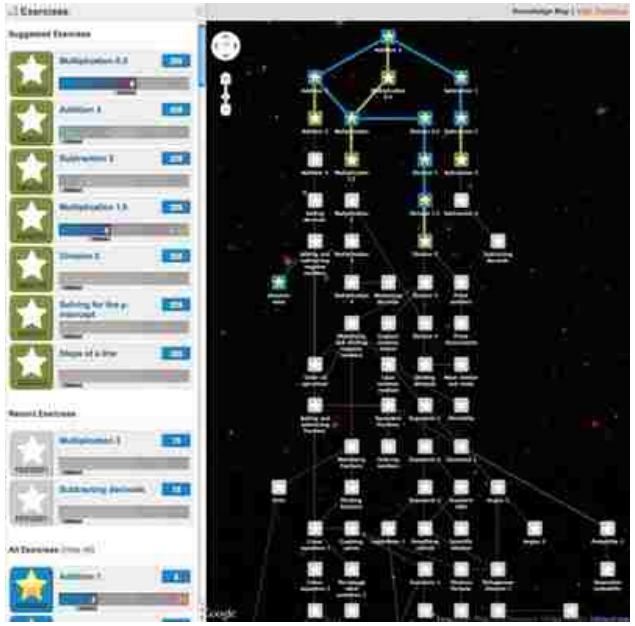


Figure 3.13 Khan Academy Learning Tree Algorithm

graders will have their own tablet device that will be used as their main connection to their daily course schedule and lessons. Homework, assignments, and progress will all be through the tablet device. Students will be able to take home these devices and work outside of school time and connect to teachers and students to ask questions or collaborate. The middle school curriculum and environment will be most different from their traditional equivalent of today.

The Role of the Teacher

The role of the teacher traditionally was to teach a classroom full of students. Teaching a class is different than teaching a student. In a class, the teacher needs to teach a single way to meet the understanding of majority of the students. Some students will be advanced and become bored, and others may struggle and need outside help (Fig. 3.12). In this sense, when the teacher teaches class the probability that every child is learning to their needs is unlikely. Technology that is 'smart' like the adaptive algorithm lessons (Fig. 3.13), assignments, and schedules seen in the *Khan Academy* and *The School of One* allows each student to learn in the way that fits them best. This new way of teaching allows students to discover by themselves or collaborate with others. For example, a teacher may tell students that they will be having a class lesson about DNA after lunch. The teacher can tell students to get together in small groups for ten minutes before lunch and research what they can online or in their e-books. After lunch the teacher may start off the lecture by asking "What is DNA, or where can I find it?" Students and groups may then chime in with different answers from what they found, or post digitally from their tablet to the IWB. Students in this situation will have a broad understanding of what they will be learning next and already be actively involved.

The role of the teacher is still the same, but the method in which she or he teaches will change. The teacher may still teach the entire class at one time, but the teacher's position will also be a group facilitator and personal tutor. The teacher of the future classroom will be more personal in the same way technology makes lessons

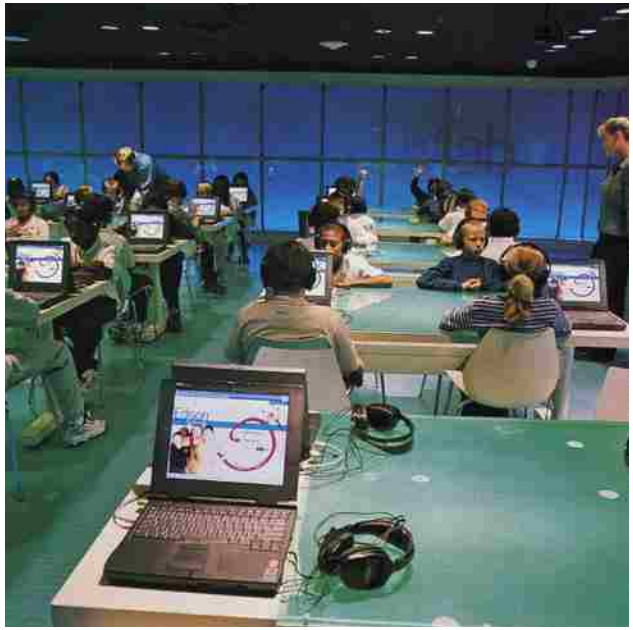


Figure 3.14 EdLab by Edison Schools

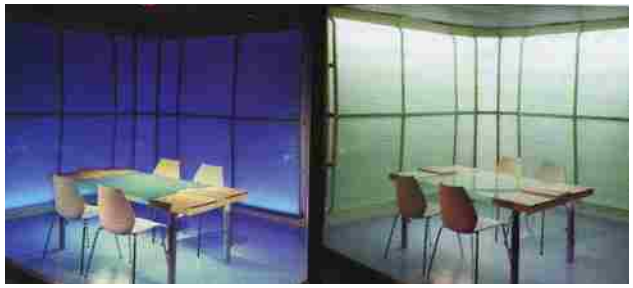


Figure 3.15 EdLab prototype

and assignments individually unique. Some teachers are frightened that the teacher will be replaced, but it is widely understood that technology will not replace the teacher because it is just a tool. Harri Skog says during *The New York Times Schools for Tomorrow* discussion, "Technology will not replace teachers and will not put them out of work. You can't replace the human collaboration."[44]

Spaces Created for ICT

"Many architects are interested in buildings as monumental objects … this simplification and commodity approach to designing large schools is incompatible with the spatial complexity required for modern learning environments."[45]

It is important not to get carried away with grand visions of technology, and get drawn into a utopian idea of how things will work in the "future." Forcing a specific technology to work a certain way against humanistic intentions will not work. The EdLab by Edison Schools (Fig. 3.14 - 3.15) is an example of an environment creates strictly around technology. This open plan environment cuts off all visual connection to the outside environment to eliminate distractions. The classroom resembles a petri dish while students learn at stations with laptops and headphones. The teacher also controls the lighting of the space to simulate changes in work or exterior settings. While this may work for certain assignments and lessons, Tom Schuck, a teacher says, "to be in it all day would be a mistake." The role of teachers dramatically changes in this contained environment and students are suppressed into learning in what some teachers describe as a "cookie cutter" approach to curriculum.[46]

The ICT previously mentioned, the tablet and IWB, have both been used and

44 The New York Times Company. "Schools For Tomorrow: Bringing Technology into the Classroom." *The New York Times SFTM White Paper* (2011). 3. Print.

45 Mäkitalo-Siegl, Kati. *Classroom of the Future: Orchestrating Collaborative Spaces*. Rotterdam: Sense, 2010. 20. 59. Print.

46 Ward, Jacob. "Too Cool for A School." *Architecture* 90.2 (2001): 39-42. Print.

tested in learning environments with success and support. We need to take "… a relatively grounded approach to thinking about the design of schools for the future, an approach that moves away from 'grand visions'. Whereas we understand the ways in which new information and communication technologies potentially change the relationship between concrete and virtual spaces for learning, we also argue that more attention should be paid to the design on physical space when building schools for the future."[47] The goal is not to create an environment where this technology is specifically integrated into the learning environment. The goal is to design spaces that best facilitate the functions of the new technology, but not to make the same mistake of creating an overly broad, open, and flexible space like the open classrooms of the 1960's and 1970's. A balance between technology, human interaction, and development needs to be desired to create these successful spaces.

"[T]he notion that learning must occur with a defined setting such as a school 'classroom' is now being challenged and may become increasingly redundant."[48] The need to provide dark spaces for computer rooms is unnecessary today. "ICTs should be designed to be part of an almost invisible infrastructure of a school."[49] Spaces can be used for multiple functions due to wireless technology, but the spaces need to be designed for the teaching and learning methods that will be occurring in that space along with the number of students. Traditional classroom settings where there are many students in one room with one teacher will not be abandoned completely, but that room should also be flexible to be used for other functions. The need to be active instead of passive throughout the day will also shape these different spaces, so adjacent spaces should also be designed for small collaborative groups.

---

47 Mäkitalo-Siegl, Kati. *Classroom of the Future: Orchestrating Collaborative Spaces*. Rotterdam: Sense, 2010. 20. 57. Print.

48 John, Peter D, and Steve Wheeler. *The Digital Classroom: Harnessing Technology for the Future of Learning and Teaching*. London: Routledge, 2008. 93. Print.

49 Mäkitalo-Siegl, Kati. *Classroom of the Future: Orchestrating Collaborative Spaces*. Rotterdam: Sense, 2010. 20. 57. Print.

Section 4: Sustainable Technology and a Healthy School Environment

In addition to communication and information technology, sustainable technology has proven to be incredibly important to the learning environment for children. A sustainable school makes for a healthier environment and can lead to increased productivity and less sick days. By teaching and learning in an environmentally healthier environment, students will develop the habits of sustainability that will carry on later into their life. Benefits of a sustainable school include higher test scores, lower operating costs, increased student attendance, enhanced teacher performance and satisfaction, increased building life, and lower environmental impacts.

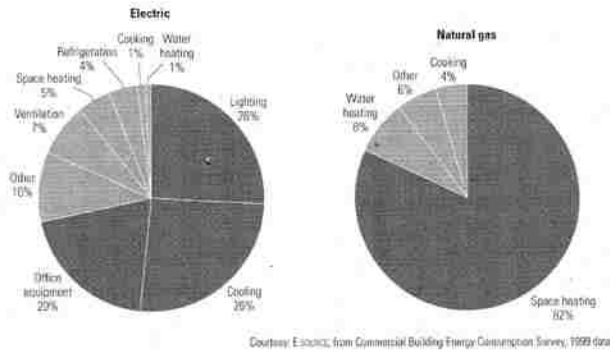


Figure 4.1 Lighting in building energy use percentage

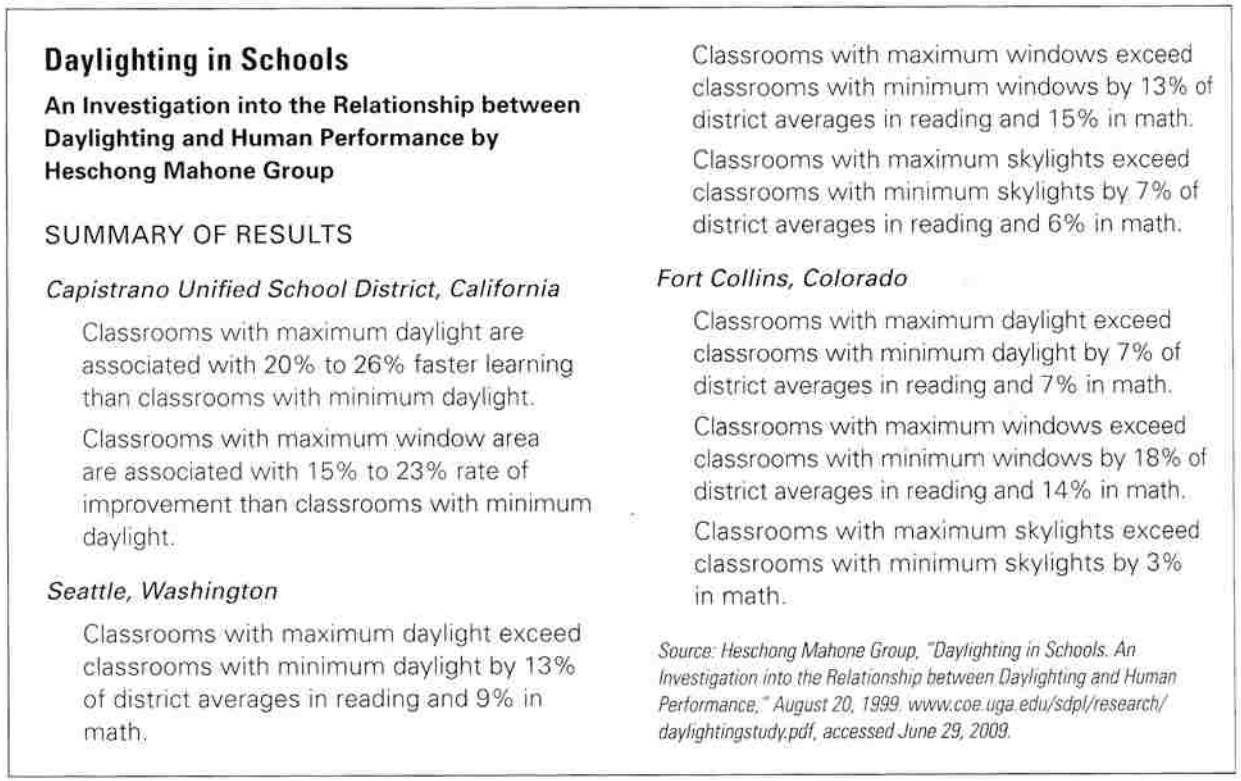
"Daylighting is one of the best investments you can make in the design of a learning environment."[51] Some schools used up to 26% of their energy to artificially illuminate schools during the middle of the day.[52] By combining controlling daylight, electric loads can be dramatically reduced. Students are higher in attendance and have better test scores when they have access to daylight.[53] Research by Heschong Mahone Group has shown that classrooms in Washington state that have adequate daylight produce students that have 7% to 18% higher test scores than students with the least daylight.[54] Teachers and students perform better when a connection to the outdoor environment can be established (Fig. 4.2). An issue that may arise with the combination of daylit spaces and electronics screens is the ability to see the screen clearly. It can be difficult to read the screen if there is a reflection on the screen, but this should not sacrifice a daylight space from being used with technology. Tablet devices are easy to

51 Gelfand, Lisa, and Eric C. Freed. *Sustainable School Architecture: Design for Primary and Secondary Schools*. Hoboken, N.J: John Wiley & Sons, 2010. 85. Print.

52 Gelfand, Lisa, and Eric C. Freed. *Sustainable School Architecture: Design for Primary and Secondary Schools*. Hoboken, N.J: John Wiley & Sons, 2010. 12. Print.

53 Gelfand, Lisa, and Eric C. Freed. *Sustainable School Architecture: Design for Primary and Secondary Schools*. Hoboken, N.J: John Wiley & Sons, 2010. 83. Print.

54 Gelfand, Lisa, and Eric C. Freed. *Sustainable School Architecture: Design for Primary and Secondary Schools*. Hoboken, N.J: John Wiley & Sons, 2010. 3. Print.



Daylighting in Schools

An Investigation into the Relationship between Daylighting and Human Performance by Heschong Mahone Group

SUMMARY OF RESULTS

Capistrano Unified School District, California

Classrooms with maximum daylight are associated with 20% to 26% faster learning than classrooms with minimum daylight.

Classrooms with maximum window area are associated with 15% to 23% rate of improvement than classrooms with minimum daylight.

Seattle, Washington

Classrooms with maximum daylight exceed classrooms with minimum daylight by 13% of district averages in reading and 9% in math.

Classrooms with maximum windows exceed classrooms with minimum windows by 13% of district averages in reading and 15% in math.

Classrooms with maximum skylights exceed classrooms with minimum skylights by 7% of district averages in reading and 6% in math.

Fort Collins, Colorado

Classrooms with maximum daylight exceed classrooms with minimum daylight by 7% of district averages in reading and 7% in math.

Classrooms with maximum windows exceed classrooms with minimum windows by 18% of district averages in reading and 14% in math.

Classrooms with maximum skylights exceed classrooms with minimum skylights by 3% in math.

Source: Heschong Mahone Group, "Daylighting in Schools. An Investigation into the Relationship between Daylighting and Human Performance," August 20, 1999. www.coe.uga.edu/sdpl/research/daylightingstudy.pdf, accessed June 29, 2009.

Figure 4.2 Daylighting linked to student performance.

adjust by the user to a more preferable angle if the interior allows for that flexibility. IWB can be used in daylit spaces. Direct sun is not desirable on the devices, but direct sun is also not desired in the building. Blackout shades or darker rooms can be designed so that comfort with the technology can be achieved based on the user's desire, but a lighting synthetic lighting solution like the EdLab classroom is a poor choice for a large environment.

Schools that do not address learning environments as sustainable environments create negative settings for students to endure and can result in draining working conditions for teachers. Buildings that do not connect to the outdoor and daylight changes disrupt an individual's circadian rhythm, or biological clock. Our health can be related to the circadian rhythm, and a building that allows us to constantly connect to the diurnal cycle is a healthier environment. Since children spend so much time in schools and the average person spends about 90% of their life indoors, it is important that children grow up with sustainable and healthy expectations for buildings. If students and teachers are accustomed to poor quality environment conditions, they will become stoic to their environment. "Environmental stoicism" and "place machismo", defined by Michael Benedikt, both relate to the acceptance of poor indoor environments. "Whereas stoicism advises calm acceptance of what cannot be improved, machismo—less a philosophy than an attitude—recommends pride in the grim embrace of harsh realities."[55] It is important to understand the need for a sustainable and healthy environment because places designed specifically for TV's and other electronics devices are sometimes the worst offenders of this "place machismo".

CHPS (Collaborative for High Performance Schools), LEED (Leadership in Energy and Environmental Design) for Schools, and WSSP (Washington Sustainable School Protocol) are criteria checklists and rating systems that are currently helping architects design better sustainable schools. CHPS was developed before LEED for schools and it

[55] Benedikt, Michael. "Environmental Stoicism and Place Machismo." *Harvard Design Magazine* Winter/Spring.16 (2002): 1. Print.

Figure 5.2 Exterior view of Leutshenbach School in Zurich

Figure 5.2 Leutshenbach School interior common space

Section 5: Urban Schools

Schools are often built in suburban areas and span long distances across the land. The locations of these schools are often hard to get to by walking or biking. They typically are one or two stories tall, and circulation relies on long walks between wings or around courtyards. The footprint and area of a suburban school uses much more land and has a bigger impact on the ecosystem. Vertical schools are typically in urban infill areas and don't have large footprints. They rely on stairs and elevators for circulation, but access to light and the exterior is easy due to the smaller floor plate. Visual connection between floors for interaction is important for a sense of community. A diversified floor to floor height also puts emphasis a more communal and special spaces.

An example of a modern vertical school is the Leutshenbach School in Zurich, Switzerland (Fig. 5.1, 5.2). It is a six story elementary school. Because of its smaller site, it creates a small footprint to open up area around the building for play. Stairs and common spaces connect each floor and create transparency and community between floor levels. The gymnasium is placed at the top of the building and has maximum daylight and views to the surrounding areas. This school does a good job at using its verticality to its advantage by connecting to the context and providing outside space. Even though the building has multiple levels, the spaces seem to flow together through the floor plates.[57]

Building a school in an urban setting reflects the "smart growth" patterns that are happening in Seattle. More people are moving to urban and suburban areas around cities. "King County has grown by about 330,000 residents, or 21%, since 1994… King County is forecasted to grow by an additional 320,000 persons, or 16% by 2030."[58]

---

57 Lentz, Linda. "Leutschenbach School: Christian Kerez." *Architecture Record* Jan. 2012: 110-115 Print.

58 USA. King County. Department of Development & Environmental Services. *King County Comprehensive Plan*. 2012 ed. Seattle: King County, 2011. Print.

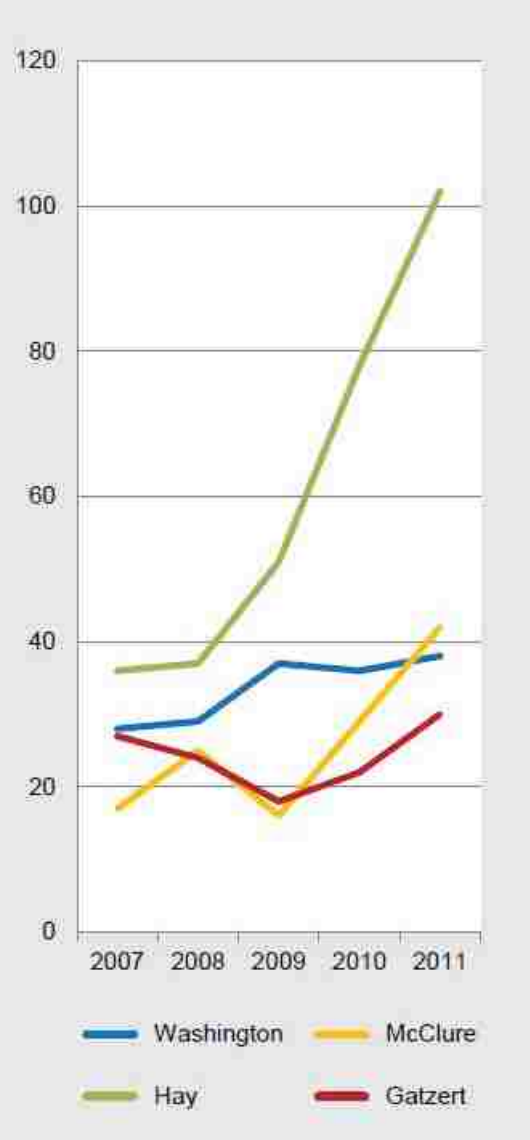


Figure 5.3 Changes in Downtown Enrollment by Attendance Area Schools (2007-2011)

Sprawling outwards from downtown Seattle has created long commutes to work and the idea of moving back to the city has become appealing to many people. As more people begin to move back, the urban infrastructure including schools needs to accommodate this new smart growth.

During the completion of this thesis, the summer of 2012, there has become great interest in the topic of a establishing a "downtown school". The growing population of students in the current public school system has sparked interest from the Downtown Seattle Association. The D.S.A. published a downtown school feasibility study that evaluates the needs for a downtown school and the populations' projections for current schools. Mayor McGuinn also spoke in support for a school in South Lake Union along with a proposal to rezone the height-limiting district. According the D.S.A. study, "Downtown Seattle has been the fastest growing neighborhood in Seattle for more than two decades. This trend is projected to continue with Downtown set to absorb 60 percent of future population growth within the City of Seattle over the next 12 years. The largest growth in student enrollment between 2007 and 2011 occurred in South Lake Union, where enrollment grew by more than 65 percent." "The Moderate Growth Scenario projects that the Downtown K-8 population will increase by more than 50 percent to 571 students in 2020."[59]

John Hays Elementary School is overcrowded with students from the growing downtown population (Fig. 5.3). According to the study, John Hay will see an increase of 200 to 300 students alone from the downtown area by the year 2020. If a school is built, it will draw more people those currently working downtown to live there as well. The increase of the downtown population is creating a denser and safer downtown. A school requires safety for the children, but it is also a promoter for an increase in safety and involvement of the community and surrounding area. An increase of residential development is a sign of the desire to move closer to the heart of Seattle (Fig. 5.4 - 5.7).

59 Downtown Seattle Association. *Downtown School Feasibility Study*. June 20. 2012. Print.

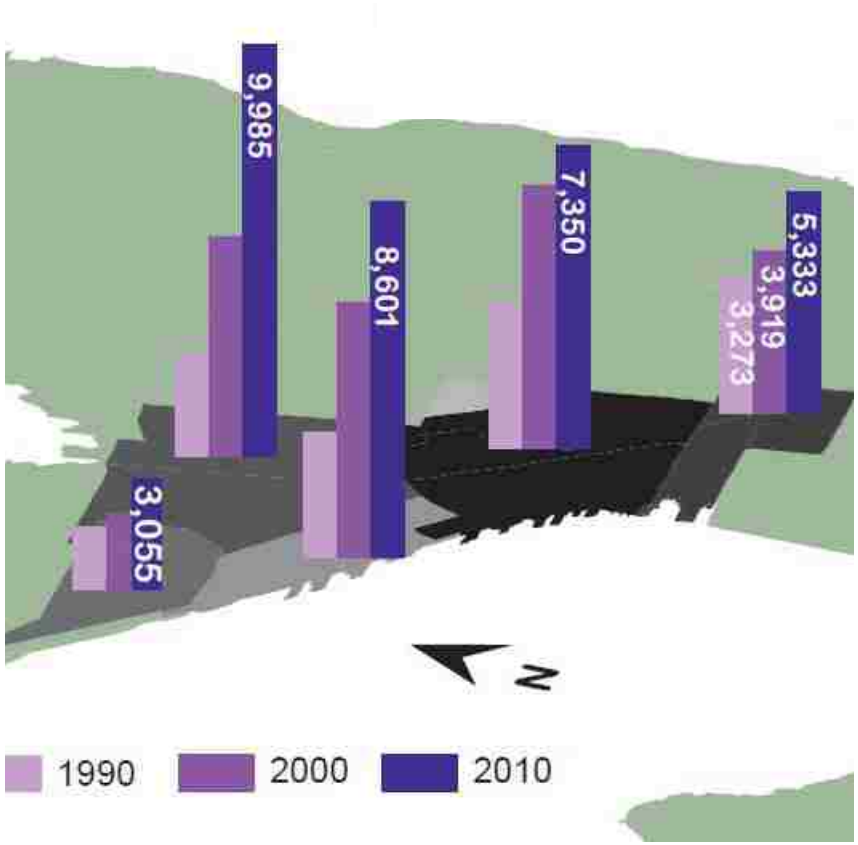


Figure 5.4 Total Downtown Population Census Tract (1990-2010) *Source: US Census Bureau*

Figure 5.5 Downtown Residential Construction *Source: Downtown Seattle Association*

Locating a school in an urban area has many opportunities and challenges. With a location like Seattle, there are many chances to exchange and share spaces within the context and community. By engaging with the community, spaces in the school can be used after school hours and spaces out in the community can be used by the school. The *Expeditionary Learning School* is an example of putting knowledge and skills to work by engaging learning with the surrounding context and community. Doing real tangible projects with the community gives students the feeling of responsibility for their work, as well as sense of purpose and ownership.[60] By being involved in the community, it brings the community in to support the school. Sharing sports fields and community spaces along with other functions provides a mutual positive relationship between the school and the community.

60 "Expeditionary Learning." *Expeditionary Learning*. Outward Bound. Web. 25 Feb. 2012. <http://elschools.org/>.

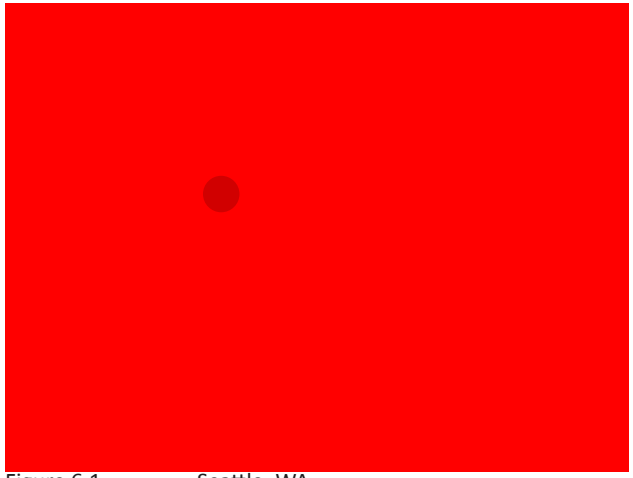


Figure 6.1 Seattle, WA

Figure 6.2 South Lake Union, Seattle

Methodology

Part 1. Site and Program

Site and Surrounding Context

The manifestation of the future learning environment is an urban K-8 school for the Seattle Public School system. In the process of selecting a site for this project many factors have been considered. The decision to locate the school in an area that fits the criteria for a dense urban school in a growing location that could possible serve a viable community of Seattle (Fig. 6.1, 6.2) in the future. Locating downtown, unlike somewhere further away puts the building in a context that is restricted to the urban grid, but free to a taller height limit. There is also not a public school located in the downtown area, even though living in the downtown area has become appealing again. A school in close proximity to downtown can take advantage of the city and its growing community as an outside resource.

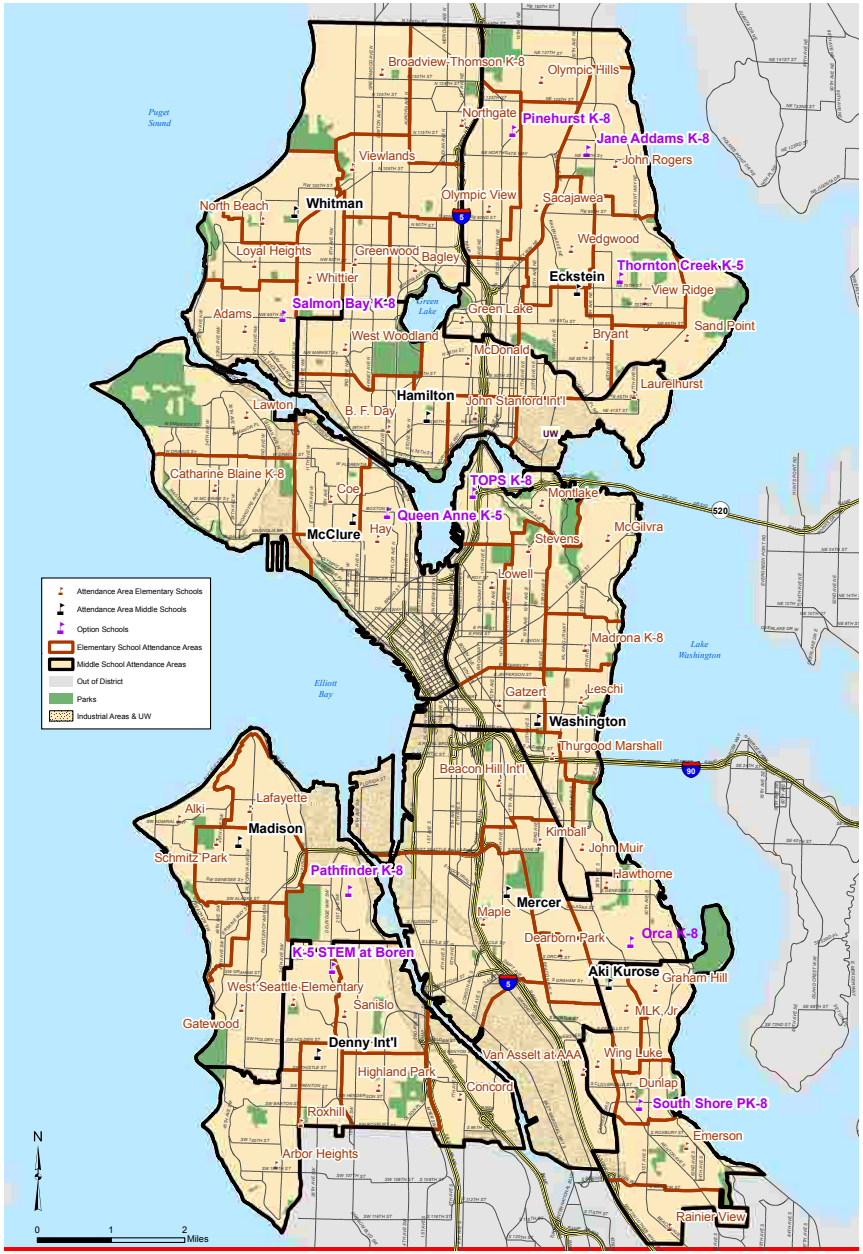
South Lake Union (sometimes referred to as the Cascade District) was chosen because it is central to the new development and already has many community resources for the school to connect. South Lake Union is north of downtown in an area that is currently being developed heavily by a developer called Vulcan Real Estate owned by Paul Allen of Microsoft. The plan for South Lake Union is to increase density in the area and grow upwards, not outwards. South Lake Union is a growing community full of new businesses and new young residents. It is also likely to share it resources like athletic fields at the Seattle Center. It is the home of an Amazon Campus and UW Medical, along with other business drawn to the newly developed area. Since this project is dealing with the future of a learning environment and new technologies, it is more appropriate that the school be located in this area, where the community may be very supportive of this new technological related school. Parents will be more inclined to live and work in this area if the school gives their children an education they support.

Currently students that live in this area go to John Hay Elementary School in Queen Anne. The closest magnet school is Queen Anne Elementary School. Students in Eastlake also do not have a school in their area and must go to Montlake Elementary or Lowel Elementary in Capitol Hill. A school in South Lake Union could draw students from Eastlake as well as those in South Lake Union and Downtown (Fig. 6.3). This school could also retain students till high school, so traveling to McClure Middle School in Queen Anne would not be necessary. The area works well with projected growth trends and provides a new type of context in which children can learn.

Deciding on a specific site for the school is based upon zoning, surrounding buildings, resource proximity, current growth, likely growth patterns, vehicular traffic, and physical obstacles and boundaries. Like downtown, South Lake Union is has great topography changes, although it is much more manageable thanks to the Denny re-grade. The eastern portion of South Lake Union is at the edge of The Seattle Center; home of the Space Needle, Key Arena, and The Pacific Science Center. The new Gates Foundation building and chain hotels are also in this area. The Seattle Center has its own master plan for the next 50 years, but it is not design in conjunction with Vulcan and the rest of South Lake Union. Connecting to this area is appealing for a school, but the challenges outweigh the benefits. There is a lot of traffic, a lack of crosswalks, major obstacles like streets, stairs, and tunnels; the location is not central for most housing in South Lake Union. Connecting to the Seattle Center by transit or bus will be the most viable solution for the school

The two most appealing sites are north of Denny Park, and on the northwest corner of Denny Way and Fairview Ave. Both sites are relatively central to the area, and are in growing areas. The Denny Park site is very close to two parks and has unblocked access to sunlight from the south. The drawbacks to this are that there is existing church there already, and it sits between two unfriendly pedestrian streets that are heavily traveled by fast moving vehicles. If a school were to put in this area, restructuring of

Figure 6.3 Seattle Public School District Map for Elementary and Middle School



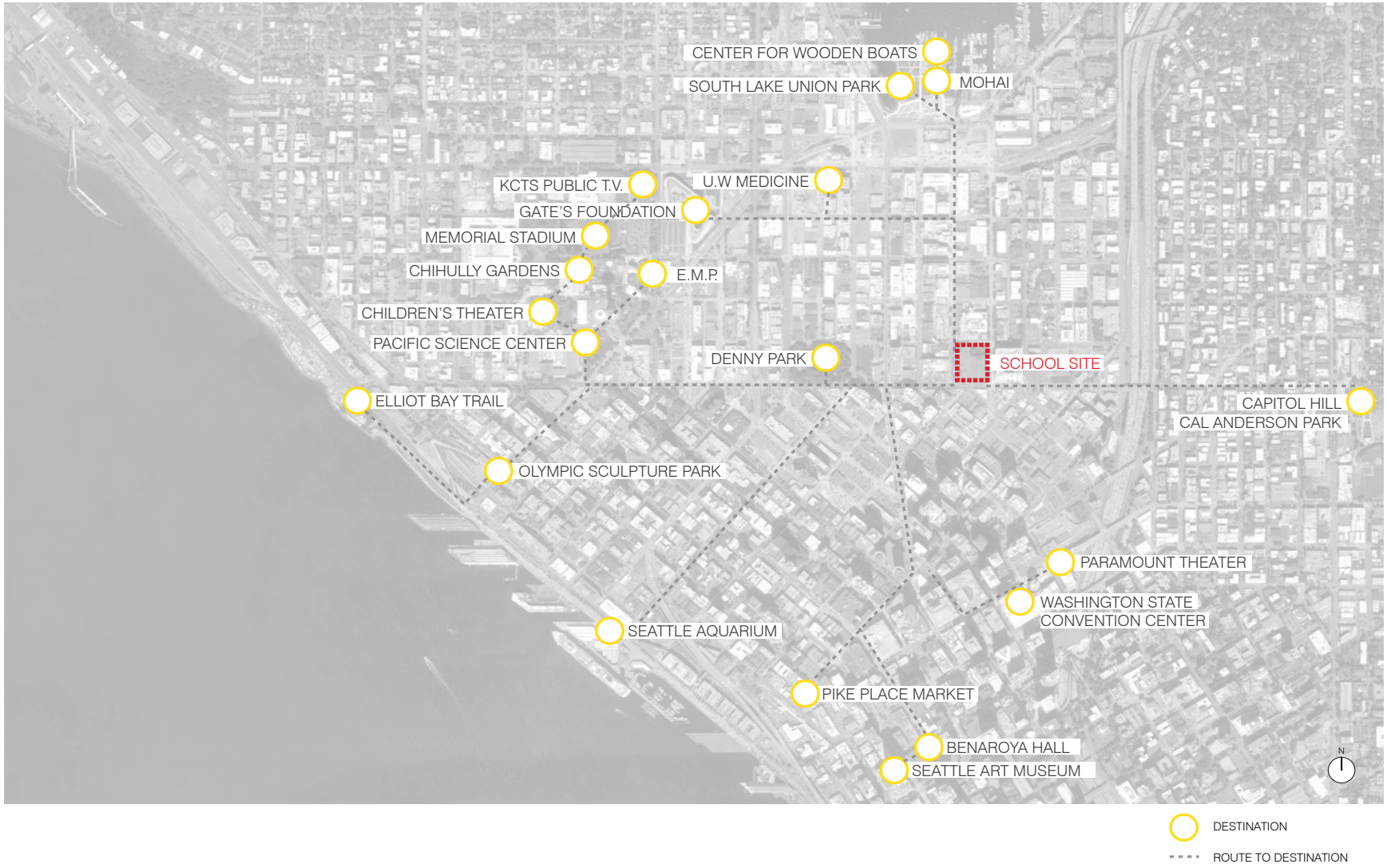


Figure 6.4 Seattle Context and Adjacencies

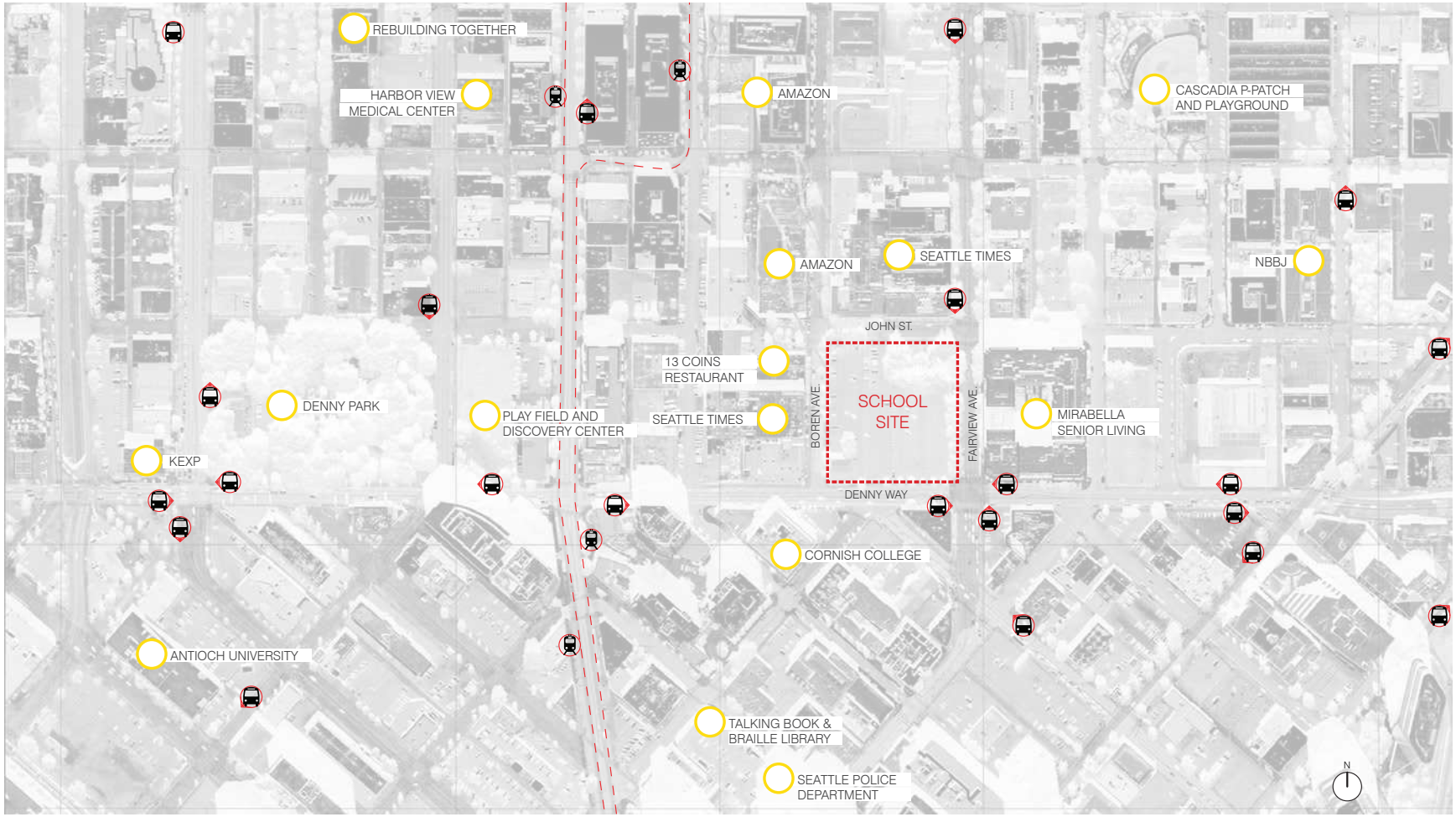


Figure 6.5 Site and immediate adjacent context. (Walkable)

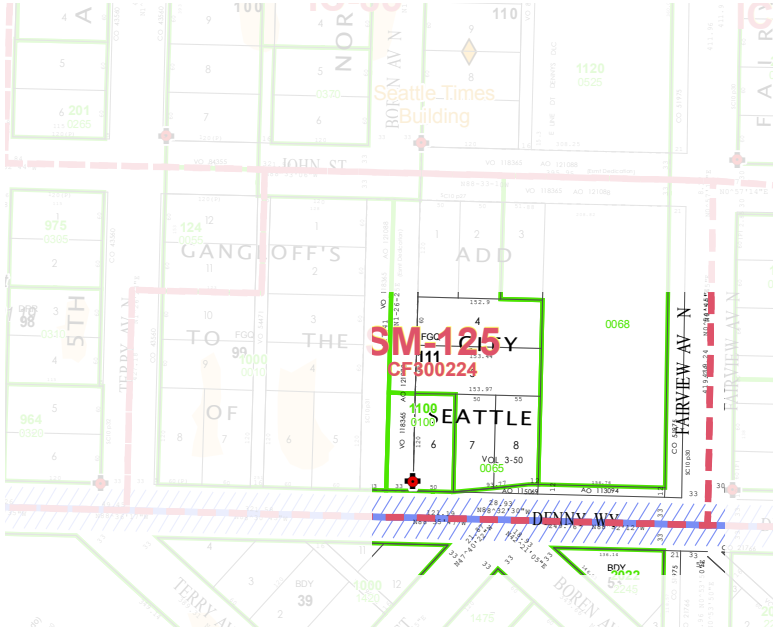


Figure 6.6 Seattle zoning map for South Lake Union.

Figure 6.7 Existing site conditions.

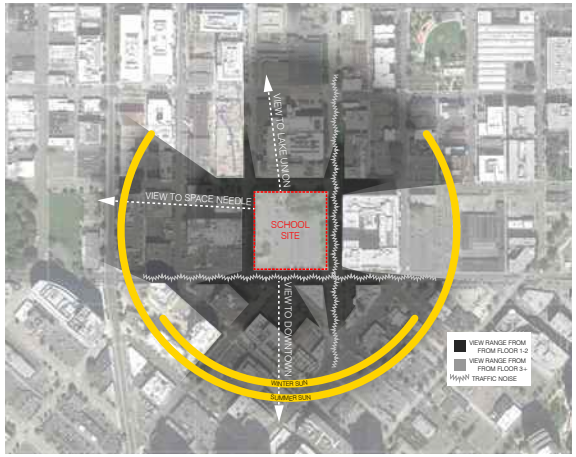


Figure 6.8 Site Analysis of Environmental Forces

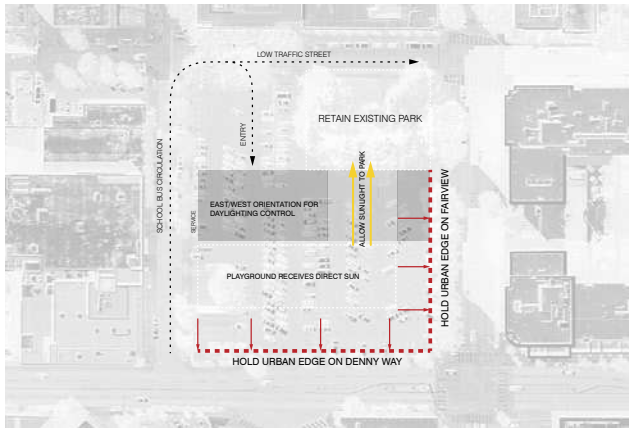


Figure 6.9 Site Analysis of Contextual Forces

alleys would also need to occur. The other site is an existing parking lot and small park with tall trees for a restaurant called 13 Coins and the Seattle Times Newspaper (Fig. 6.4 - 6.9). The site is relatively flat compared to the steep hill down to the east. This gives potential upper stories good views west and to the Space Needle. The site is next to the Amazon Campus and housing development to the east. It sits between Fairview Ave and Westlake Ave; two very pedestrian friendly streets with two types of public transportation. John Street and Boren Avenue are very quite streets which can be used for services and school drop-off. This site is also best because it is in a tall zoning height and is closer to downtown, but doesn't have large buildings or blocks to the south that prevent sunlight from getting to the site. This will be the site of the school for South Lake Union. The contextual response to the site is one that is fits to the urban grid and addresses light and views with an appropriate massing (Fig. 6.9 - 10).

Program

The manifestation of the future learning environment is an urban K-8 school for the Seattle Public School system. A standard elementary school (K-5) makes sense for the current situation of South Lake Union, but the main reasoning for including middle school (6-8) was because of size and scope. By expanding into middle school grades, it allows more exploration of technology in more advanced development stages of school along with those different physical spaces. The site for the school is large enough and zoning heights are tall enough to fit the building square footage multiple times. This leaves room for outdoor space and circulation. The site is not large enough for track and field events, so students will have to use other fields like the one at Seattle Center.

The program of the school will be split into development stages and separated in grades groups (Fig. 6.11). The groups are split into Kindergarten, first and second grade, third through fifth grade, and sixth through eighth grade. Each group will have a different curriculum and an altered approach to using technology and physical spaces. First through second grade and third through fifth grade will have different curriculum

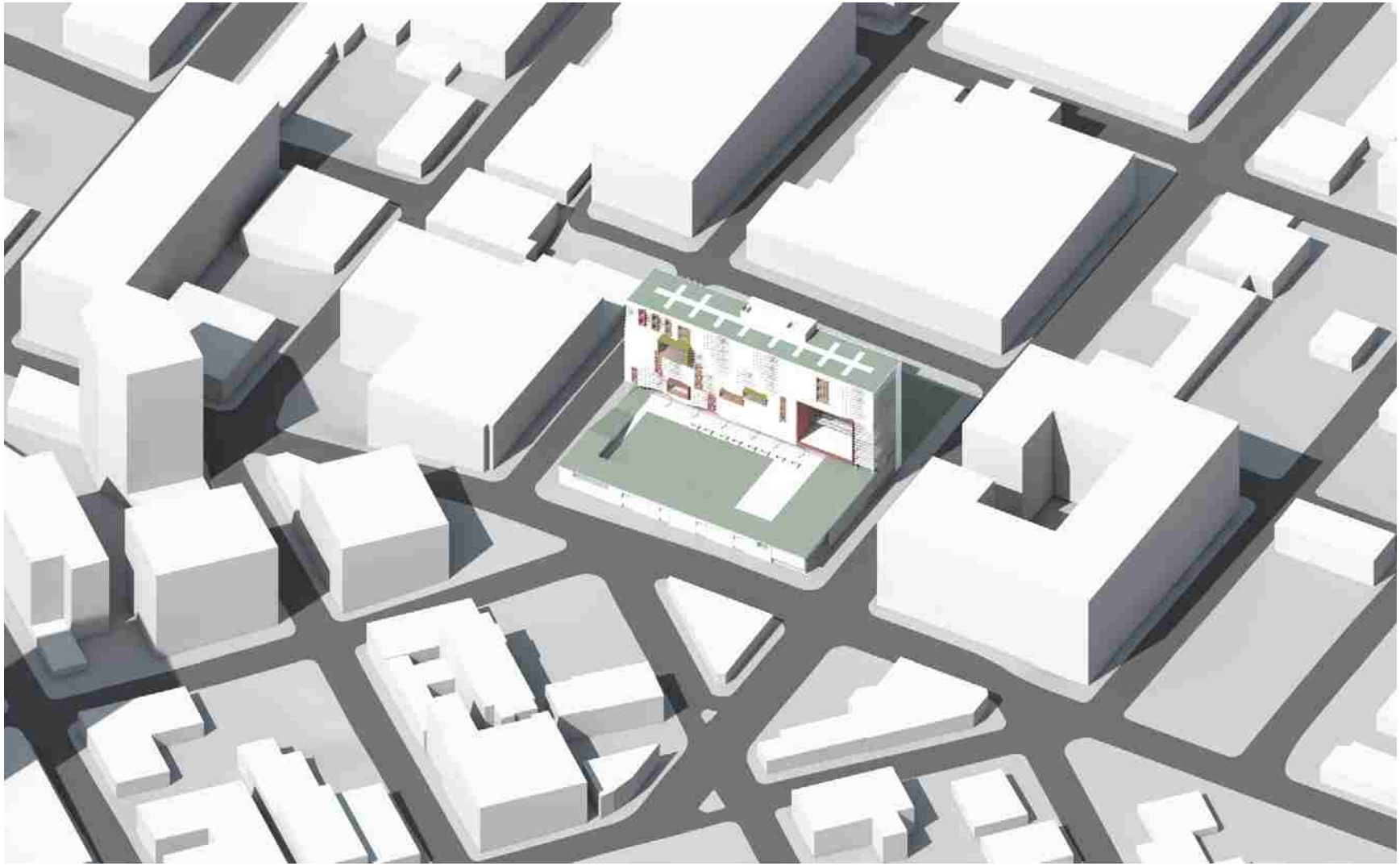


Figure 6.10 Areal view of the School on the Site

but similar physical learning spaces.

In addition to the learning spaces, there will be a community gathering space, administration and office space, a gymnasium, a cafeteria, commons, a mixing chamber, and course specific classrooms such as music and art class. The organization and connection between all of these elements vertically is important so that floors do not become dividing planes. The orientation and amount of light that each of these spaces can omit will also impact the location and grouping of certain spaces (Fig. 6.13). A sense of visual community and identity is important for a successful school. Another way of creating a strong school community and identity is by being involved in the community and bringing the community into the building and site. Making the school a community owned and invested space will benefit the students and the public. By providing this community space in combination with the gymnasium, the relations with the context will grow to where the building could be used all day and afternoon. Building technology, sustainable technology, and learning in general thus can reach a larger audience.

The primary intention of this thesis is to explore the learning environment for the technology created learning typologies. While the focus of the design will be interior spaces and architectural design, the program and site analysis speaks to a broader understanding and appreciation for the larger context. The selection of an urban site and the addition of program is a contextual consideration to overall improve the current place and continue the improvement of South Lake Union.

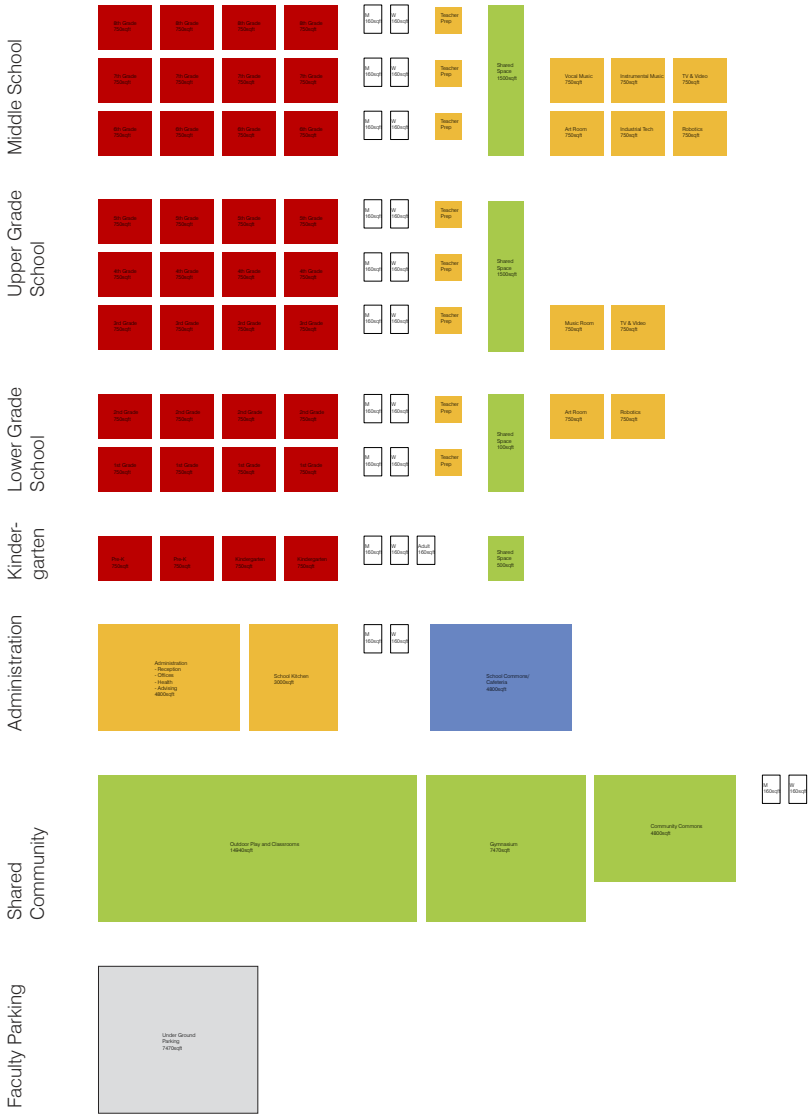


Figure 6.11 Programming and Square Footage

Figure 6.12 Programming Conceptually Grouped and Reorganized

Space / Users	Tasks	Daylight	Sunlight	View to the Exterior	Access to Exterior
Reception	People/Paper/Screens	Yes	Accept-able	Yes	Entrance
Admin Offices	Screens	Yes	No	Yes	No
Health	Students	Yes	No	Maybe	No
Gymnasium	Sports	Yes	No	Maybe	Yes
Community	Multiple Tasks	Yes	Accept-able	Yes	Yes
Cafeteria	Food and People	Yes	Accept-able	Yes	Yes
Mixing Chamber	Books, Screens, People	Yes	Maybe	Yes	No
“Classrooms”	Screens, People, Books	Yes	Maybe	Yes	Maybe
Bathrooms	Fixtures, Mirror	Maybe	Accept-able	No	No
Art Rooms	Art, Paper, Clay	Yes	Maybe	Yes	No
Music Rooms	Paper, People	Yes	No	Maybe	No
Industrial. Tech.	Equipment	Yes	No	No	No
TV and Video	Screens, Controlled Light settings	No	No	No	No
Shared Space	People, Stairs	Yes	Yes	Yes	Maybe

Figure 6.13 Lighting Criteria

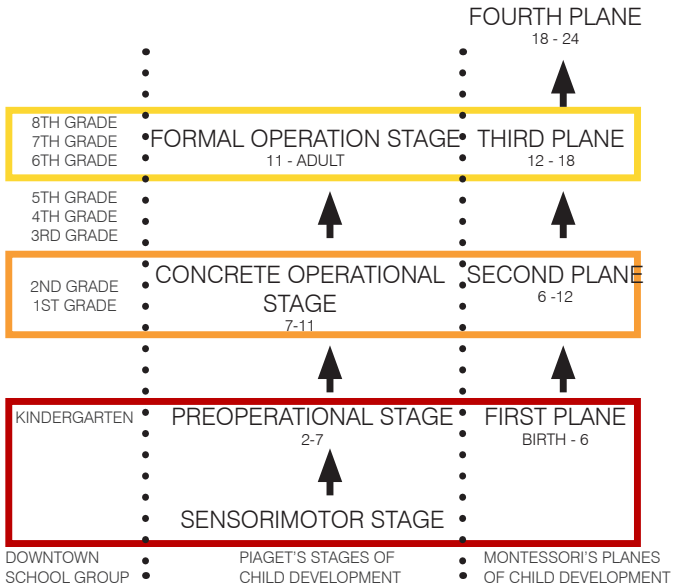


Figure 7.1 Age Development Groups and Grade

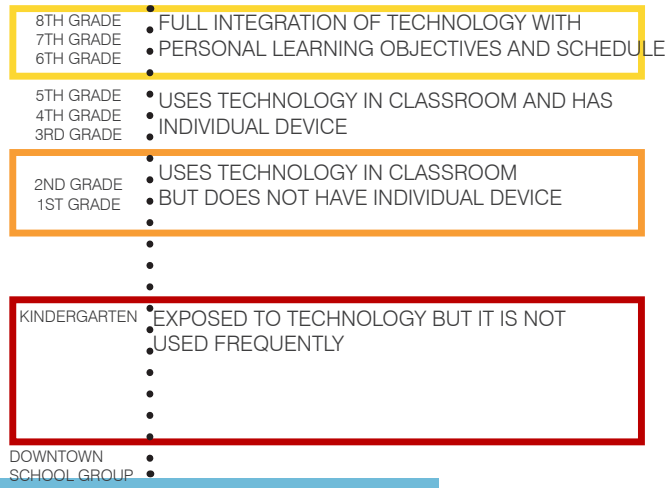


Figure 7.2 How Age Groups learn with Technology

Part 2. Learning Types and Age Development Groups with Technology

Learning with technology allows for new freedoms and new learning types outside of the traditional classroom setting. As mentioned previously in the thesis, these freedoms allow for more active and personal learning types. The use of personal ICT devices can be fully integrated in a curriculum but it is not appropriate for every age of student. Because different age groups are not as developed or responsible as older children, certain technologies and learning types are not available till the student reaches an older age.

The figures to the left (Fig. 7.1, 7.2) provide a guideline for how a curriculum might be set using different technologies. The general idea is that ICT would not be fully integrated in learning till the student reaches the oldest age group. Children in the earliest age group would use ICT devices very infrequently so that other sensory skills can be developed that are critical in this age stage. This would allow students in this age to be familiar with ICT devices in a less formal way. In the next age groups, first and second grade, the use of technology is used in the classroom for group assignments and projects and occasionally for personal learning and tutoring. The third through fifth grade age group would then use the devices in class more regularly and eventually be able to take home their own device to work and learn from outside of the school. In middle school, students are at the point where they should be familiar with the devices to use them in a comprehensive way where they have a unique learning curriculum that is fit their specific learning needs. This will allow students to progress to their full potential. Students will see what they are succeeding in and where they are struggling. The full integration of ICT promotes a freedom from the traditional classroom learning type and frees up for different learning types and environments. These learning types are response to the effects of ICT and the goals of the 21st Century Framework to have a more active, transparent, community, and collaborative learning environment.

Figure 7.3 Learning Types

The learning types that are identified are represented with the symbols and colors (Fig. 7.2). These learning types are found in different learning environments through out each age development group but the physical learning environments may be completely different. It is also possible, and very likely, that multiple learning types can happen in one learning environment.

The red colored learning type represents the standard traditional classroom where one teacher is with twenty-five students teaching in a lecture format. The two orange colored learning types are active group settings where students discuss and learn from one another with the guidance of a teacher, technology, or an assigned project. The yellow colored learning types represent more informal social and gathering learning. These learning types are used to display work to others as well as take advantage of the physical interactively that happens between students at school, unlike that of a digital social space. The green learning type symbolizes the hands on learning and other technological learning that can occur that is not digital. The blue colored learning types are ones that are typically more passive and personal. These learning types are used for tutoring, small group lectures, and self studying.

Because ICT has provided freedom from the traditional classroom learning environment, these learning types are able to be used more frequently. These learning types that expand on the classroom are then organized physically around the traditional classroom to create learning communities (Fig. 7.3 - 7.5). To help achieve these new learning types, an appropriate environmental and architectural response is necessary to make these them work and also meet to goals of the 21st Century Framework.

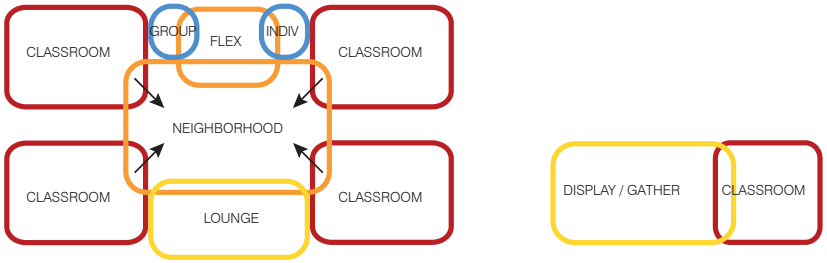


Figure 7.4 First - Second Grade Program Diagram

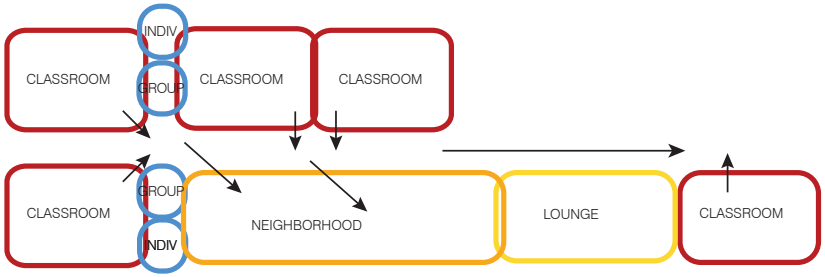


Figure 7.5 Third - Fifth Grade Program Diagram.

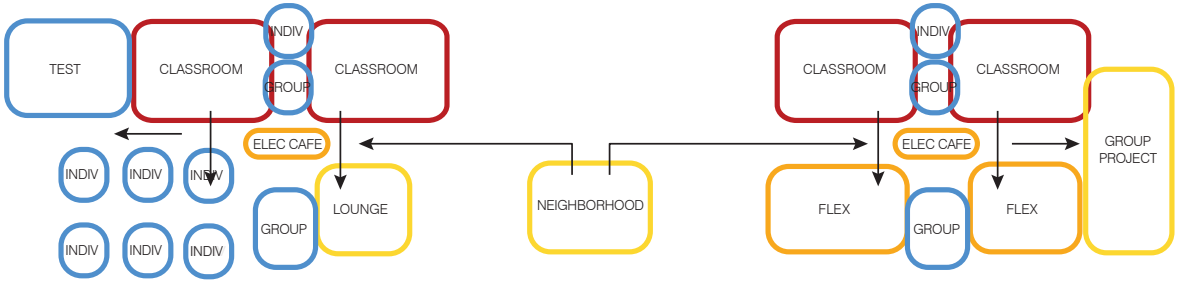


Figure 7.6 Sixth - Eight Grade Program Diagram.

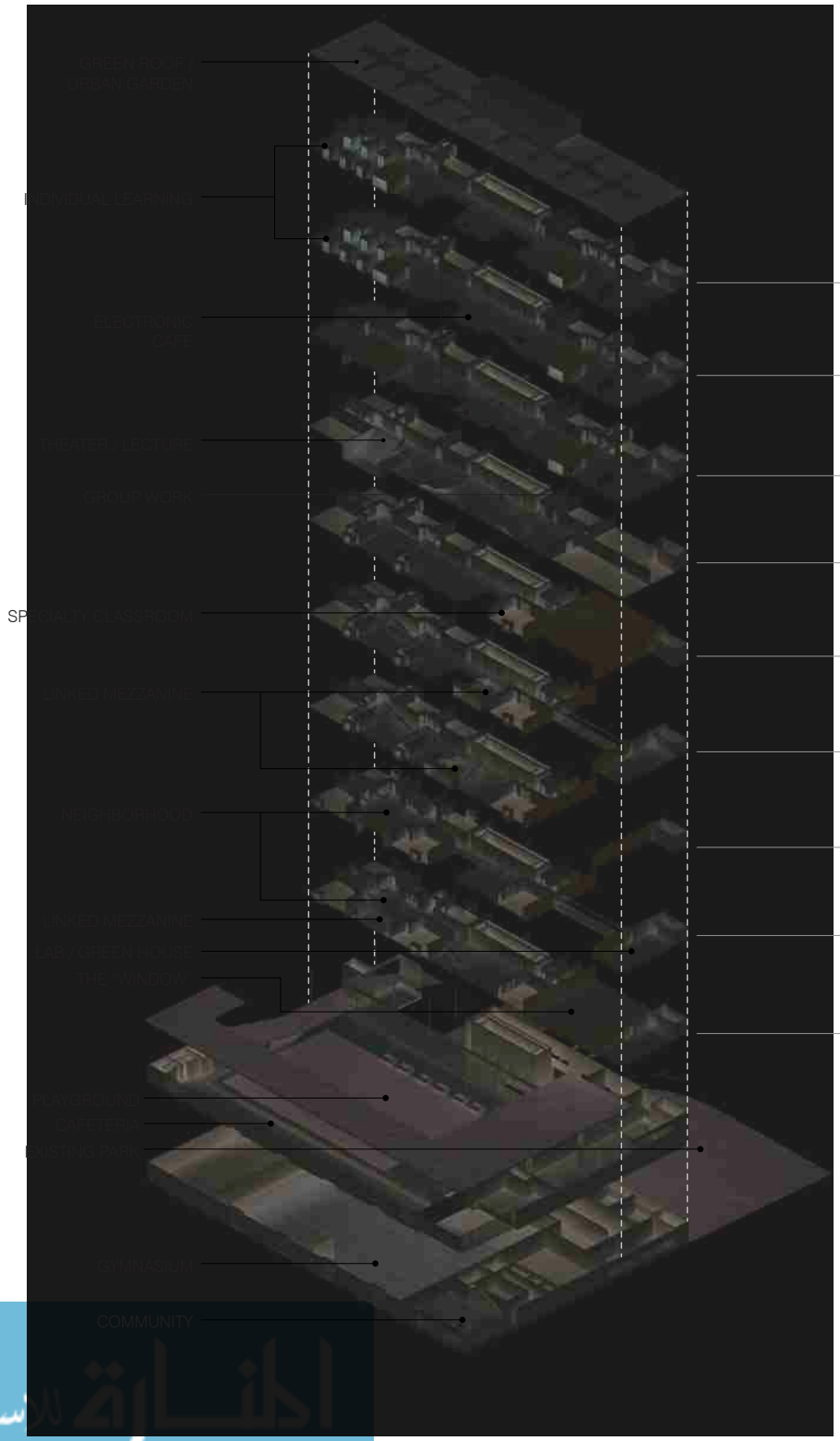
Part 3. The Learning Environment

The learning types that were discussed earlier are supported with different learning environments in the school. The learning environment has typically been thought of just the classroom space. The resulting learning environment for this thesis expands on the classroom with the new learning types to make active, transparent, and collaborative spaces for students to learn.

As mentioned earlier, these spaces differ based on age development group. The school itself has physically been broken down into these three age development groups. Each floor of the school, starting at the third floor, contains one grade level. These floors and grades have been designed internally to create collaborative spaces to interact between students and teachers outside their home classroom, called neighborhoods. These neighborhoods are spaces that typically house the orange and yellow learning types. Another dimension is added to the neighborhood concept by connecting between floors. Because not all students learn at the same age but are in the same age group, double and triple height mezzanines are designed to connect the different levels and grades within the age groups. For example, first and second grade have a connecting mezzanine, and third through fifth have two connecting mezzanines.

To further support these age groups and neighborhoods within the designed high-rise school, a high capacity elevator is able to carry a class load of students to a designated floor in the age group and their corresponding floors (Fig. 7.6). Students and teachers then can walk up or down one flight of stairs to reach their destination. This creates a better sense of community among those floors and grades within the age group.

The first age group, first and second grade, organizes the classrooms around a central space in the center (Fig. 7.11, 7.16). Each classroom has a transparent garage door that opens up to the central space so it can become one large area if needed. In



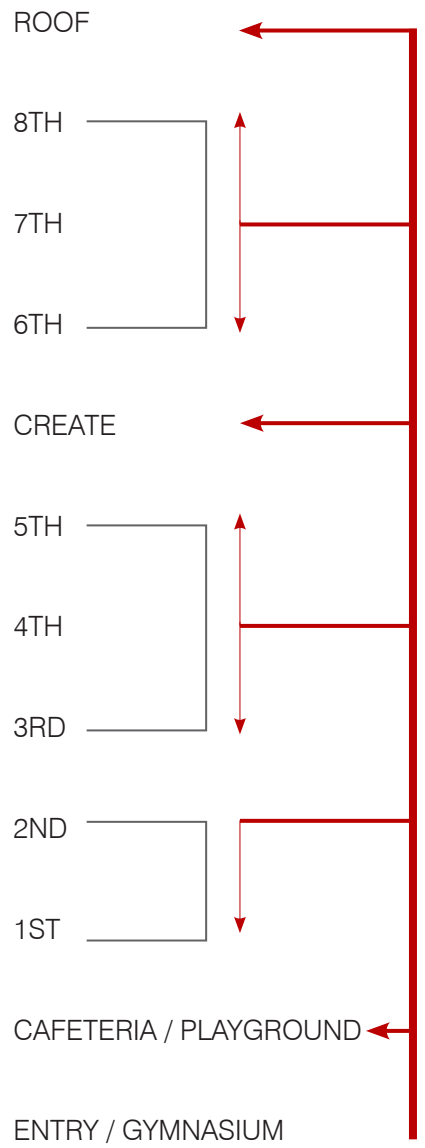


Figure 7.7 Building Axon Diagram
40 Person capacity elevators allow a full class to move to the middle floor of the age group and then take the stairs up or down one floor.

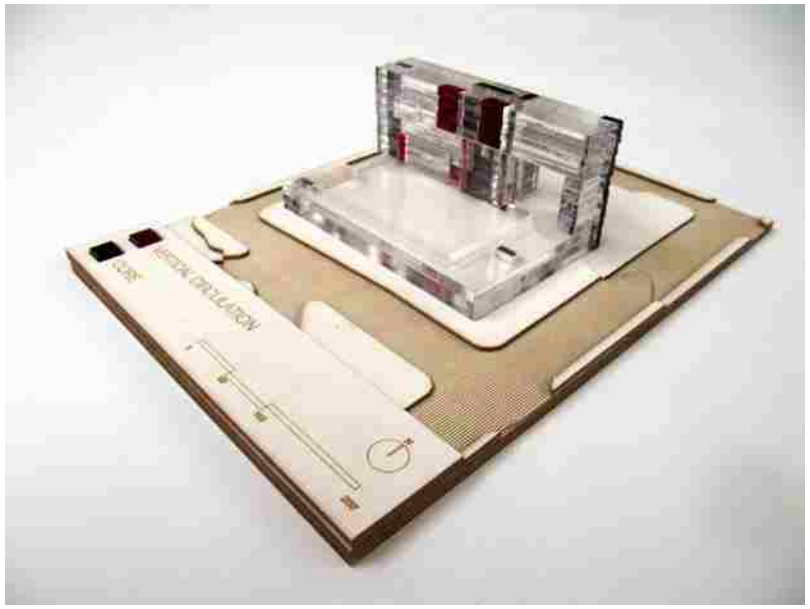


Figure 7.8 Diagram of Vertical Circulation

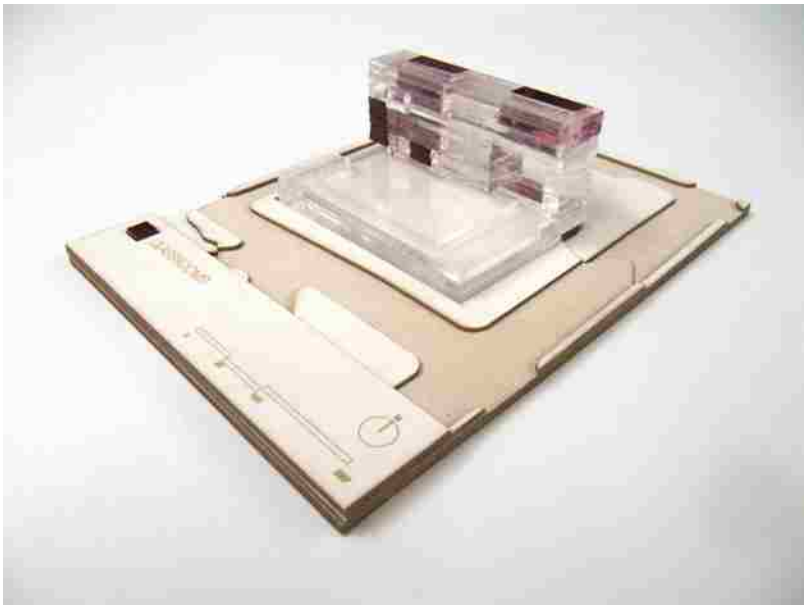


Figure 7.9 Diagram of Classroom Locations

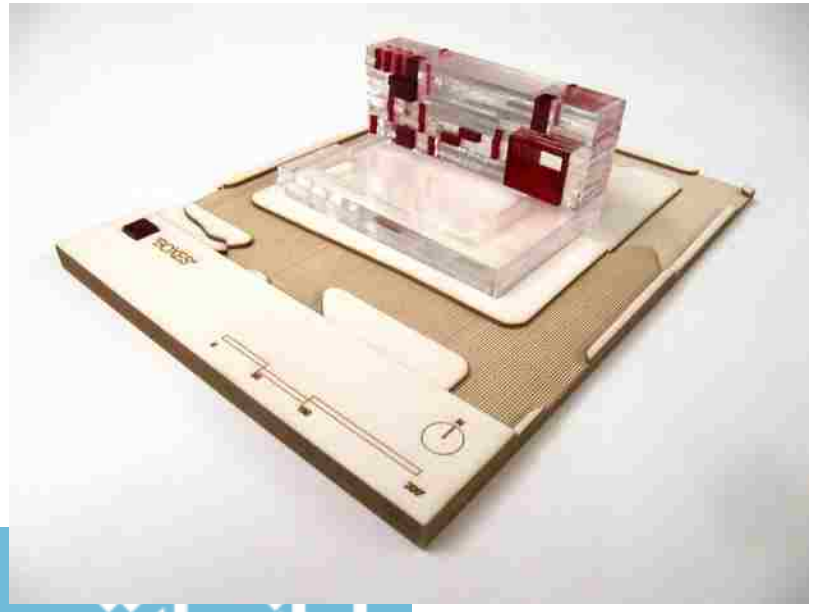


Figure 7.10 Diagram of “Boxes”

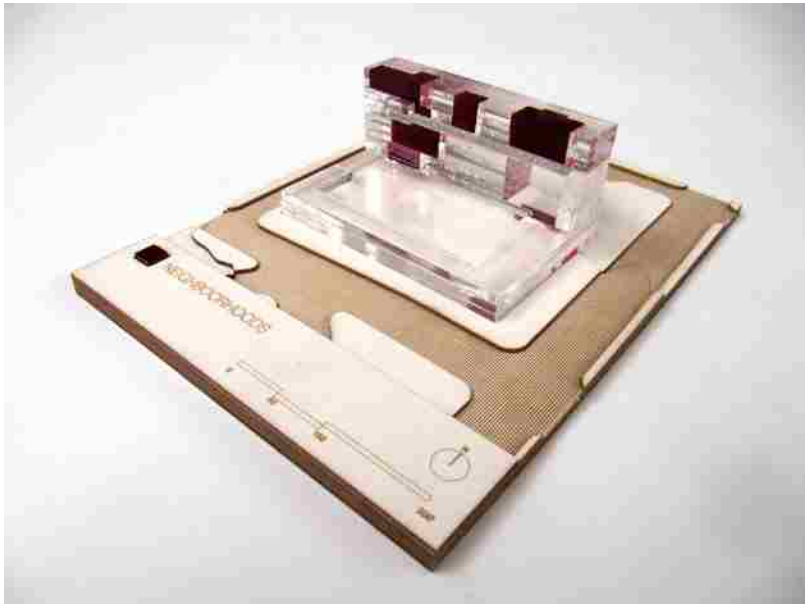


Figure 7.11 Diagram of “Neighborhoods”

the central space are different areas to work in groups. This area is an active area and may sometimes become loud. Enclosed spaces linked to the central spaces are designed for large groups and small tutoring sessions. These spaces support the blue color learning types: quite and personal learning. On the south side, a connecting mezzanine allows direct light into the social space and links the two grades together. To the east, the "window", a large opening in the building, is used to learn about plants and other hands-on outdoor education. It is important that students and teachers have this direct access to the outdoor. This young age group in comparison to the older ones is very secure and monitored. The children are still very dependent and need supervision. While most of the time will likely be spent in the classroom in this age development group, the neighborhood space is the strongest because of it central location to all the classrooms.

The second age development group (Fig. 7.12, 7.17), third through fourth grade, is very similar to the previous age development group discussed except that it is more open and allows more freedom. The use of technology for this age group increases but the main reason to separate this age group and the previous is because of the physical size and maturation change in students. The classrooms open out onto a larger space and the neighborhood expands beyond the floor. This age group has two mezzanines that connect the three floors. In this learning environment, there are more group discussion tutoring rooms for students. The connection the outdoor is by a bridge that spans over too a science / wet lab room. Instead of a large open area, this bridge provides space for hanging plants. The design of the second age group is a progression from the previous age group design toward a more open and active environment between grades.

In the final age group in this thesis (Fig. 7.13, 7.18), sixth through seventh, the physical learning environment is designed to meet the use of a fully integrated use of technology and independent curriculums. Four floors are connected together with a

Figure 7.12 Age Group: 1st Grade - 2nd Grade

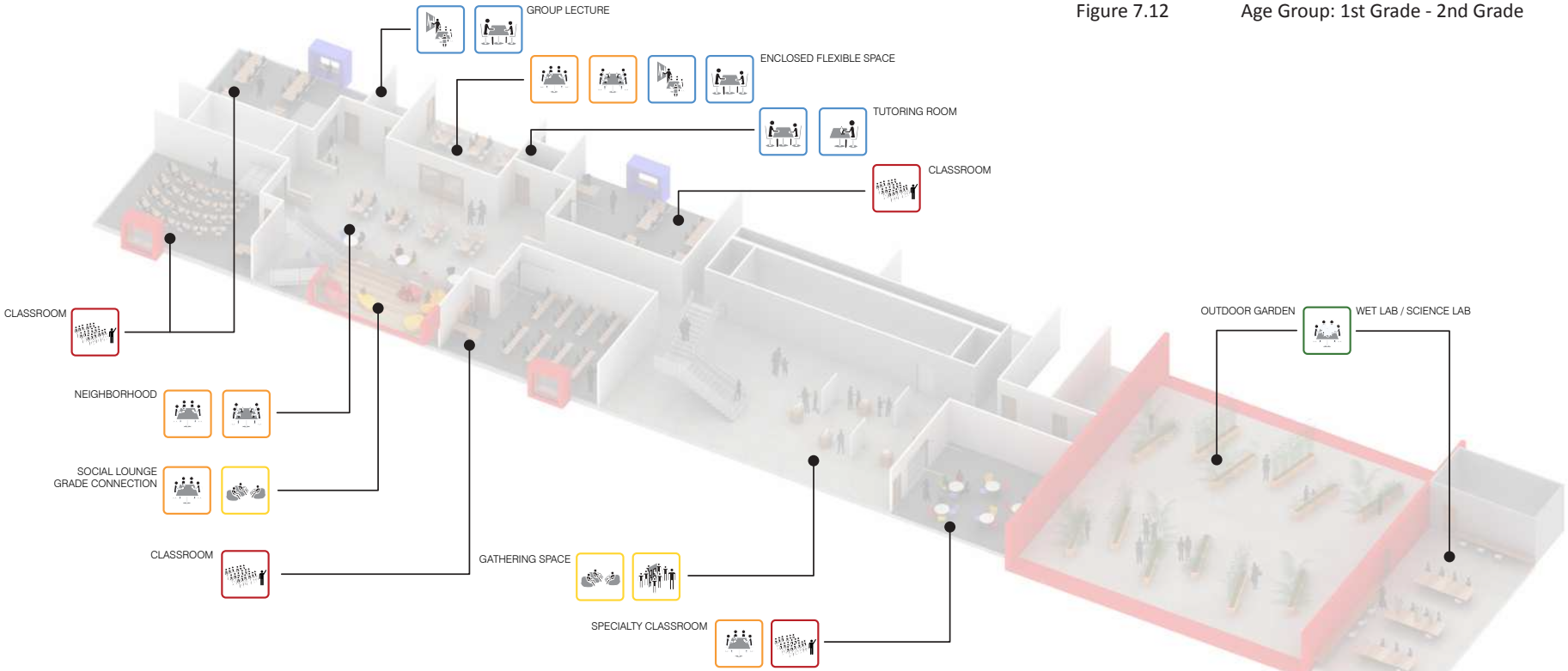


Figure 7.13 Age Group: 3rd Grade - 4th Grade

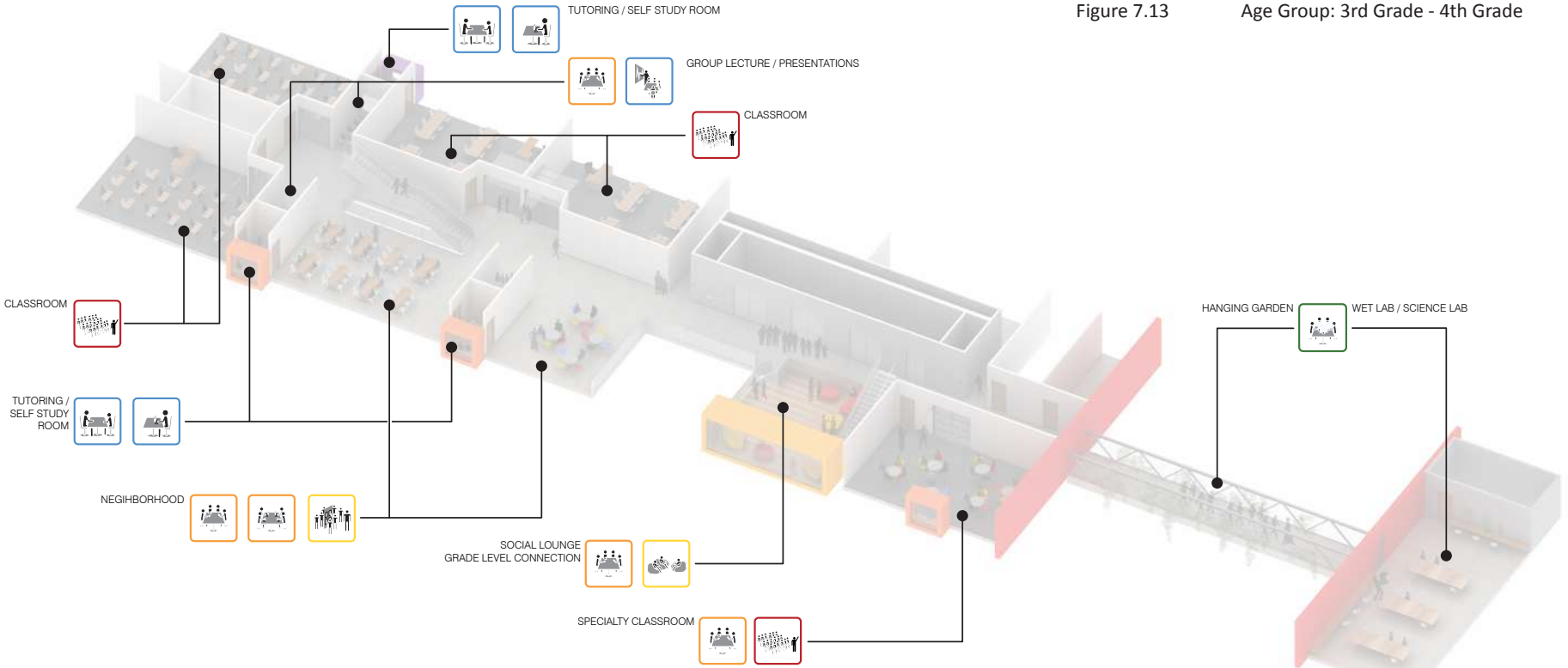
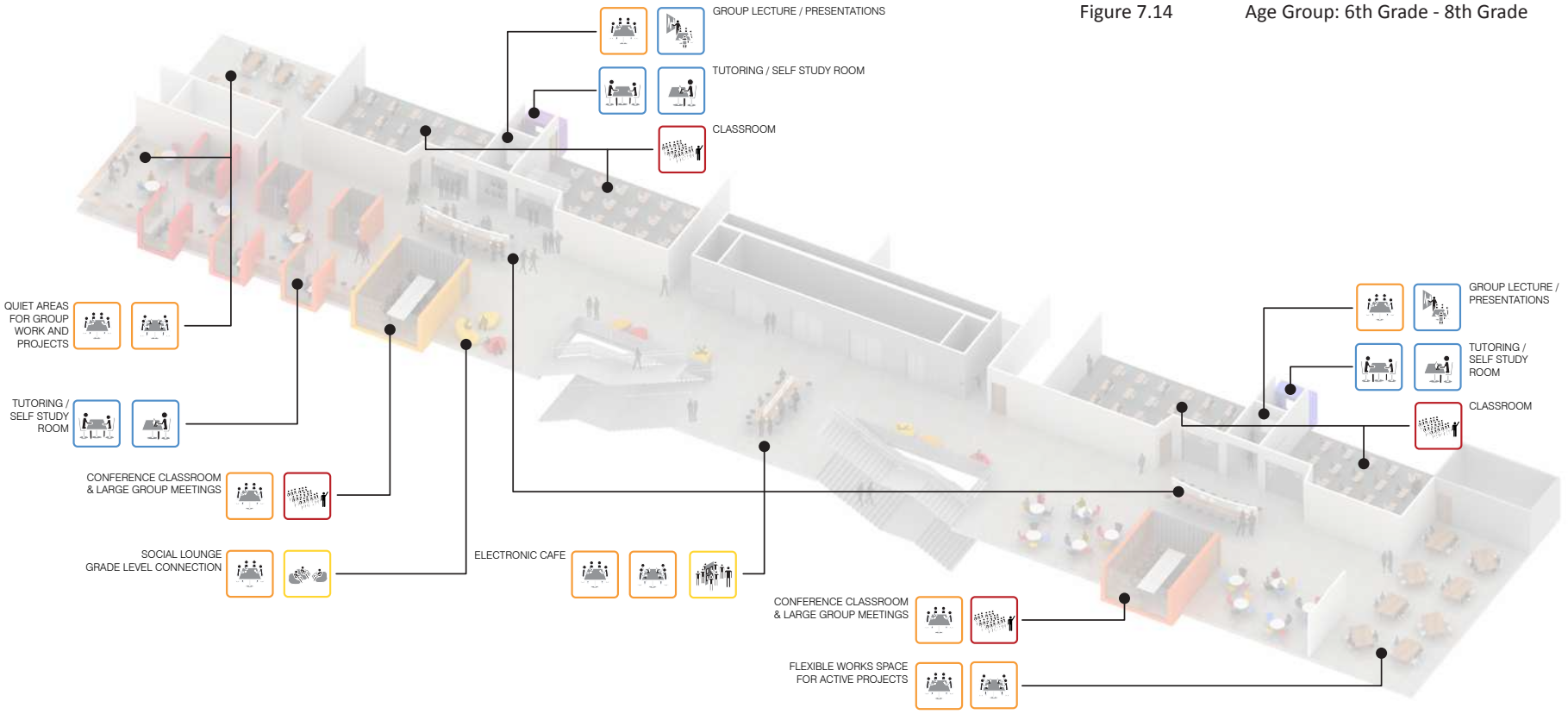


Figure 7.14 Age Group: 6th Grade - 8th Grade



main central staircase. At the landing of the staircases are “electronic cafes”. These spaces are meant to be physical spaces to exchange information, in contrast to sharing information digitally. Students can plug in their devices, upload and download, and check their schedules and other events at these locations. A similar “cafe” is located at the entrance of clustered classrooms. In this scheme, classrooms serve for specific subjects and may only be homerooms at the beginning and ends of the day. The clusters have a tutoring room between them and a small lecture room as well. They are close to the classrooms so they may be used by students that may be in class at that time but need additional help or instruction. These classroom clusters occur on the north side of the school, and all of the active learning type spaces are on the south side. The spaces on the south side use the colored boxes for enclosed private learning types. Some “boxes” are larger than others and can hold a large discussion groups or a small class. The smaller “boxes” are individual tutor and study rooms. These spaces can be controlled and adapted to the functions inside, unlike the open and flexible spaces outside of them. The floor plan is arrange so that two ends are contrasting. The west end with the small tutoring and study rooms are designed to be a quiet end, while the east end is designed to have active and collaborative projects and assignments. Unlike the elementary school grades who use the “window”, the middle school has access to the roof for garden and outdoor education. Overall, the middle school age group is designed to accommodate the wide variety of learning types that were identified earlier while still achieving a transparent, active, and collaborative setting where students can learn.

The focus of this thesis is the interior of the building and the differences in age group learning environments, the overall building design attempts to resolve the larger issues of a K-8 high-rise school in an urban area. The colored “boxes” (Fig. 7.15) that were mentioned have another purpose for the students while on the exterior. The boxes

are a visual cue to those outside the building. The color and sizes of the “boxes” break down the scale of the building by showing the students where spaces they use are in relationship to the whole. By showing where a student works from the outside of the building in relationship the entire building gives a sense and understanding of what is happening on the interior.

In addition to the “boxes”, a fluctuating shading system shows spaces that need to be shaded and those that do not need to be shaded. This is not only a response to environmental forces, but another way to connect the outsider to the inside. Using these two languages throughout the overall building design gives the building and school a unified design that also signifies the program differences between the different age groups.

The learning environments are a reflection of the learning types that information and communication technology has freed from the traditional teaching method in a single classroom. The design of the interior keeps the idea of a traditional classroom because of its success and familiarity it has in the history of schools. The way the learning environment is used will be determined by the teachers and their dedication to technology and how students learn, but the grade levels have been designed to facilitate the foreseeable needs of the future learning environment.

Figure 7.15 School Entryway

Figure 7.16 School Playground

Figure 7.17 1st Grade Neighborhood

Figure 7.18 3rd-5th Grade Social Lounge

Figure 7.19 6th-8th Grade Electronic Cafe

Conclusions

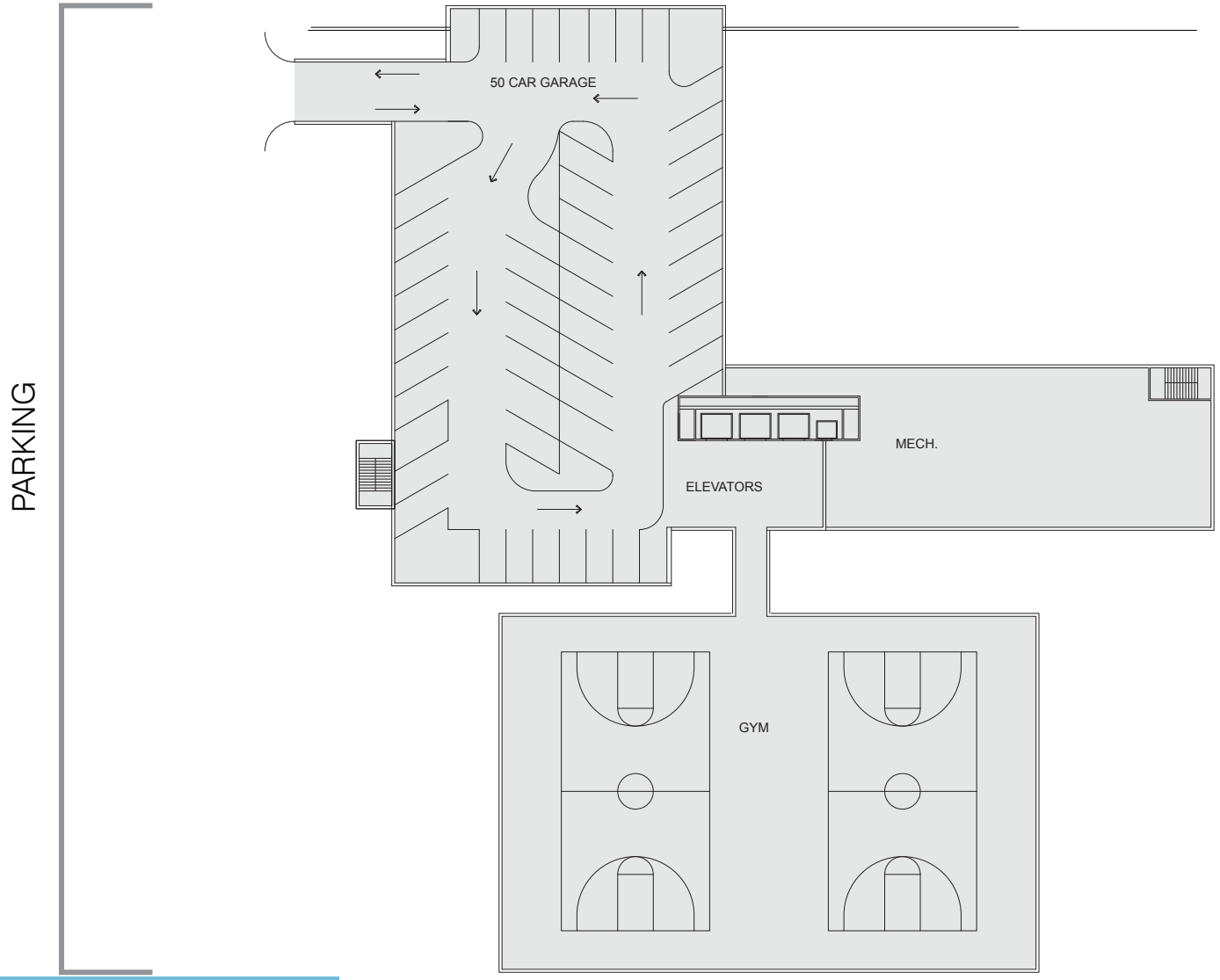
During the final review of the thesis, there was a discussion with the jurors on the resulting learning environment. The main question that was brought up was not whether information technology had influenced my design or not, but if the learning environment could be used without technology and if my design methods produced a type of environment that was actually different from something today that is without the influence of information technology. The defense for this question was that the learning environment could be used with out technology but the use of the space is designed to facilitate for all types of learning to take place including learning with information technology. These types of spaces would be possible without technology with a large amount of teachers for supervision and instruction, but the thesis takes an approach that proposes a realistic number of instructors and that information technology allows freedoms from the classroom because it is used as a teaching tool to create these additional learning types and additional learning environments. Trying to bridge technology to learning types and curriculum, and then to the learning environment has caused an unclear connection between the beginning and the end. Because the thesis tries to facilitate an ever changing field of technological devices, the spaces and their uses feel a little ambiguous. In the end, the spaces are the result of my process of trying to provided for the learning types resulted from the use of digital devices while still meeting the goals of the 21st Century Framework.

The strongest attribute of my thesis that was discussed during the thesis review was the design of the neighborhoods and the double height mezzanines that connect the different age development groups. The breakdown of age groups and connection of the different grade levels between floors was a strong design solution for a multi-story building. The decision to vary the learning types and environments has lead to a more comprehensive and realistic solution that takes a broader look at technology and age.

I believe that the goal for the design of the thesis was to really dive into the interior of the building and try to figure out what these different types of learning spaces would look like and how they would be arranged. The end result is still diagrammatic in a sense, but it takes a good look at what may be possible in the different age groups. The design of the connecting mezzanines and double height spaces are where the building comes alive and is the most exciting. Other questions in the discussion during the final review dealt with the overall building design and the relationship of the interior to the transparency of the skin. While there were valid points on the overall building design, this was not the focus of the thesis. The thesis design does though set up a language that can be used to solve these issues if the design were to go further. Through the process of the thesis I have gained a significant amount knowledge about the history of schools, the changes in child development, the last uses of technology in education, and the controversies that arise during the discussions of having technology in schools.

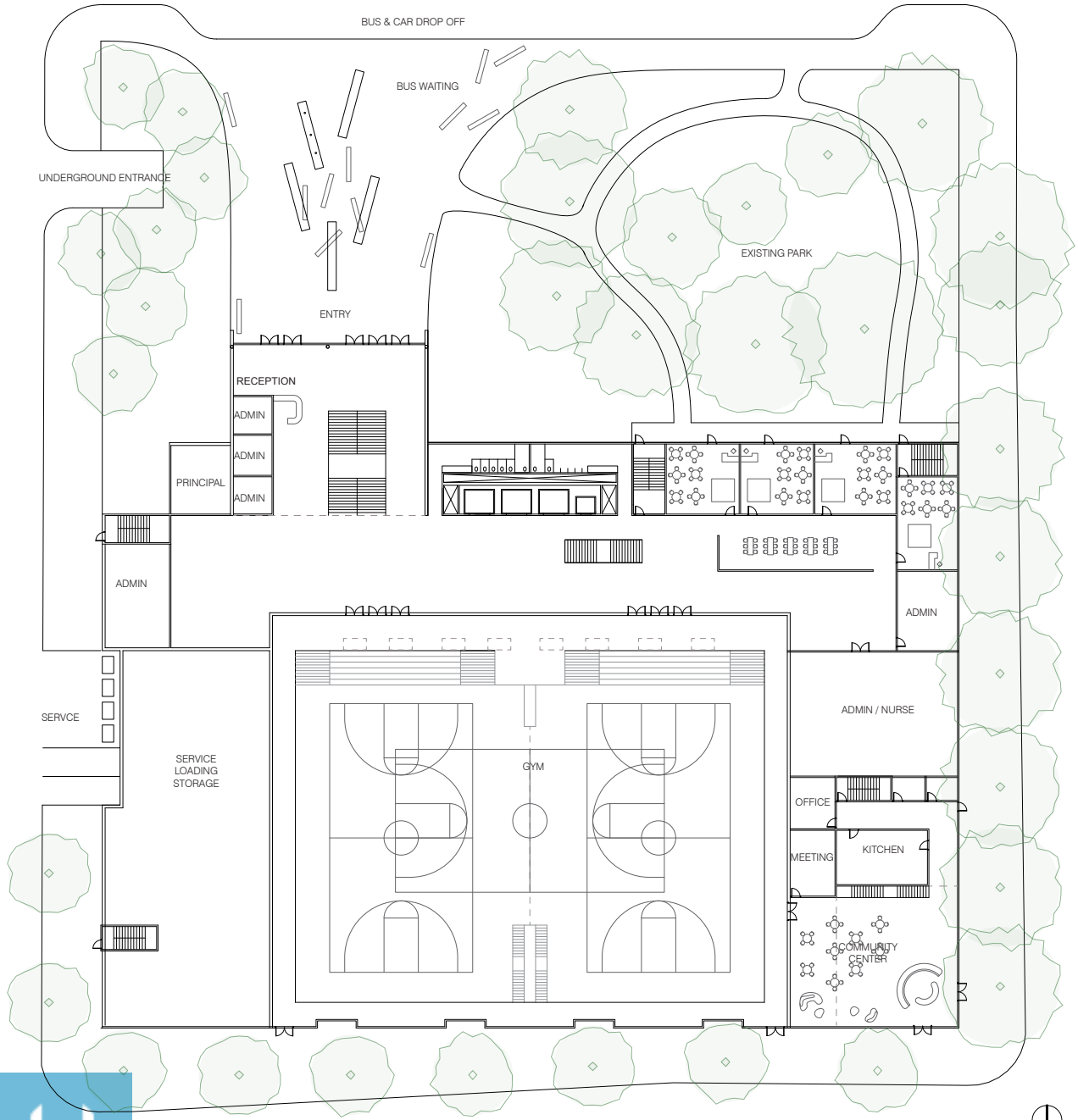
In conclusion, the learning environments designed were influenced by my findings about school history, age development, and the future of information and communication technology. The learning environment is one that has multiple types of spaces for different learning types. The age groups provide a way to explore different levels of digital integration. The resulting building design and organization is a response to these findings and site context forces such as daylighting, views, and the urban street edge. The overall building location is a response to the need of downtown Seattle's growing population and densification. In the end, information and communication technology is just a learning tool, but the effects of this tool can spread to the built environment it is used to its full potential. It is the responsibility of future architects to design for this possible potential while still designing to achieve the other goals of the 21st Century Framework.

Appendix



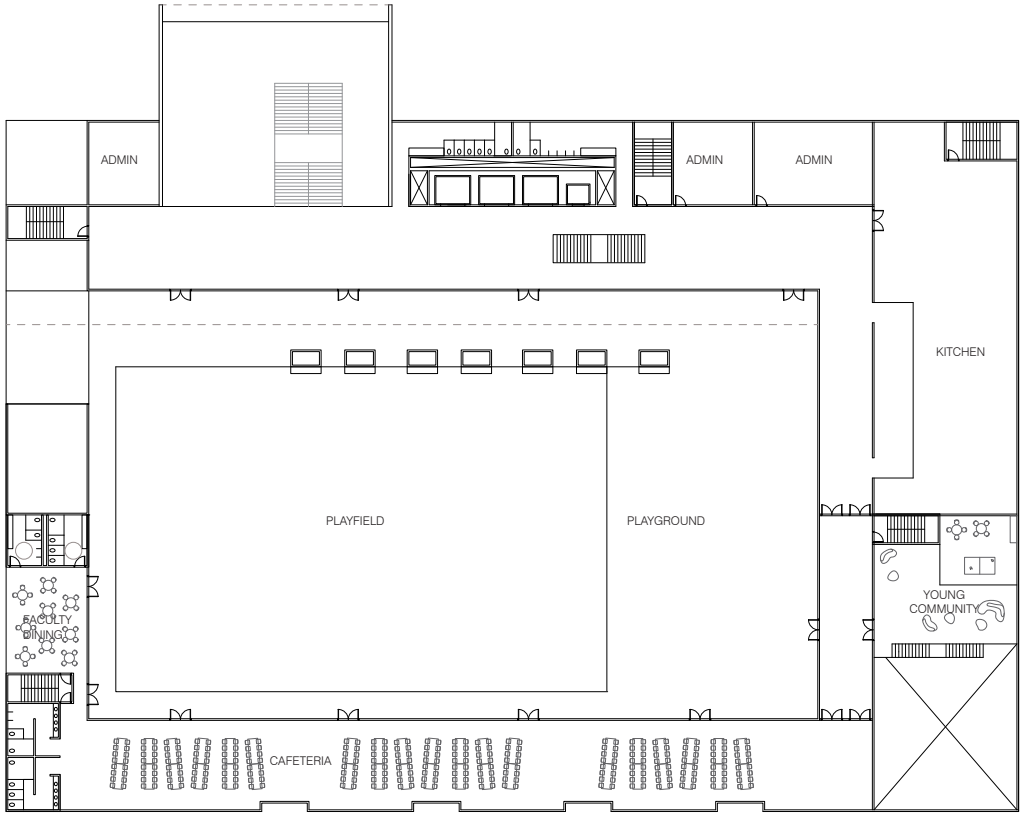
FLOOR 0 - PARKING

ENTER / CONNECT / EXERCISE



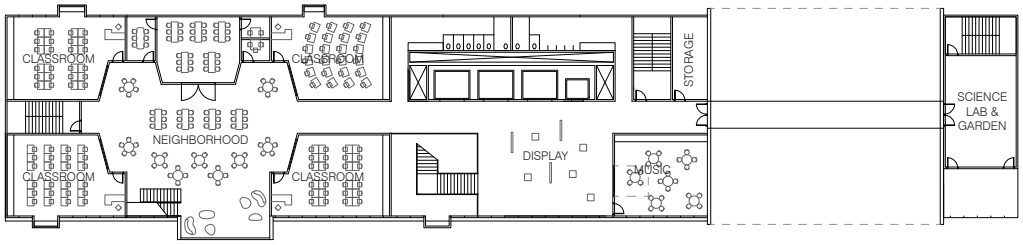
FLOOR 1 - ENTRY, KINDERGARTEN, GYM, COMMUNITY CENTER

EAT & PLAY

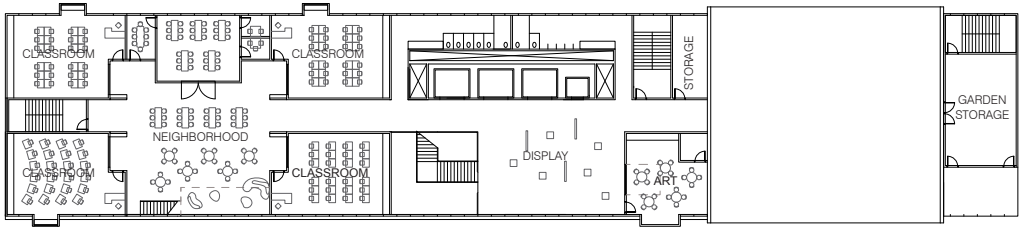


FLOOR 2 - CAFETERIA & PLAYGROUND

STARTING AGE GROUP

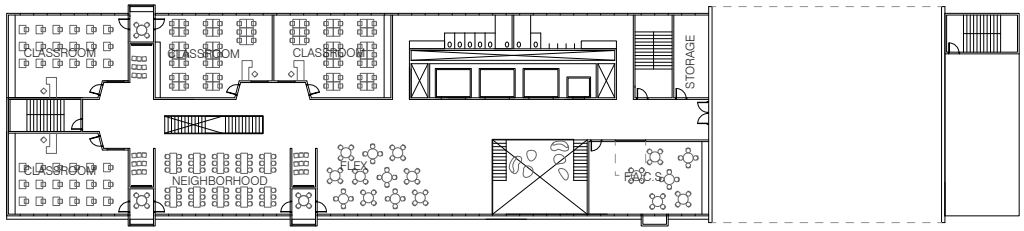


FLOOR 4 - 2ND GRADE

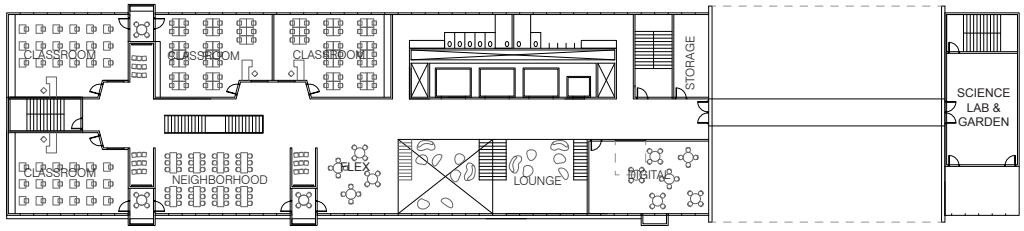


FLOOR 3 - 1ST GRADE

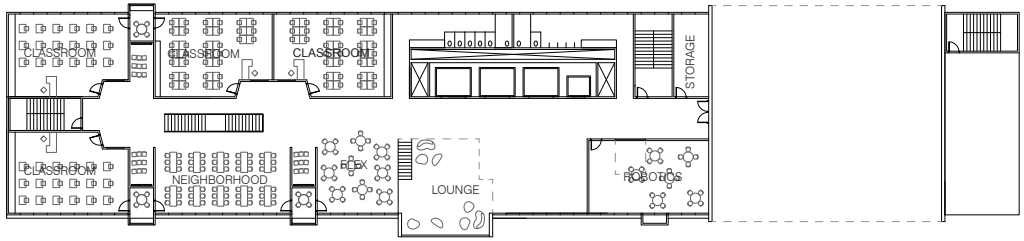
UPPER ELEMENTARY AGE GROUP



FLOOR 7 - 5TH GRADE

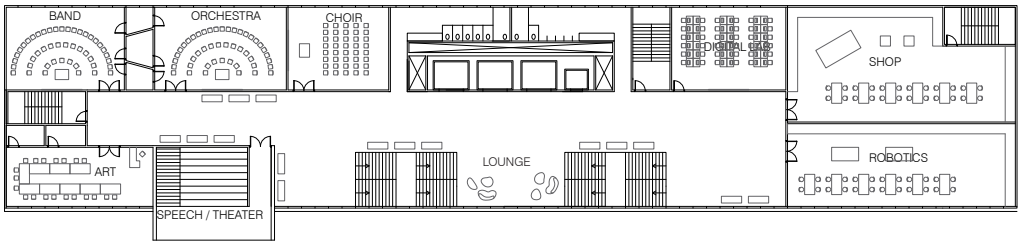


FLOOR 6 - 4TH GRADE



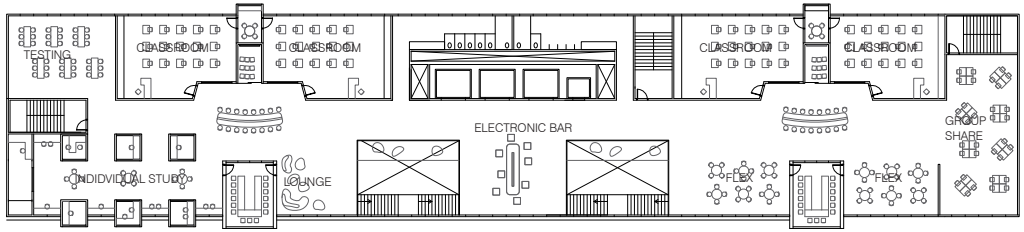
FLOOR 5 - 3RD GRADE

CREATE

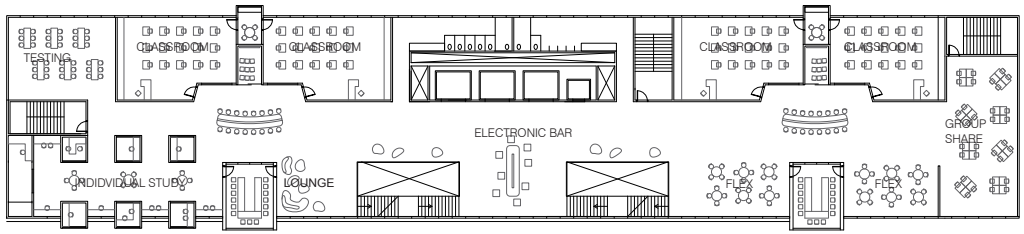


FLOOR 8 - CREATE

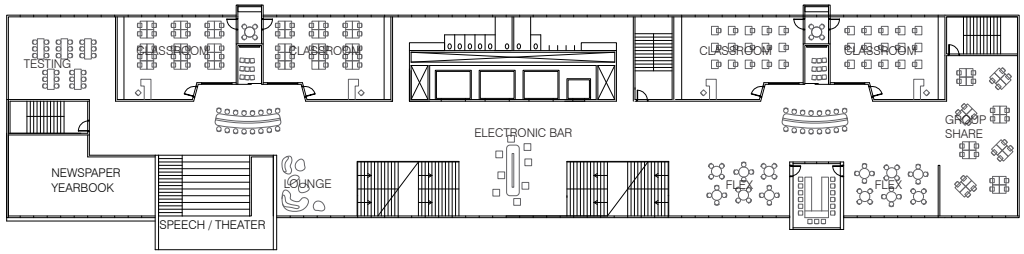
MIDDLE SCHOOL AGE GROUP



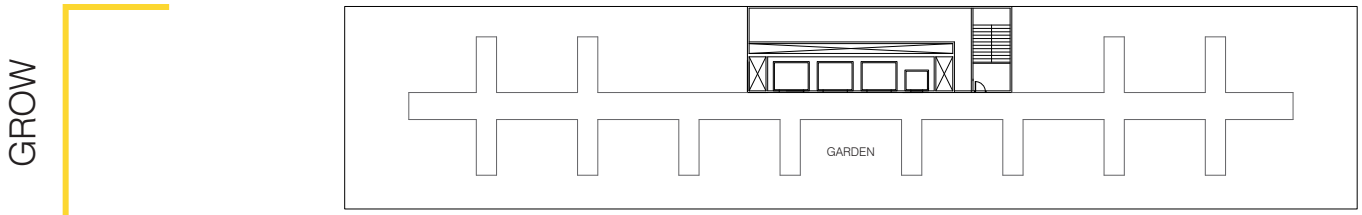
FLOOR 11 - 8TH GRADE



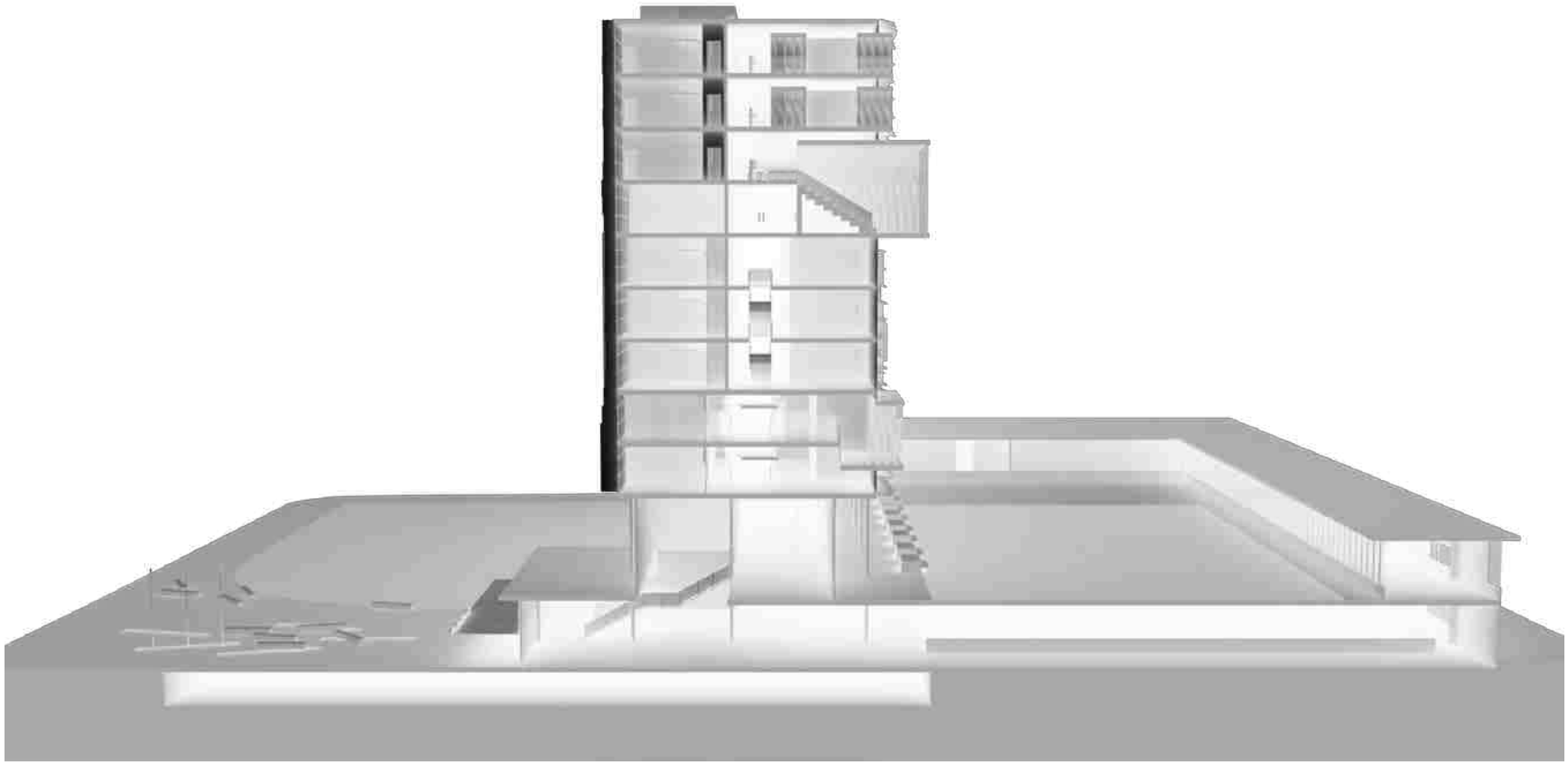
FLOOR 10 - 7TH GRADE



FLOOR 9 - 6TH GRADE



ROOF PLAN



Section

Bibliography

Benedikt, Michael. “Environmental Stoicism and Place Machismo.” *Harvard Design Magazine* Winter/ Spring.16 (2002): Print.

Elkind, David. *Child Development and Education: A Piagetian Perspective*. New York: Oxford University Press, 1976. Print.

Burke, Catherine, and Ian Grosvenor. *School*. London: Reaktion Books, 2008. Print.

Caudill, William Wayne. *Toward Better School Design*. [S.l.]: F.W. Dodge, 1954. XI. Print.

Davies, Douglas. *Child Development: A Practitioner’s Guide*. New York: Guilford Press, 2004. Print.

“Expeditionary Learning.” *Expeditionary Learning*. Outward Bound. Web. 25 Feb. 2012. <http://elschools.org/>.

Gelfand, Lisa, and Eric C. Freed. *Sustainable School Architecture: Design for Primary and Secondary Schools*. Hoboken, N.J: John Wiley & Sons, 2010. Print.

Hefling, Kimberly. “Challenge to Schools: Embracing Digital Textbooks.” *Seattlepi.com*. Associated Press, 1 Feb. 2012. Web. 25 Feb. 2012. <http://www.seattlepi.com/news/article/Challenge-to-schools-Embracing-digital-textbooks-2916164.php>.

Hille, R T. *Modern Schools: A Century of Design for Education*. Hoboken, N.J: John Wiley and Sons, 2011. Print.

Hu, Winnie. “Math That Moves: Schools Embrace the IPad.” *The New York Times*. The New York Times, 04 Jan. 2011. Web. 20 Feb. 2012. <http://www.nytimes.com/2011/01/05/education/05tablets.html?pagewanted=all>.

John, Peter D, and Steve Wheeler. *The Digital Classroom: Harnessing Technology for the Future of Learning and Teaching*. London: Routledge, 2008. Print.

Kohler, Richard. *Jean Piaget*. London: Continuum International Pub. Group, 2008. Print.

Lentz, Linda. “Leutschenbach School: Christian Kerez.” *Architecture Record* Jan. 2012: Print.

Lippman, Peter C. *Evidence-based Design of Elementary and Secondary Schools*. Hoboken, NJ: J. Wiley, 2010. Print.

LPA, Inc. *Green School Primer: Lessons in Sustainability.* Mulgrave, Vic.: Images Pub. 2009. Print.

Mäkitalo-Siegl, Kati. *Classroom of the Future: Orchestrating Collaborative Spaces*. Rotterdam: Sense, 2010.

20. 57. Print.

McGregor, Jane. “Space, Power and the Classroom.”*Forum: for Promoting 3-19 Comprehensive Education*. 46.1 (2004): 15. Print.

Montessori, Maria. *The Four Planes of Education*. Amsterdam: Association Montessori Internationale, 1971. Print.

Montessori, Maria, and Anne E. George. *The Montessori Method*. New York: Schocken Books, 1964. Print.

The New York Times Company. “Schools For Tomorrow: Bringing Technology into the Classroom.” *The New York Times SFTM White Paper* (2011). 3. Print.

“The Partnership for 21st Century Skills.” *The Partnership for 21st Century Skills*. Web. 24 Feb. 2012. <http://www.p21.org/>.

Rury, John L. *Education and Social Change: Themes in the History of American Schooling*. Mahwah, N.J: L. Erlbaum Associates, 2005. Print.

“Salman Khan: Let’s Use Video to Reinvent Education.” *TED: Ideas worth Spreading*. TED Conferences, LLC, Mar. 2011. Web. 24 Feb. 2012. <http://www.ted.com/talks/salman_khan_let_s_use_video_to_reinvent_education.html>.

The Third Teacher: 79 Ways You Can Use Design to Transform Teaching & Learning. New York: Abrams, 2010. Print.

“Skill Map and Playlist.” *School of One – Concept*. School of One. Web. 25 Feb. 2012. <http://schoolofone.org/concept_keyfeatures.html>.

USA. King County. Department of Development & Environmental Services. *King County Comprehensive Plan*. 2012 ed. Seattle: King County, 2011. Print.

Ward, Jacob. “Too Cool for A School.” *Architecture* 90.2 (2001): Print.

Zumthor, Peter. Atmospheres: Architectural Environments, Surrounding Objects. Basel: Birkhäuser, 2006. Print.