

BUILDING TOMORROW'S PRIMARY SCHOOLS TODAY:
USING FUTURES STUDIES TO DETERMINE HOW INCREASED TECHNOLOGY
USE IN EDUCATION MIGHT EFFECT CURRENT PRIMARY SCHOOL DESIGN

Eric Siwy
December 2011

Submitted towards the fulfillment of the requirements for the Doctor of Architecture degree

School of Architecture
University of Hawai'i

Doctorate Project Committee
Stephen Meder, Chairperson
James Dator
Mark Hines

**Building Tomorrow's Primary Schools Today:
Using Futures Studies to Anticipate How Increased
Technology Use in Education Might Effect Current
Primary School Design**

Eric Siwy

December 2011

"We certify that we have read this Doctorate Project and that, in our opinion,
it is satisfactory in scope and quality in partial fulfillment for the degree of
Doctor of Architecture in the School of Architecture, University of Hawai'i at Mānoa."

Chair

STEPHEN MEYER

(Print)

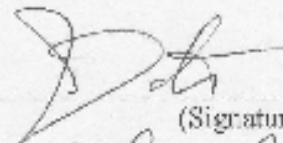


(Signature)

Member

JIM DATOR

(Print)

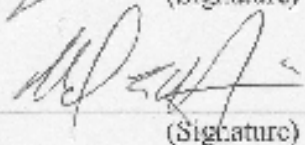


(Signature)

Member

Mark Hines

(Print)



(Signature)

TABLE OF CONTENTS

List of Figures	5
List of Tables	7
1. Abstract	8
2. Introduction.....	9
3. Education Policy in the U.S.....	15
3.1 A History.....	15
3.2 Current State of Elementary Education Policy	22
4. Primary School Design in the U.S.....	26
4.1 Beneficial Learning Environments	29
4.2 Case Studies	35
4.2A. Base Case (Typical Primary School in U.S.).....	36
4.2B. Case Study: Technology in the Classroom.....	38
4.2C. Case Study: Mixing Technology with Progressive Education	41
5. Technology in the Classroom	44
5.1 History of Use.....	46
5.2 Benefits	52
5.3 Challenges in Implementing Technology	55
5.3A. Not Understanding the Medium Being Used	56
5.3B. Infrastructure	56
5.3C. Instructor Training.....	57
5.3D. Security and Nuance.....	58
6. The Current State of Primary Schools	61

6.1	Current Trends in Technology Usage	61
6.2	Trends in Education	65
6.3	Trends in School Design.....	69
7.	Futures Studies and Assumptions	76
7.1	General Societal Considerations	78
7.1A.	Fifteen Years Out (2010-2025).....	78
7.1B.	Thirty Years Out (2025-2040).....	83
7.2	Futures Assumptions for Primary Schools	85
8.	Updated Design Trends and Representative Future Learning Spaces	91
8.1	Futures Matrix of Events and Architectural Ramifications	92
8.2	Updated Design Trends.....	96
9.	Conclusion	102
10.	Bibliography	104

LIST OF FIGURES

Figure 1: An unidentified kindergarten in Los Angeles (1900) incorporating Froebel’s ideas of gardening, geometry, and free play	17
Figure 2: Bear Creek School's single room schoolhouse (Iowa, circa 1870)	26
Figure 3: Computers in East Boston Early Education Center are pushed up against the wall with several located in a back corner near a large window which may cause glare issues	27
Figure 4: Longmeadow Center Elementary School uses appropriate furniture, proper lighting, and static-free carpets for their educational computers	27
Figure 5: Montessori School of Los Altos in Palo Alto, CA. Note the variety of spaces	31
Figure 6: “Everybody is a genius, but if you judge a fish by its ability to climb a tree, it will live its whole life believing that it is stupid” – attributed to Albert Einstein; (disputed)	32
Figure 7: It’s important to create spaces that appeal to and allow for different types of learners and learning	33
Figure 8: Students at the School of One in the Bronx check their assignment for the day on the monitors on the way in to their converted classroom	39
Figure 9: The School of One pilot used a converted library to house all 80 students. It was arranged to accommodate different modalities of learning including small groups .	39
Figure 10: Mid-Pac’s multi-modal open floor plan learning space	41
Figure 11: Several of the younger students film a dance routine while two others look on while videoediting at the Mid-Pacific Institute.....	42
Figure 12: It’s important to create spaces that appeal to users in order to encourage their use	43
Figure 13: Projected images have been aiding instruction in primary schools for over half a century.....	47
Figure 14: Image of a Plato Computer in use	49
Figure 15: A modified version of Moore’s Law as put forth by Ray Kurzweil showing a logarithmic plot of calculations per \$1,000 over the 20th century	50
Figure 16: A young girl using an interactive white board	51

Figure 17: An exchange from a Facebook wall showing a teacher’s disciplinary action followed by parental response occurring almost in real time	59
Figure 18: Compare/contrast classrooms in operation 71 years apart; not much of a difference	63
Figure 19: Computer Lab at the Hawaii Technology Academy	68
Figure 20: Kindergarten classroom at the Hawaii Technology Academy	68
Figure 21: Overcrowded classrooms have become the norm due to budget cuts	72
Figure 22: Young students gather around a tablet to learn using educational apps.....	74
Figure 23: Possible futures abound, but this project will attempt to outline a plausible future and not just a preferred scenario.....	77
Figure 24: French Artist Villemard’s 1910 depiction of the year 2000.....	85
Figure 25: Daniel Gantenbein Winery	87
Figure 26: Ecopod self-organizing tower competition entry by Howeler + Yoon	88
Figure 27: A man paints using a robotic arm controlled by his mind.....	89
Figure 28: A student learns their numbers tracing on an iPad	100

LIST OF TABLES

Table 1: Multiple Intelligences as they relate to school spaces	35
Table 2: Internet Access in U.S. Public Schools and Classrooms	51
Table 3: Worldwide IWB usage per segment	52
Table 4: Projected carbon emissions for commercial buildings alongside	79

1. ABSTRACT

Technology is ubiquitous in today's society and has been slowly working its way in to classrooms and educational facilities for over half a century. Over the last 10-15 years the rate at which the internet, computers, and other tools have been used for educational purposes in the classroom has increased (though still not at the rate many suspected it would). Unfortunately, the majority of existing primary schools and even "schools of the future" that do attempt to incorporate solutions for technological use generally optimize the building for today's already widespread technology. The average primary school is expected to last for forty years. A school built today still needs to be effective and functional as it approaches the world of 2050. Given the current rate of technological change this is too short-sighted.

While education theorists have given quite a bit of thought as to how technology might improve a child's ability to learn, there seems to be a lack of literature on how future technology may affect the requirements of a school building or even allow the building itself to aid in instruction. Much of the research dealing with technology in education also seems to be coming from educators and less so from futurists. This is important as educators seem less confident in making predictions about technology and its effect the farther they look in to the future.

This project is two-fold: 1) use a Futures Studies lens to lay out the path of governance, economics, environment, culture, and technology over the next forty years time to forecast a future scenario that makes clear how technology is likely to influence education, and 2) show how those pedagogical changes substantially alter the architectural design requirements from the current norm over the course of a school building's lifespan.

In order to maximize a school building's effectiveness over time, architects should be well-versed in current and projected trends in education and technology; this will also minimize costly retrofits or additions. The goal of this project is not visioning or backcasting in order to bring about a preferred future by changing the present, but merely to consider what steps designers should be taking in current primary school design to account for these anticipated trends. Based on a historical analysis, a brief review of current design guidelines, and case studies, this project shows that current primary school architecture fails to take in to account the concurrent plausible scenarios of rapid advances in technology, its continued introduction in to the classroom, and how to best plan for that assuming a resource-constrained future society using a new set of revised design trends.

2. INTRODUCTION

Technology will likely never be the panacea for the educational system that its proponents believe it is, but few would argue that it will play a much larger role as a tool in educating the nation's children in the near future. The No Child Left Behind Act of 2001 explicitly states that a goal of U.S. education is to ensure "that every student is technologically literate by the time the student finishes eighth grade". This emphasis on technology has brought with it new requirements for instructional spaces including increased energy usage and wiring, along with storage, reliability, and security concerns that didn't exist before. Dealing with sophisticated screen technologies has also increased awareness of and changed requirements for lighting, air quality, and temperature controls. These and other concerns are just beginning to be taken in to account in school design, but the requirements specific to technology is only part of the picture. Technology is changing how students are educated and what they are being taught. New subjects and new methods of learning will alter overall programmatic requirements as well as classroom layout, materials, and furniture.

There exists now quite a bit of evidence to suggest that current educational theory and school design is moving away from the model of one certified teacher lecturing at the front of a fixed-size classroom along a double-loaded corridor (single-loaded in some warmer climates). Trends also show technology will likely be integrated into collaborative, open-space learning zones, outdoor areas, and even the architectural components and systems themselves. New technologies and learning devices such as computers, smart boards, laptops, tablets, mobile devices, as well as those yet to be invented will bring their own set of spatial, tactile, acoustical, programmatic, and infrastructural requirements.

Technology, and more specifically computer technology, has permeated every facet of society from cars down to children's toys and greetings cards. Something as revolutionary as having all of recorded human history along with real-time global information beamed down by satellites in space upon request to a device that fits in one's front pocket is seen as perfectly normal in most developed countries. This would probably have been seen as amazing or even science fiction to most people no more than fifteen years ago. For today's youth smart phones are their baseline. What will be the "amazing" technology in fifteen years? How might it translate to a classroom of 2025, or even 2040? "Future" technologies like augmented reality, cloning, anti-gravitational technologies, re-growing body parts, cybernetics, etc. already exist in some pre-natal form today helping designers and futurists to get a glimpse of what might be. Technology has also advanced to or near a point where it can aid not only in the three R's, but in socialization, emotional development, motor skills, and other characteristics of a

successful early childhood education as laid out by child development and educational theorists.

Since much of an architectural design is responding to contextual cues it's important for a designer to understand the place and time of the planned building as best they can. This of course becomes more difficult when the "time" being looked at is up to forty years in to the future; however, this should still be an essential part of all architectural design (or at least the vast majority that's intended to last more than a temporary exhibition). The document will allow an architect, and to a lesser extent an educator, to plan better when designing primary schools in the United States with regards to the future of technology in the classroom. Designing a building for today's conditions results in a building that is potentially outdated by the time it's finished being constructed. To a certain extent this can't be avoided as humans cannot know the future. It is possible, however, to make educated guesses about likely possibilities by identifying trends and patterns, running predictive models, and even taking actions that would help to lead events in a particular desired direction and then designing for those outcomes.

Given how commonplace technology has become (the average household as of 2003 had 60+ microprocessors in it, with each car in the driveway/garage having at least an equal number more¹), it's easy to imagine future advances in technology playing a substantial role in a classroom. In fact, it's already happening. According to the National Center for Education Statistics the percentage of instructional rooms in public schools with access to the internet rose from 51 percent in 1998 to 93 percent in 2003 with nearly all schools having access to the internet in some form since 2003 (though penetration rates in to every classroom still remain low in some districts). To remind the reader how rapidly technology changes, while relatively recent, the above statistic was taken in 2003 when Netscape and AOL were popular and before Facebook (2004), YouTube (2005), or Twitter (2006) even existed. Despite its popularity and innovativeness, the social networking service MySpace, which came out in 2003, is already defunct and replaced by a newer better version in the form of Facebook. Facebook is used by over half a billion people worldwide and is currently seen as worth hundreds of billions of dollars and untouchable among social networking sites, but anyone who believes it won't look completely different or have been replaced in five years hasn't been paying attention to history.

Given how quickly technology has invaded personal and social contexts over the past decade with the aforementioned websites and mobile devices it can also be surmised that the adoption rates of computers and other information and communications technology

¹ "Embedded: It's a Way of Life" 5, no. 1 (2003),
<http://www.nd.edu/~engineer/publications/signatures/2003/wayoflife.html>.

(ICT) in the classroom will follow suit. However, technology's inexorable growth and adoption rates do not guarantee successful use or applicability to the primary school environment. In order for this increased usage to be effective it requires an informed school district administration, teachers that are prepared and trained for it, a sufficient budget, and the purview of this paper: facilities conducive to such a change.

The Committee on Education and Labor in the U.S. House of Representatives convened a panel on June 16, 2009 entitled "The Future of Learning: How Technology is Transforming Public Schools". The Chairman of that panel, Representative George Miller (CA) stated "discovery and innovation are really the only sustainable sources of economic growth in the world today", but "this does not sound like what we are preparing today's kindergarten students to participate 16 years from now or even 12 years from now. This is not today's education system in America."²

The government and countless other scholars recognize the value of introducing technology in to the classroom in a major way. The United States is no longer an industrial society, but an information-based society. President Obama even recently appointed the nation's first Chief Technology Officer.

In order to hope to understand possible futures it's necessary to better understand how the present condition came to be. Consequently, it will be important to understand the driving factors of modern education beginning in the mid-19th century with the common school era and the introduction of compulsory taxpayer-funded education. By the early 20th century nearly all states had instituted similar compulsory programs as the United States transitioned out of an agrarian society. Today all fifty states have required primary education for their residents, though the start age ranges from 5 to 8.

During that time schoolhouses have gone from single room mixed-grade classrooms with one teacher serving tens of children to multi-million dollar buildings often with upwards of several thousand students. In part this is due to population increases, but also due to a newfound appreciation of school administration and boards of education touted by educator Ellwood Cubberley around the turn of the 20th century. Schools and school districts were then consolidated with a movement in the 1960s in order to save on infrastructure costs. This has led to overcrowding and large expenditures required for any new schools or renovations to be considered. Being that school districts are funded by taxpayer dollars (mostly at the state level), they're subject to political whims and budget cuts. In that regard technology expenditures will be affected in so far as everything else is, but according to surveys conducted by Education Week in the late 90s "Americans overwhelmingly understand that technology can play a vital role in education." And 85 percent of those surveyed believed schools with technology have "a major advantage

² "United States. Future of Learning: How Technology is Transforming Public Schools", n.d.

over schools that are poorly equipped.”³ This brings with it funding, but technology can be expensive if not done carefully and with forethought. Schools must better understand its uses and weigh the pros and cons of different types as well as what is potentially being replaced as a result (often the arts and other similar “non-essential” programs). If technology is better understood and schools are designed to maximize the use and benefits of the tools selected than students can learn how to play piano on a tablet PC in the same space they just learned math with only minor changes and little additional cost.

In the pre-Common School era the single room schoolhouses had very little in the way of books or equipment to teach students, and technology was all but non-existent, except for maybe an abacus.⁴ Today’s situation is very different. Even in the poorest school district one can find radios, televisions, overhead projectors, and public address systems (though maybe not as many as that district would like). In a society where even the homeless find it essential to have email addresses and cell phones (a story in the *The Washington Post* from 2009 estimated 30-45 percent of the homeless population in Washington, D.C. at the time had cell phones), increased technology in school systems is inevitable. This can further be seen by the prevalence of computer use outside the classroom. Not surprisingly there has been a lot of discussion on how technology can and should be integrated in to primary school education. Technology is already fundamentally changing how students learn at every level. In his book *Digital Natives, Digital Immigrants*, Marc Prensky talks about the neuroplasticity of the brain and how the more children interact with technology (or anything for that matter), the more they’re re-wiring their brains.⁵ This creates a brand new set of programmatic and spatial requirements and accompanying challenges for primary school design. It is in this area that the current literature is lacking. Current “schools of the future” have had varying levels of success creating schools that have fully integrated technology in to the classroom, curriculum, and building versus simply purchasing cutting-edge technology. The School of the Future in which Microsoft collaborated with the City of Philadelphia seems to have done the latter well. It is a high school, but still relevant as an example. The formats of schools are changing as well with blended learning (a mix of online and on-site also referred to as a hybrid model) becoming more prevalent as well. Other schools that will be looked at with regards to technology use include Hawaii Technology Academy and Mid-Pacific Institute both here on Oahu and the experimental School of One program implemented in a few middle schools in New York City. A representative “average” school will also be reviewed. Renowned Futurist Alvin Toffler discusses recent history in terms of waves and in his

³ A. Loveless and B. Dore, *ICT in the primary school* (Open University Press, 2002), 7, <http://books.google.com/books?id=astqQgAACAAJ>.

⁴ "The Common School." *SCHOOL: The Story of American Public Education*. PBS: 03 Sep 2001. Television. 7 Feb 2011

⁵ M. Prensky, *Teaching digital natives: partnering for real learning* (Corwin, 2010), <http://books.google.com/books?id=BOv6iFWTEAYC>.

landmark book *Future Shock* from 1970, he lays them out as the First Wave (agrarian society), the Second Wave (industrial society), and the Third Wave (post-industrial or information age society).⁶

The aforementioned congressional hearing as well as Mark Dudek (*Kindergarten Architecture*), Milton Chen (*Education Nation*), and other education theorists would (rightfully) argue that the United States is operating industrial age school buildings on an agrarian schedule for children who are living in a new information age. This problem will not be news to anyone in the field of education and probably not to anyone that deals with the architecture of educational facilities on a regular basis. What might come as a surprise is how quickly technology may alter this landscape in the next decade or so whether those in charge want it or not. Modernizing schools to more accurately reflect today's learning landscape is commendable since too few are doing it, but will just lead to the same issues thirty years down the road if designers don't realize that the year 2040 will see children in the recently coined "dream age" having to learn in then outdated information age buildings.

Technology changes so rapidly it will be near impossible to accurately predict where it will be fifty years from now. However, if Moore's Law and the current rate of technological change are understood, believed, and drawn out to logical conclusions, then Ray Kurzweil's concept of the technological singularity, or the point at which computing power and intelligence of a machine becomes equivalent to the human brain, might only be 10-20 years away. There's not surprisingly some debate over the implications of the above and on human-level artificial intelligence in general, but by looking at current cutting-edge technology with regards to learning (human and artificial), healthcare, cognitive functions, cybernetics, and architecture among other things it's not absurd to discuss the possibility of a majority of students not even being physically present when learning and interacting with others at whatever it is the schoolhouse becomes. In fact, thirty-nine different states already offer some form of online public school learning. This also leads to a greater point, that regardless of specific technology, students, educators, and the buildings they inhabit will need to be able to adapt to and with rapidly changing technology or else schools will cease being the most important place for learning.

The skills of the future (and some like David Whitebread⁷ and Milton Chen⁸ would argue, the present) will deal less with rote memorization and more about the application of knowledge and an ability to adapt quickly to new technologies. Toffler has stated that:

⁶ A. Toffler, *Future shock* (Bantam, 1971), http://books.google.com/books?id=D_o1SwAACA AJ.

⁷ D. Whitebread, *The psychology of teaching and learning in the primary school* (Routledge/Falmer, 2000), http://books.google.com/books?id=MUKPkT_VPjYC.

⁸ Sara Armstrong and George Lucas Educational Foundation., *Edutopia : success stories for learning in the digital age*, 1st ed. (San Francisco CA: Jossey-Bass, 2002).

"The illiterate of the 21st Century will not be those who cannot read or write, but those who cannot learn, unlearn and relearn."⁹ Technology moves fast, and the ability to adapt to new technology on almost a daily basis will serve a primary school educator well.

Technology is working its way in to the classroom, but if it's to be successfully integrated over the short and long-term then it will be important to analyze the rate of adoption and more importantly ensure the primary school building and classroom is able to adapt. An intelligent building will be able to monitor and adjust visual and thermal comfort, indoor air quality, maintain optimal acoustic levels, and adjust all sorts of other variables previously shown to be optimal for young children to learn. Those things can also be used as teachable moments if students are able to interact with that environment digitally.

Superintendents that spent a lot of money building a wired school in the late nineties were disappointed only five years later if they hadn't also planned for wireless technology. More important than an educator's being disappointed, however, is that their decision hampered options available to the educators in that building. Now consider a future classroom that will be able to reconfigure walls, seating, light levels on the fly based on subject matter, number of students, and teacher/student desire. Students who'd like to go off on their own to read can be viewed safely from a distance with technology monitoring progress, page turns, and even retinal movement without disturbing the child's perceived autonomy. It's clear this will require forethought to minimize future inconveniences and costs. It should be noted, the above example may imply somewhat of a big brother concept, but whether a building is paternalistic is more a reflection of that school's values than of the technology.

The goal of this project is to make it more apparent to end-users and administrators how technology will allow the school building to be better utilized as a tool for both education and educating. School districts that fail to plan ahead and take in to account the characteristics of possible programmatic requirements these new technological advances and environmental constraints might have on a primary school are doing a disservice to the tens of thousands of young students that will teleport through its walls over the years.

⁹ Alvin Toffler, "alvin + heidi toffler {futurists} :: Gallery," *alvin + heidi toffler {futurists}*, 2011, <http://www.alvintoffler.net/?fa=galleryquotes>.

3. EDUCATION POLICY IN THE U.S.

3.1 A HISTORY

What we think of as modern public education began in the mid-19th century with Horace Mann of Massachusetts leading his state to become the first to implement compulsory taxpayer-funded education for all of its young (white) residents in 1852.

Thomas Jefferson and others had advocated for public education for all of the country's citizens (which at the time meant excluding African-Americans) after the United States of America had won its independence roughly $\frac{3}{4}$ of a century earlier, but it wasn't until Mann, a former Secretary of the Massachusetts State Board of Education as well as a former Congressman implemented the idea in Massachusetts that things really began to move.

In addition to implementing state-wide required public education Mann also increased the school year to 6 months, increased the quality of the buildings, and instituted formal training for teachers. Prior to this movement, dubbed the Common School Movement classes were taught only a couple of months out of the year by a young woman, usually unmarried, with no formal training, and most often in a one room school house built and furnished by the students' parents. The short school year, sometimes lasting as little as a few weeks¹⁰, was due mainly to agricultural seasons and children having to work the fields as the crops demanded.

Not everyone at the time agreed that public education for all children was a necessary or even worthwhile use of taxpayer dollars. Education had to this point been the purview of the wealthy. It should be noted that the first private schools in the United States had been around for over two hundred years at this point; Harvard University was founded in 1636. Formal education was not unheard of even for young children, but it was expensive and localized, and therefore not accessible to the average citizen. However, in a true democracy where every citizen's voice is equal, the idea was that an educated populace leads to better decisions and more nationalism. Compulsory education also ensured all immigrants got a primer on the United States and the benefits of democracy. This was an effort to continue a nation that minimized major class divisions by providing the equal footing of a common education.

¹⁰ "The Common School." *SCHOOL: The Story of American Public Education*. PBS: 03 Sep 2001. Television. 7 Feb 2011 "The Design of Learning Spaces [Book]", n.d., http://www.google.com/products/catalog?hl=en&safe=off&q=design+of+learning+spaces&um=1&biw=972&bih=652&bav=on.2,or.r_gc.r_pw.&ie=UTF-8&cid=13496626396402408949&sa=X&ei=DYCXtaz0J4S0sQPtloDdBQ&ved=0CFoQ8wIwAA#.

The changes implemented by Mann spread quickly across the country in the late 19th century. There were a number of contributing factors including rapid industrialization over agriculture, a large influx of several million immigrant children, and child labor laws that prevented those below a certain age from working. By 1918 all American citizens were required to attend Elementary School. These are laws that stand to this day though the exact age requirements vary by state. Pennsylvania and Washington don't require mandatory school attendance until the age of 8; the other states start ages are between 5 and 7. All fifty states provide Kindergarten classes that are widely attended even when not required.

It was just before the Civil War in 1860 that the first English-speaking kindergarten in the United States was founded in Boston based on the teachings of the German theorist Friedrich Froebel (the person who coined the term kindergarten). Froebel wrote that the role of education was to direct the formation of the mind from “one-sidedness, individuality and incompleteness” toward “all-sidedness, harmony and completeness” through an understanding of the “mathematically generated logic underlying the ebb and flow of creation”.¹¹ He used a combination of physical and mental activities such as dancing, gardening, and playing with a set of educational toys in order for children to involve all of their senses. He stressed the need to learn by doing something with purpose as opposed to simply listening to external facts in a lecture format. As an aside, some of the finest architects of the last century, Buckminster Fuller, Frank Lloyd Wright, and Le Corbusier, were all educated with the Froebel method and that is reflected in the Bauhaus movement.¹² These ideas of free play, exposure to nature, and the use of educational toys to encourage experimentation and pre-reasoning perceptions are echoed by other theorists later on including Maria Montessori.

Froebel believed early childhood education should allow a child to bloom and grow ('kinder garten' literally means child's garden in German). The goal of making the learning environment a sensorial place is one area where architecture and technology can coincide nicely with child development and education theorists. Learning is an experiential process and the environment (the “third teacher” behind parents/educators and peers – as outlined in the book of the same name) plays a critical and often overlooked role.

¹¹ “The Institute For Figuring // Exhibition:INVENTING KINDERGARTEN,” *The Institute for Figuring*, n.d., <http://theiff.org/oexhibits/kindy01.html>.

¹² M. Dudek, *Kindergarten architecture: space for the imagination* (Spon Press, 2000), 58, <http://books.google.com/books?id=PgX0Sr52MRoC>.



Figure 1: An unidentified kindergarten in Los Angeles (1900) incorporating Froebel's ideas of gardening, geometry, and free play¹³

Noted American education theorist John Dewey was influenced by Froebel's focus on the child's experience. Dewey came to prominence around the turn of the 20th century stressing that one of the goals of early childhood education is to help students realize their full potential. He believed education should not simply be rote memorization, but learning how to think and live and interact with others in a socially-conscious way. He along with Froebel would be considered adherents to what well-known child development theorist Jean Piaget would later coin as Constructivism. Constructivists believe that it's the interaction between direct experience and one's ideas where knowledge-making occurs. This has become a popular theory among education reformers and teachers over the years undergoing several ups-and-downs in the last century, and it is currently experiencing a resurgence of interest. This popularity has not led to widespread adoption; however, as administrators must balance what is best for each child with what is best for all children due to resource constraints. Constructivism and the individual attention it requires taxes even the best funded school districts. One of the reasons for its current resurgence is the view that technology can play a role in assisting teachers by formulating and providing content for individualized learning. Further evidence of this will be presented later in the TECHNOLOGY IN THE CLASSROOM section.

¹³ "The Institute For Figuring // Exhibition:INVENTING KINDERGARTEN."

Between Froebel, Mann and the present day there have been major changes to education administration most notably with the industrial management theory of Ellwood Cubberley in the early 20th century to integration and the Elementary and Secondary Education Act of the 1960s.

Cubberley is a bit of a controversial figure now as many of his views were overly paternalistic and regarded education as a way of social engineering. He's quoted as saying: "We should give up the exceedingly democratic idea that all are equal and that our society is devoid of classes. The employee tends to remain an employee; the wage earner tends to remain a wage earner... One bright child may easily be worth more to the National Life than thousands of those of low mentality."¹⁴ Comparing this to the idea that no child should be left behind it's clear why many object to his views in the present (though many would argue the No Child Left Behind Act [NCLB] doesn't live up to its name), but at the time the administration of schools hadn't really been formalized. Mann had tackled teacher training, but administrators still learned on the job. Cubberley used statistical and quantitative means through surveying to assess each schools strengths and weaknesses (that part sounds more like NCLB). Thus began the next century of teachers and education theorists battling with administrators and politicians over accountability, budgets, and curriculum.

In 1939, J.S. Brubacher wrote *Modern Philosophies of Education* and outlined well the differences between progressive and traditional education scholars. These distinctions and even the terminology remain largely relevant today. The below information taken from that book via Delecató's *Elementary School of the Future* lists characteristics of each along with the educator who was most focused on each point.

PROGRESSIVE EDUCATION

Characteristics of Pupil

Freedom
 Independent Thinking
 Initiative
 Self-reliance
 Interest, urges and needs
 Social orientation
 Social organization and shared experience
 Problem Solving
 Activity
 Individuality

Educators

John Dewey
 Boyd Bode
 W.H. Kilpatrick
 Carleton Washburne
 Ralph Tyler
 Carson Ryan
 Lester Dix
 James Tippet
 Caroline Zachry
 E.L. Thorndike

¹⁴ Petula Dvorak, "D.C. Homeless People Use Cellphones, Blogs and E-Mail to Stay on Top of Things," *The Washington Post*, March 23, 2009, <http://www.washingtonpost.com/wp-dyn/content/article/2009/03/22/AR2009032201835.html?sid=ST2009032300833>.

Self-expression	Harold Rugg
Purposeful learning	George Counts
Connection with normal life outside school	Murray and Doris Lee
	Alice Keliher
	Harold Hand

Characteristics of Theory

Guidance of the child
 Development of the “whole” child
 Democratic sharing between pupil and teacher
 Individual differences
 Change and novelty
 No final or fixed values in advance
 Constant revisions of aims
 Experimental techniques of learning and teaching
 Education as reconstructor of Society

TRADITIONAL EDUCATION

Characteristics of Pupil

Freedom as a social privilege
 Freedom as an outcome,
 not as a means of education
 Discipline as needed in life
 Learning as a realization, not a creation
 Initiative as self-disciplining activity
 Interests as a part of law and order
 in the universe
 Intellectual development
 Learning for future use
 Gap between school life and the outside world

Educators

W.C. Bagley
 H.H. Horne
 M. Demiashkevich
 T.H. Briggs
 H.C. Morrison
 Franklin Bobbitt

Characteristics of Theory

Education as eternal striving for the perfect or absolute
 Training of the child for adaptation to the mores of society
 Certain fixed educational values
 Set curriculum
 Minimum essentials which all must learn, such as the
 classics in literature, mathematics, history, and science
 Education as conformity to the laws of the universe
 Education as creature, not creator of society
 Education as the process of transmission of the heritage and

culture of the race¹⁵

The above breakdown of traditional and progressive is over 70 years old, but interestingly enough much of the represented philosophical divide over how to educate still holds true today. What has changed over the years is which of the above bullets has been prescribed for children's education at a given point in time. In general, school administrators have leaned towards the more traditional approach as fixed answers and absolutes allow for an easier quantification of the success of learning. Educators and theorists tend toward the more individualized Progressive education where learning isn't as easy to quantify, but involves a more nuanced interaction between the teacher and each student. Much of the debate may stem from whether one views education and teaching as more art or science.

Even those districts that maintained a more traditional approach couldn't fully escape the ideas of Dewey. According to a *Time* magazine article in 1938, by that point Progressivism "had touched every school in the U.S."¹⁶. After World War II the feedback from the military was that the average student that had joined the armed forces was well-versed in math and civics, but lacked an inquiring mind. This further called in to question the Traditionalist view at the time. In response, more school districts began to incorporate the teachings of Dewey and the Progressive movement, however, most schools still continued along the same traditional/conservative approach ignoring (or not aware of) this feedback. The military's influence was only a slight bump and Dewey's influence in schools declined post-World War II with a minor resurgence in the 1960s (and now again in the present day).

It shouldn't come as much of a surprise that given the climate and culture surrounding the Vietnam War and social change in the 1960s, educators and society at large rebelled against the paternalistic and bureaucratic views of Cubberley's conservative industrial management style while touting Dewey's child-centered view that stressed exploration and experiential learning. This resurgence as well, however, was short-lived.

The Elementary and Secondary Education Act of 1965 provided additional funds for primary and secondary education while maintaining that each individual state would retain control over curriculum decisions, though the state and federal government's role was increased. That increase of state and federal power consequently increased a demand for accountability from local school boards while simultaneously reducing their autonomy and power to act. This model remains intact in the United States today.

¹⁵ Carl H. Delacato, Ed.D, *The Elementary School of the Future: A Guide for Parents*, 1st ed. (Springfield, IL: Charles C Thomas, 1965), 4.

¹⁶ L. Cuban, *Teachers and machines: the classroom use of technology since 1920* (Teachers College Press, 1986), 11, <http://books.google.com/books?id=uQeEn1vEUSQC>.

The No Child Left Act (NCLB) of 2001 (a reauthorization of the Elementary and Secondary Education Act) was signed in to law in January 2002. It put a renewed focus on standardized testing and an acquisition of specific knowledge and skills. That aspect has been called in to question recently and President Obama has pledged to revise the current law. One aspect that has been carried over by the Obama administration is tying funding to results. In this age of extremely tight state and local budgets it has given the federal government an influence over curriculum disproportionate to the percentage of funding.

Separately, the Act also put a large emphasis on technology integration in classrooms. It encourages schools to build up a technology infrastructure that includes library media centers, classrooms, and administrative offices. Section 2404(b)(2)(B) explicitly lists one of the goals of NCLB as assisting “every student in crossing the digital divide by ensuring that every student is technologically literate by the time the student finishes the eighth grade, regardless of the student's race, ethnicity, gender, family income, geographic location, or disability.”¹⁷ To that end, NCLB encourages parental involvement and provides training to parents as well as electronic access to their child’s student data. It also encourages technology-focused and project-based programs such as the JASON Project, the Global Grocery List, and ePals Classroom Exchange.

There are many theorists over the years that have had a profound impact on education theory in the U.S. today. Two major ones that will be addressed here are Maria Montessori and Rudolph Steiner. They’re two that, in terms of actual pedagogy being practiced in schools today, have been the most successful at implementing their vision. How that pedagogy has been reflected in the built structure will be discussed later.

Others like Friedrich Froebel and Dewey who have already been discussed have a renewed following and have come back in to style more recently as current theorists begin espousing similar beliefs (often times in Montessori schools or Steiner’s Waldorf schools). Today’s emphasis on these ideas can in large part be connected to technology and the hope that it can finally be used to implement some of the personalized learning and flexibility that Progressivists have been trying to implement for years, but have been unable to fund; whether this is likely or even possible will also be looked at later.

Many aspects of modern day education, including an agricultural schedule and industrial buildings, are outdated for today’s world. Part of planning for the future is to understand the points of contention and likely trends moving forward. Anticipating decisions on charter schools, vouchers, online learning, the use of community spaces like gyms and auditoriums, what will happen to libraries as eBooks emerge, longer school days/years,

¹⁷ *United States. No Child Left Behind Act of 2001. Washington,,: Government Printing Office, 2001. Web. Jan 29, 2011., 2002.*

and estimated funding levels for American elementary education in general is crucial to understanding how schools should be designed today.

3.2 CURRENT STATE OF ELEMENTARY EDUCATION POLICY

The No Child Left Behind Act (NCLB), and its focus on standardized testing, has largely been seen as unsuccessful by the educational community, especially the educators themselves. Teachers are forced to “teach to the test” necessitating many other subjects and activities to be eliminated in an effort to improve test scores to ensure continued Federal funding.

Hawaii Schools Superintendent Kathryn Matayoshi has stated NCLB was unreasonable from the start: "No state was expected to meet the requirements of No Child Left Behind; the act required **100 percent of students** to be proficient in reading and math at the levels designated,"¹⁸ [emphasis added]

Ironically, as time spent studying for the test increases and other activities get dropped, students become less able to focus. Studies have shown that students able to move and engage in physical activity several times a week performed better on tests than their sedentary counterparts. Other subjects that aren't math or English haven't fared well either as 71% of schools report a reduction in history, arts, language and music since 2007.

Accountability is necessary, but the improved test scores in core disciplines such as math, reading, language arts, and science have not followed. Those states that have shown improvement according to the NCLB standards aren't necessarily proving anything since states are able to decide their own metric for “success”. Many states have admitted to simply lowering the bar in order to improve results, and thirty-one states have set their 4th grade reading proficiency standard lower than the basic level determined by the NAEP.¹⁹ A 2007 study by the National Center for Education Statistics (NCES) found that “there is a strong negative correlation between the proportions of students meeting the states’ proficiency standards and the NAEP [National Assessment of Education Progress] score equivalents to those standards, suggesting that the observed heterogeneity in states’

¹⁸ Paul Drewes, “Hawaii Could Set Benchmarks In Education - Local News - Honolulu, HI - msnbc.com,” News, *MSNBC*, October 11, 2011, http://www.msnbc.msn.com/id/44870816/ns/local_news-honolulu_hi/#.TpXud3KH0mE.

¹⁹ Amanda Paulson, “Obama proposes new way of uniformly raising academic standards,” News, *The Christian Science Monitor*, February 22, 2010, <http://www.csmonitor.com/USA/Education/2010/0222/Obama-proposes-new-way-of-uniformly-raising-academic-standards>.

reported percents proficient can be largely attributed to differences in the stringency of their standards.”²⁰

In 2007 NCLB was up for reauthorization, but the Democratic controlled Congress and President Bush failed to come to any agreement. Without another clearly demonstrable way to measure success Congress has yet to implement anything new. This obviously becomes important to school design as for the past decade a high percentage of instruction and resources within a school were used for teaching to this standard. Large amounts of money spent on other programs or facilities were in large part not utilized. Dedicating resources to programs or courses that will not be needed or supported over time is obviously something a school district would want to avoid where possible. This seems like a good time to reiterate that this project is concerned with how a school would be utilized in the plausible future outlined in Chapter 7, and not necessarily how it *should* be constructed and used. Not utilizing an art or music classroom may not be a preferred future for some, however, if that is what seems most likely then it needs to be accounted for in design guidelines. This project will attempt to show that technology’s role in changing education is being undervalued and is likely to allow for some of these problems with accountability versus proper learning to be reconciled. The school designs recommendations in Chapter 8 will be based on existing trends in educational policy and theory along with technological advances; any bias of partisan beliefs will be minimized as much as possible. That said, the discussion will be framed by theories of how children learn and what the best environments are for that learning.

President Obama has recently (Spring 2010) put forth a new *Blueprint for Reform* alternative to NCLB that allows for states to design their own criteria for educating students as long as by 2020 they produce high school graduates that are “college and career ready students”. Promising federal money for standards that don’t exist yet has been met with some criticism. What constitutes “college and career ready” is also open to interpretation, but as a testament to the dislike for NCLB (and shrinking budgets), forty eight states have already signed on that they will provide a proposal to use new common standards (with only Texas and Alaska abstaining).

Hawaii Superintendent Matayoshi is excited that schools can focus on individual learning again instead of the unrealistic goal of having every student of the same age meet a designated standard: “Instead of national standardized tests, Matayoshi wants to focus on individual student growth.” *Where are they at the beginning of the year? Where are they at the end of the year? We want to see students growing,*” said Matayoshi.”²¹

²⁰ “NAEP Studies - Mapping 2005 State Proficiency Standards Onto the NAEP Scales,” *NCES (Dept of Ed)*, n.d., <http://nces.ed.gov/nationsreportcard/pubs/studies/2007482.asp>.

²¹ Drewes, “Hawaii Could Set Benchmarks In Education - Local News - Honolulu, HI - msnbc.com.”

A 2005 NCES budget report shows federal money only accounts for 8.5% of a public school district's budget, but with the nation on the edge of a recession few if any states can afford to not take advantage of additional money. The remaining school budget is on average provided 48.7% by the state and 42.8% locally, but these numbers vary widely (Hawaii, for example, is funded 90.1% by the state). It's also likely the while the overall money hasn't changed much, the percentage of money that comes from the Federal government has increased since 2005 as budgets have been cut drastically due to recent economic troubles.

Schools are the largest item in most state budgets and have faced substantial budget cuts in the past few years. The following list taken from an MSNBC.com article shows cuts made by a few major cities in the United States as of March 2010:

- The Kansas City, Mo., School District is closing nearly half of its 61 schools, with almost 300 teachers among those losing their jobs once 29 campuses go dark.
- The Montgomery, Ala., Public School Board voted last week to lay off more than 600 employees, including 415 teachers, in what it said was just the first phase of staff reductions.
- In the northwest suburbs of Chicago, the Illinois 46th District school board this week approved a proposal to lay off more than 1,000 employees — about 25 percent of the district's staff — to help make up a projected deficit of \$44 million. More than 700 teachers would lose their jobs, including all first-, second- and third-year instructors.
- Detroit, where enrollment has fallen by 49 percent since 2002, announced Wednesday that it plans to close 44 underused campuses and a support facility;
- Cleveland, where enrollment has fallen to its lowest level since the 1890s, plans to close 16 schools, or more than 10 percent of its facilities;
- Pittsburgh, where enrollment has fallen by 35 percent since 1997, has closed 18 schools and put them up for sale.²²

Any discussion on school construction and the future of public education that didn't discuss huge budget shortfalls would be completely unrealistic. New schools that are being built are going to have restricted budgets making it all the more important that each dollar is spent wisely, but ideally cuts to the designed building are not at the great expense of future generations. While this project deals with how to address the new schools that are being built, it should be fairly obvious at this point that an equally important undertaking would be to address renovations and retrofits to existing schools. This would require both making schools still in use more tech friendly for future students as well as how to convert schools that have been closed in to other building types.

²² Alex Johnson, "U.S. schools in 'category 5' budget crisis - US news - Education - msnbc.com," News, *MSNBC*, March 18, 2010, http://www.msnbc.msn.com/id/35883971/ns/us_news-education/t/us-schools-category-budget-crisis/#.TpXc93KH0mF.

Many educational reforms over the years have called for a wider variety of courses, lower student to teacher ratios, and a greater focus on allowing individual students to construct their own understanding of different concepts instead of straight acquisition of facts. These are all costly additions to programs that are struggling financially and so are unlikely to happen in the near future despite proven effectiveness. Montessori and Waldorf schools have used these methods to great effect over the past century; how that has been enhanced by building design will be discussed in the next chapter under CASE STUDIES. Why these methods are likely to be employed and modified in more schools moving forward thanks to technology will be discussed further in Chapter 6: THE CURRENT STATE OF PRIMARY SCHOOLS

4. PRIMARY SCHOOL DESIGN IN THE U.S.

In the pre-Common School era the single room schoolhouses had very little in the way of books or equipment to teach students, and in terms of technology they were lucky to possess a single abacus.²³ However, architecturally it was sufficient for what was needed to serve a small rural community.



Figure 2: Bear Creek School's single room schoolhouse (Iowa, circa 1870)²⁴

As more immigrants appeared and rapid urbanization began, the schools became larger, but the method of instruction, one lecturer at the front of a room of desks didn't really change. Consequently, most schools built since this period have been a large number of adjacent "single room schoolhouses", but under one roof and connected by hallways.

Even those that have introduced computers have generally placed those computers in to existing classrooms in to the same layout of front-facing rows of desks. This is a problem because it blocks view to the teacher, and doesn't allow for more than a couple of people to comfortably view the screen at a given time. This may result in problems with power, glare, poor acoustics, and poor layout that doesn't allow for group projects. Other rooms will stick computers in to the corner or against a wall without adequate space. In general, classroom spaces were not re-designed specifically for the computer's use and consequently aren't optimized for that use. See the below image from East Boston Early Education Center for an example.

²³ "The Common School." *SCHOOL: The Story of American Public Education*. PBS: 03 Sep 2001. Television. 7 Feb 2011

²⁴ Rotraut Walden, *Schools for the Future: Design Proposals from Architectural Psychology* (Cambridge, MA: Hogrefe & Huber Publishers, 2009), 21.



Figure 3: Computers in East Boston Early Education Center are pushed up against the wall with several located in a back corner near a large window which may cause glare issues²⁵

When introducing computers it's necessary to have furniture designed for the task, while still at the child's scale; diffuse lighting and static-free flooring are a few other considerations. Longmeadow Center Elementary School has incorporated their "computer lab" in to an open library setting with better results.



Figure 4: Longmeadow Center Elementary School uses appropriate furniture, proper lighting, and static-free carpets for their educational computers²⁶

²⁵ Bradford Perkins, *Building Type Basics for Elementary and Secondary Schools*, 1st ed., Building Type Basics (New York: John Wiley & Sons, Inc, 2011), 7.

²⁶ *Ibid.*, 187.

Jean Piaget along with John Dewey's work stresses that a variety of environments are necessary as different personalities have different ways of learning, and that there are corresponding spaces that they will thrive in. This may seem somewhat obvious to those involved, but educational curriculum, policy, and design have very strong institutional inertia.

Education theorists have been calling for "flexibility" in learning spaces for years; however, schools don't have the resources (space or personnel) to have every student or even small groups of students working at different paces on different lessons. Schools are designed so those of similar ages (not necessarily similar intellect or similar interests) move through the curriculum at a designated pace not determined by any student's intellect or interest. Those that can keep up move on, those that can't repeat the entire year even if they were only stuck on one section.

Briefly in the 1960s the open floor plan became popular allowing for a variety of learning spaces within a single classroom. However, the combination of noise and visual distractions along with the shrinking enrollment and shrinking budgets of the 1970s and 1980s caused many schools to revert back to the old "proven" model. Had some of those distractions and budget cuts been anticipated, the overall superior flexible learning space might have been maintained and refined instead of abandoned.

The average new elementary schoolhouse built today costs in the range of \$21 million.²⁷ There's therefore a substantial amount of money invested in maintaining the facility for as long as possible. The odds that a school district will come up with another \$21 million fifteen years later if the school isn't optimally meeting the needs of its occupants is slim to none. What is more likely is that students will be forced to learn in a building that doesn't suit the pedagogy, or even worse (and what happens frequently whether intentional or not) is the pedagogy becomes limited by the space and doesn't change as society and technology outpace it.

"The design of educational facilities has a profound impact upon how students learn and on how well they serve the communities in which they are located. Facilities that strengthen these relationships are often the most successful."²⁸

School design cannot be forgotten about when discussing educating children; the connection between environment and learning is proven.

²⁷ Ibid., 202.

²⁸ Whitebread, *The psychology of teaching and learning in the primary school*.

4.1 BENEFICIAL LEARNING ENVIRONMENTS

There is no such thing as a perfect learning environment. There are, however, widely agreed upon characteristics of environments beneficial to learning. Both of these statements hold doubly true as the means and methods of how students learn over the coming years changes, since this will also change the requirements of the learning spaces (as is put forward in this paper). These characteristics will need to be kept in mind during any discussion on how school design might change due to changes in pedagogy. Optimal learning environments should of course be geared towards optimal learning practices and so those too must be considered.

“Traditional classroom design, with its rigidly arranged seating, high-silled windows on the left, and authoritarian location of the teacher, was based on several assumptions: That all students were right-handed. That daylight beamed on just a few rows was enough for the whole room. That neither teacher nor students should ever move into groups, or change location. That teacher-to-student lectures, recitations, and at-desk study were the sole activities in the classroom. That the world around the classroom had nothing to teach the student... Today’s classroom design [should be] based on other principles, most basic of which is flexibility – to keep pace with changing concepts of education’s role in society, and of the teacher’s role in the learning process. Also, the classroom must reflect the teaching methods of the school; it must be an efficient tool and a suitable atmosphere for education, regardless of the educational approaches used.” – Lawrence Perkins (1957)²⁹

That quote is 54 years old, but might as well have been written yesterday. Almost since formal education began in the United States there have been theorists who believed the industrial model of having children sit in rows for long periods of time passively listening to lectures before all getting up and moving together at the sound of a bell was not the best way for students to learn. Children, especially younger children of primary school age, learn best through direct hands-on experience that engages all five senses. The old Confucian adage: “Tell me, and I will forget. Show me, and I may remember. Involve me, and I will understand” is often quoted among education theorists. Intuitively this seems to make sense, and most educators know they have to engage the students or try to find a way to personalize the material to get a student interested in a given topic. As Bill Gates has found through his Foundation’s research, however, the intuitive guess isn’t always the right one, but most of these principles have been understood and verified over the years, but figuring out a way to engage each individual student is time-consuming for an instructor and just not able to be funded. The educational model has out of necessity become a form of triage where instructors must teach in such a way as to advance the

²⁹ L Perkins, *Elementary and Secondary Schools* (New York: Wiley, 2001), 99.

most number of students. Students learning at a slower pace for a particular unit are never able to catch up and students learning at a faster pace become bored or uninterested as they remain unchallenged. This is alleviated somewhat in high school as honors and AP classes are broken out, but generally in primary schools the third grade is the third grade regardless of aptitude.

There have been some school systems over the years that have fostered the ideas of Froebel, namely those of Maria Montessori and Rudolph Steiner. They both, not coincidentally, also recognized the importance of the school environment in educating the young, something many key educational theorists have neglected entirely. Steiner formed the first Anthroposophical Society in 1912 and working with its artist and craftsmen members, “enter[ed] in to the experience of a harmonious building process which defined the essential nature of his philosophy.” Understanding that preschool and kindergarten are a time of great personal growth, one of Steiner’s Waldorf schools’ key architectural characteristics was a metamorphosis of form. In fact, it maintains a fairly consistent architectural style “sometimes adopted by kindergarten architects who are not designing to Steineresque principles. To a certain extent, it has become the ‘alternative style’ for Kindergarten architects,”³⁰

Maria Montessori has had a profound effect on early childhood educational theory over the last century. Montessori stressed the child’s individuality and couched it in developmental / cognitive levels appropriate to each child and their age. Interaction with the environment to bring about independence and self-construction is a key tenet. This entailed free play within a controlled environment. Furniture was sized to the child and configurable to allow for movement and flexibility within that loosely constrained space. The educational materials that were brought in were those limited to the developmental stages of the children in the room. Those children usually were of mixed-age groups. The standard subjects were taught including math, history, the sciences, language development, as well as the arts, but the interdependence of the subjects as well as the beauty and order of the natural world were also stressed through group work, outdoor play, and weekly field trips.

³⁰ Dudek, *Kindergarten architecture: space for the imagination*, 64.



Figure 5: Montessori School of Los Altos in Palo Alto, CA. Note the variety of spaces and connection to the outdoors

(Source: <http://www.montessorischooloflosaltos.org/>)

It's not a coincidence that many of the current popular trends that will be discussed later in this paper mirror those used by the most successful Montessori schools.

This idea of individualization is one that has been brought up repeatedly, but is difficult for schools to do well with limited resources, and as a result, it is often only employed at very expensive private schools. Since this paper advocates for that position, but also sees it as completely plausible that technology will finally allow for its mainstream adoption, let's look in to it a little further.

Katherine Briggs and her daughter Isabel Myers developed and first published the now famous Myers-Briggs personality test in 1962. It classifies people in four different categories, combinations of which result in one of sixteen personality types. These categories, when applied to different student learners, along with experiments by Jean Piaget have shown that people learn and process information differently from one another. Not all students synthesize and analyze as Dewey had expected. Some students crave the 'why', while others prefer and are fine with only knowing the 'who', 'what', 'when', and 'where'-type questions.

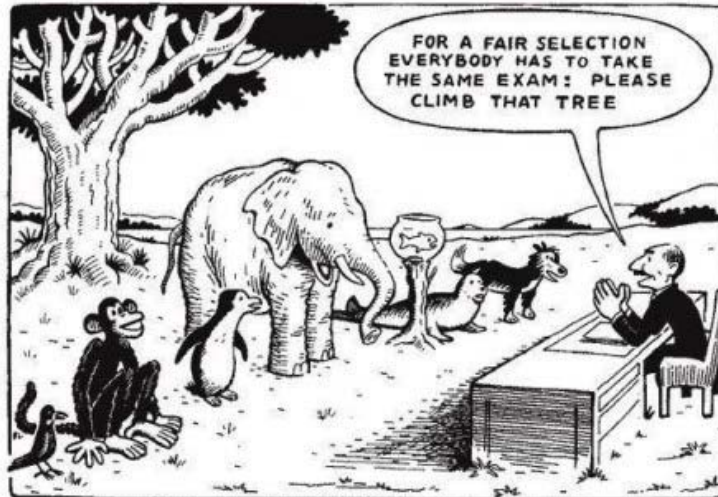


Figure 6: “Everybody is a genius, but if you judge a fish by its ability to climb a tree, it will live its whole life believing that it is stupid” – attributed to Albert Einstein; (disputed)

(Source: <http://weknowmemes.com/2011/10/the-educational-system-comic/>)

Howard Gardner is famous for his Theory of Multiple Intelligences first put forth in the early 1980s. There are eight different intelligences with a ninth (existential) sometimes discussed but not formally included by Gardner. They include:

- **Logical:** reasoning and recognizing abstract patterns
- **Spatial:** good with puzzles and visualizing with the mind’s eye
- **Linguistic:** has to do with verbal intelligence with reading, writing, and telling stories.
- **Bodily-Kinesthetic:** learning better when it involves movement by doing and muscle memory over simply hearing about it
- **Musical:** strong auditory component involving rhythm and tone, lectures are effective
- **Interpersonal:** interacting with others (extroverts), learning through discussion and debate
- **Intrapersonal:** introspective (introverts), understanding one’s own thoughts, feelings, and motivations
- **Naturalistic:** relating information to the outdoors and one’s surroundings
- **Existential** (not always included as Gardner himself is still unsure): recently added, can be thought of as a spiritual intelligence or the ability to contemplate beyond

sensory data. This doesn't mean Extra-Sensory Perception (ESP), more astrophysicist than psychic.

Unlike the Myer-Briggs classifications, Gardner's Theory should not be thought of as each person falling in to a single category, but rather each individual contains all types, but on a spectrum. Each individual will be higher in certain areas than others. This theory in no way implies that students who excel in a given area should not attempt to harness other areas. An introvert (Intrapersonal) should still participate in physical education and drama class even if challenging; while that same drama class will likely appeal to Musical, Bodily-Kinesthetic, Spatial, and Interpersonal learners.

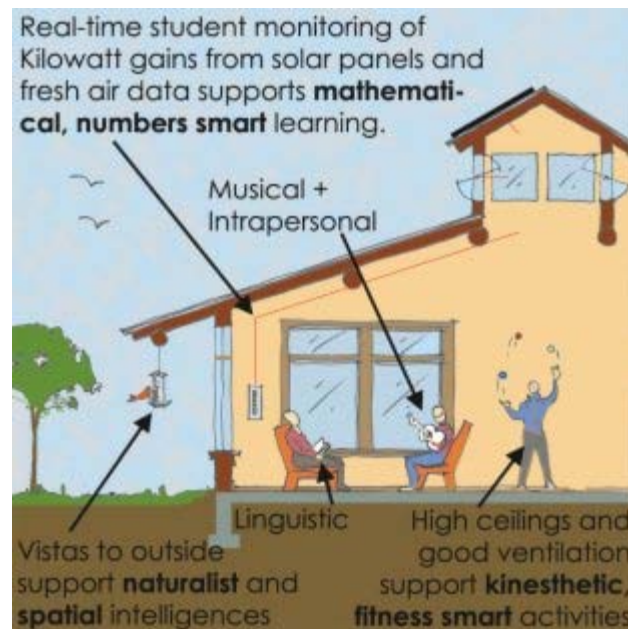


Figure 7: It's important to create spaces that appeal to and allow for different types of learners and learning³¹

Even if the educational system continues to insist that the only skills worth knowing to make one "college and career read," which happen to neatly fall in to fall in to the Linguistic / Logical-Mathematical models there still needs to be an effort to deliver those skills to other types of learners. Shakespeare was meant to be heard and seen, not just read in a book.

Everyone has had those "a-ha!" moments when an instructor was able to explain something in a way that finally made sense. Some people will appreciate and grasp Shakespeare through the familiar flow of hip-hop, some through a Leonardo Dicaprio movie remake, and others will need to look up and understand every word.

³¹ Randall Fielding, Jeffery Lackney, and Prakash Nair, *The Language of School Design*, Revised. (Designshare.com, 2005), 145.

Unfortunately, teachers don't have the time to try out 6-8 different methods of instruction for each lesson. That being the case, if technology can know each student's predisposition through a teacher's input or by learning through interaction with that student, then instructional models and methods can be tailored to that child's learning style without requiring a lower student-to-teacher ratio. The one-size fits all style of instruction that many schools employ today out of necessity can be enhanced with technology picking up some of the burden of individualizing lesson plans and tracking progress.

“As an alternative to the drill-and-recitation methods of the nineteenth century, Dewey's School and Society (1899) espoused the notion that **ideas should be grounded in experience**. In *Experience and Education* (1938), he argued that education should be based on the child's psychological and physical development, as well as the world outside the schoolroom.”³²

In order to foster such an environment, different spatial configurations and programmatic elements are necessary. Not the least of which is furniture not bolted down to the floor. When we think of the greatest success stories of our nation they're generally creative types whose purpose was discovery, pushing boundaries, and creating brand new inventions and ideas, whether that's in the stock market (Michael Bloomberg, Warren Buffet) or technology (Bill Gates, Steve Jobs). If politicians hope to regain our position of power in the world we need scientists and engineers who can think creatively, problem-solve, and work collaboratively prior to the University level.

The following table out of *The Language of School Design: Design Patterns for 21st Century Schools* shows how different spaces are conducive to different intelligence types. Not all of these spaces are necessary for every primary school in the United States, but it's important that every type be represented multiple times in the spaces that are chosen (ie- don't just add an Entrance Piazza and think the mission is accomplished).

³² “Can Sal Khan Reform Education In America?”, n.d., http://www.huffingtonpost.com/2011/04/04/the-khan-academy-and-educ_n_844390.html.

Multiple Intelligences and School Spaces. © Fielding Nair International.

	Linguistic	Logical-Mathematical	Musical	Bodily-Kinesthetic	Spatial	Naturalist	Interpersonal	Intrapersonal	Existential
Traditional Classroom	x	x					x		x
Learning Studio	x	x	x		x	x	x		x
Advisory Grouping	x	x	x	x	x	x	x	x	x
Cave Space	x	x						x	
Campfire Space	x	x							x
Watering Hole Space	x	x					x		x
Performance Space			x	x	x		x		x
Amphitheater	x	x	x	x	x	x	x	x	x
Café	x	x	x				x	x	
Project Studio		x			x	x	x		
Library	x	x	x		x	x	x	x	x
Outdoor Learning Terrace	x	x	x	x	x	x	x		
Greenhouse		x		x	x	x	x		
Distance Learning Center	x	x	x		x		x		
Graphic Arts/CADD Lab		x	x		x		x		x
Fitness Center			x	x	x		x	x	
Playfields				x	x	x	x	x	x
Blackbox Theater			x	x	x		x		
Entrance Piazza	x	x	x	x	x	x	x	x	x

Table 1: Multiple Intelligences as they relate to school spaces³³

Besides spatial diversity there are other characteristics that make a space successful including proper light and acoustical levels, specifics of which will be discussed in the next section under the base case scenario.

There are successful examples of the preceding characteristics including the School of One in Brooklyn and the Mid-Pacific Institute in Honolulu, HI.

4.2 CASE STUDIES

The intent of this section is not to rehash current standards on how to design a school. There are numerous design guidelines out there and, while several will be discussed below, summarizing each is not necessary here. Instead it is more likely that an architect will be familiar with a particular set of national and/or local guidelines and may lack

³³ Fielding, Lackney, and Nair, *The Language of School Design*, 146.

perspective on the differences amongst them, as well as in which areas they fall short, when considering the effects that technology will have on education in a future society. What follows is base case example of a typical school as well as some key information on two case studies.

4.2A BASE CASE (TYPICAL PRIMARY SCHOOL IN U.S.)

The following will be a discussion of what the average primary school looks like using a compilation of Design Guidelines including some from each of the following:

Federal

- Department of Education Recommendations
- Department of Energy: Energy Guidelines for High Performance Schools

State Level

- North Carolina
- California

Municipal / Local

- New York City
- Los Angeles

The major Design Guidelines do a fairly good job of being prescriptive in outlining what a good primary school of today should look like. What follows is some detail on what different guidelines are requiring, and also some analysis on why some of these characteristics are short-sighted.

A typical elementary school is designed using the standard 108 Gross Square Feet (GSF) per student. The minimum class size in Los Angeles is 960 square feet (though the average Kindergarten is 1,350) and not less than 30 sq ft per student. New York on the other hand has a minimum classroom size of 770 sq ft based on 27 students (this works out to about 28.5 sq ft per student. Florida is on the high end with 35-40 sq ft.³⁴

According to the Los Angeles Unified School District School Design Guide of 2007:

“Classrooms are the most important single element in the school. They must be designed to flexibly accommodate varied activities and future technologies. Designs should reflect concern for the way children work and learn in the room. Adaptability of the room to various grade levels is provided through selection and arrangement of furnishings.”³⁵

³⁴ Perkins, *Elementary and Secondary Schools*, 28.

³⁵ “School Design Guide: Los Angeles Unified School District”, January 2007, 32.

The guide, however, does not specify what those varied activities or future technologies might be. Unless the architect is well versed in education theory and future studies they'll likely fall prey to optimizing a space for today's activities and technologies without fully considering what children two generations from now will be doing in that space.

Los Angeles (L.A.) also recommends small group instruction areas (minimum 480 sq ft) adjacent to classrooms. If possible all of the above should be easily altered in size and shape without incurring substantial additional costs.

Science classrooms still call for fixed lab benches. Proper ventilation and disposal of hazardous materials are covered in the different guidelines, but none mention what technology would be employed, how many screen devices, and what infrastructure is needed for a science classroom.

All elementary school classrooms need sinks, soap dispensers, and paper towel dispensers. The Kindergarten classrooms should have their own fenced play space (play area to classroom ratio of 2:1) which should include some shade for quiet activities.

The Department of Energy's Energy Design Guidelines for High Performance Schools calls for each district as a whole to put forth an Energy Plan outlining overall goals and objectives. It states that as a rule of thumb each new school should push to be as energy efficient as another building within the top 25% efficiency of all buildings in that district. The L.A. guide calls for aiming for 15% better than required by the CA Energy Efficiency Standards (Title 24).³⁶

It also calls for optimizing daylight and the use of electric lighting and the elimination of glare. In this particular section Los Angeles doubles down and states that: "Lighting should be 'designed' not simply specified."³⁷ This is an excellent point and it leaves it open-ended for the architect to decide how to do that.

In 2005 New York City enacted Local Law 86/05 established a set of stringent sustainable design standards for public construction projects making it the largest (and one of the first) to adopt required sustainable school design, construction, and operations guidelines. Any school with a budget over \$2 million which would be all new and most major renovations are required to achieve a LEED Certified rating. This is a good first step, but anyone familiar with the LEED points system knows a building doesn't have to be truly energy or water efficient to achieve a Certified rating. Even more disappointing is that school buildings set no guidelines beyond initial construction. If a building achieves the rating under the guideline there's no impetus to continue energy and cost saving measures. So much of these guidelines are written to achieve good results point-in-time instead of considering the overall lifecycle cost.

³⁶ Ibid., 32.

³⁷ Ibid., 62.

Each guideline also has set standards for Acoustical clarity, Indoor Air Quality (IAQ), as well as a storm water management plan, and water efficiency.

Other programmatic requirements include:

Library space is supposed to be proportional to planned enrollment, but not less than the size of a classroom. Most guides have some mention of secure storage for technology and media equipment, but not a one mentioned the possibility of libraries shrinking as eBooks and digital textbooks become more commonplace.

Gymnasiums in several major cities need to be directly accessible to the public for community use and extended hours of operation with an ability to be closed off from the rest of the school so as not to create security risks to the children or adults wandering around the school corridors after hours.

The Los Angeles Guide listed a Multi-purpose room, which is a combination cafeteria, assembly hall, testing room, performing arts classroom, and physical education space all in one. In-wall tables and benches for elementary are also allowed. While it saves space, by being a jack-of-all trades a multi-purpose space often fails at all of its tasks

In California, it's also required to post at least one Permanent education display that touts the high performance features of the building, ostensibly as a learning tool.

4.2B CASE STUDY: TECHNOLOGY IN THE CLASSROOM

THE SCHOOL OF ONE, BRONX, NY

The School of One pilot program in New York City is an experiment to see if a few middle school age mathematics classrooms can utilize tech-based, personalized instruction effectively. Students are tested at the beginning of each semester to determine their learning style, and then based on those results they work with an instructor to develop a “playlist” of skills the student must master for that year. The software keeps track of which lesson each individual student is on and through algorithms decides when they're ready to move on to a new lesson and which one it should be. Teachers monitor the progress and can float amongst different students helping them on whatever lesson they're working on.

Initial results from standardized testing have been promising showing an average increase of 28% in the number of test items they answered correctly, but this model is about more than just testing. If a student in 6th grade has shown skills at a 4th grade level the software will start them on 4th grade (equivalent) skills. Articles nay-saying technology that test scores haven't improved would be better served to look at the glass half full and realize a brand new program is able to do as good as the old methods. This means it's likely that as curriculum improves test scores would increase even higher, all the while students are

utilizing cutting-edge technology and gaining skills they'll use at higher levels and out in the real world.

“School of One does not focus on test prep... we recognize that for some students that means, one step back can lead to two steps forward next year, and it depends on where they start.”³⁸



Figure 8: Students at the School of One in the Bronx check their assignment for the day on the monitors on the way in to their converted classroom³⁹

Spatially, no traditional classroom in that school (and most standard schools) could house the 80 students and 10 adults (4 instructors, 4 teacher interns, and 2 administrators) required for the pilot. Eventually they were able to make use of the library using temporary partitions and relocating shelves.



Figure 9: The School of One pilot used a converted library to house all 80 students. It was arranged to accommodate different modalities of learning including small groups⁴⁰

³⁸ Tina Barseghian, “Will School of One Expand to a School of Many? | MindShift”, June 21, 2011, <http://mindshift.kqed.org/2011/06/will-school-of-one-expand-to-a-school-of-many/>.

³⁹ Ibid.

One interesting finding was that acoustical privacy ended up not being the problem many thought it would be. It turns out the students were kept engaged by always being on lessons of a sufficiently challenging level and the background noise didn't present a significant distraction.

Below is Atlantic Senior Editor Ta-Nehisi Coates recounting how he used to struggle to pay attention in school as a young man growing up in Baltimore:

“By the time I was in high school, we were using the computer lab once a week for math. But we were using it the same way we used pen and paper—a teacher at the front of the class and all of us following along. The computer lab bored me as much as the chalkboard. By then, I knew that I wasn't taking to education-as-mass-production.”⁴¹

After visiting and reporting on the School of One he echoes many technology enthusiasts viewpoint:

“I thought I was lazy (and maybe I was) and lacking the will to learn. But as I watched the kids at I.S. 339 working at their own pace and in their own way, I wondered if all I had ever really needed was the equivalent of a warm hug from a cold algorithm.”⁴²

The cost of the School of One project is several million dollars per school, and requires wireless internet and every student in the program to have a laptop. No small undertaking, but Joel Rose the New York City Department of Education's chief executive for human capital and a proponent of the program believes they can get the cost down so as not increasing the operating budget of a school. This shouldn't be an issue even five years from now as wireless technology and laptops become even more ubiquitous in instructional spaces. What most schools don't have are proper spaces with enough variety to accommodate different styles of learning.

The results are encouraging and are the first step in proving to other school districts that the technology expenditure is worthwhile, and more importantly that the greater expenditure of building a new school needs to take in to account some variation of the School of One as the new instruction model with corresponding spaces built in.

⁴⁰ Charles Linn, “The School of One | Architectural Record | Schools of the 21st Century | Features”, n.d., http://archrecord.construction.com/schools/09_School_of_One.asp.

⁴¹ Ta-Nehisi Coates, “The Littlest Schoolhouse - Magazine - The Atlantic,” *The Atlantic*, August 2010, <http://www.theatlantic.com/magazine/archive/2010/07/the-littlest-schoolhouse/8132/>.

⁴² Ibid.

4.2C CASE STUDY: MIXING TECHNOLOGY WITH PROGRESSIVE EDUCATION

MID-PACIFIC INSTITUTE; HONOLULU, HI

The Mid-Pacific Institute, or MidPac, is a private K-12 school at the edge of the Manoa Valley in Honolulu. It has taken a very progressive stance towards the use of technology in education and made the move when building new facilities several years ago to construct facilities that would match.



Figure 10: Mid-Pac's multi-modal open floor plan learning space
Photo Credit: Eric Siwy (2011)

They've largely succeeded. There are numerous workstations as well as comfortable seating for students with laptops at desks or on the floor. The space accommodates several typical class sizes at once and the students are mostly self-guided once tasks have been assigned. They check in with their instructor periodically and he does the same. With no walls, no particular faculty member owns that space. Faculty offices reside above.



Figure 11: Several of the younger students film a dance routine while two others look on while videoediting at the Mid-Pacific Institute
Photo Credit: Eric Siwy (2011)

Some common critiques of spaces like this involve talk of too many acoustic and visual distractions. When visiting I was largely ignored by the students. Walking in to a typical rectilinear classroom and trying to hold a conversation would have instantly disturbed that class. There's also plenty of natural daylight and glass providing potential visual distractions. Ambient noise did not seem to be a factor. When students are engaged background white noise quickly fades away.

The older students made great use of the available technology. The younger primary school age children are in separate spaces though under the same umbrella and with access to much of the same technology. The spaces support multi-modal learning, though in the younger age groups the individualized technology was largely secondary to other means of instruction. As seen in Figure 12 below, putting a few computers in a corner facing a wall behind other furniture makes it less likely to be used (and likely is showing that it does often go unused). Technology was still being used in the form of a Smartboard, but still in a more typical form of pedagogy with the instructor as primary sage/lecturer.



Figure 12: It's important to create spaces that appeal to users in order to encourage their use
Photo Credit: Eric Siwy (2011)

5. TECHNOLOGY IN THE CLASSROOM

*“Books will soon be obsolete in schools. Scholars will soon be instructed through the eye. It is possible to touch every branch of human knowledge with the motion picture.”*⁴³

- Thomas Edison (1913)

“We are unalterably opposed to mass education by television as a substitute for professional classroom techniques.”

- The American Federation of Teachers (1950s)

The idea of technology as the savior of education is certainly not a new idea as the almost one hundred year old Thomas Edison quote above illustrates. Neither is the fear that technology will replace all teachers. Neither has happened, but both will occur to varying degrees over the next few decades and so it will be important to clear up the role of each in education moving forward.

Each new technological introduction in to the classroom - radio, film, television, computers, etc. - has been met with wonder, but often by those who put it there. Surveys of superintendents and administrators almost always overestimate the usage of technology in the classroom when compared with surveys of those same teachers.⁴⁴

Below is a brief chronological listing of technological additions to education. Dates are approximate and represent widespread introduction to U.S. schools, not invention dates; this is by no means meant to be a comprehensive list⁴⁵:

- 1800 – School Slate (miniature personal chalkboard)
- 1840 – Chalkboard (larger and mounted for all to see)
- 1870 – Magic Lantern (pre-cursor to the slide projector)
- 1900 – Pencil
- 1905 – Stereoscope
- 1920 – Radio
- 1925 – Film Projector
- 1930 – Overhead Projector
- 1940 – Ballpoint Pen
- 1940 – Mimeograph (pre-cursor to the photocopy machine)

Fielding, Lackney, and Nair, *The Language of School Design*, 146.

ADDIN_ZOTERO_ITEM

{ "citationID": "26bos13n2", "citationItems": [{ "locator": "146", "label": "page", "uri": ["http://zotero.org/users/558557/items/PMNUMFXS"] }] }⁴³ Cuban, *Teachers and machines: the classroom use of technology since 1920*, 11.

⁴⁴ *Ibid.*, 15.

⁴⁵ “The Evolution of Classroom Technology - Edudemic”, n.d., <http://edudemic.com/2011/04/classroom-technology/>.

1950 – Headphones
1950 – Slide Rule
1951 – Videotapes
1957 – Skinner Teaching Machine
1958 – Educational Television
1959 – Photocopier
1960 – Liquid Paper
1965 – Filmstrip Viewer
1970 – Handheld Calculator
1972 – Scantron Machine
1980 – Plato Computer
1985 – CD-ROM Drive
1985 – Handheld Graphic Calculator
1990 – World Wide Web
1999 – Interactive Whiteboard
2005 – iClicker
2006 – XO Laptop (“the \$100 laptop”)
2010 – Tablet PC (ie- the iPad)

The reader will note that the list begins and ends with personal tablets. Think about how much the world has changed in the last two hundred years, and that many schools still write on slate chalkboards to educate the nation’s children. Now look at the rate of change in the past few decades. Anyone designing a school today cannot even use their own experience as a benchmark. Even someone twenty-three years old and fresh out of architecture school likely didn’t have the internet in their elementary classroom. And given the lifespan of school buildings, they quite possibly were educated in a building designed at a time when the slide rule was cutting edge technology.

That same student likely did have a computer somewhere in their elementary school, probably in the library, possibly in a classroom. Computers have been used in classrooms for over twenty years, but with varying degrees of success. Computer labs attempted to recreate the existing classroom putting desks in rows and having all students follow along at the pace of the instructor at the front of the room. This doesn’t utilize technology to its fullest capacity and did not produce markedly better test results. Consequently, there are many skeptics of spending large amounts of money on technology.

So what about now is different? The magic bullet in this case isn’t one single piece of technology. Computing is being integrated in to smaller, cheaper devices. Mobile devices lend themselves to students’ habits and use. Like the textbook before it, a laptop or PDA allows a student to do work at school, the library, home, or even outside. Also, the internet allows for more exploration and effective distance learning. Social networks, cell

phones, and video chat make computing an interactive experience and distance no object. Thanks to the ACCESS program and video-conferencing technology, every student in Alabama High Schools currently has the capability to take Chinese Language and college-level AP courses. Technology levels the playing field, and demand will increase for its widespread use from parents and politicians. It's no longer a single device that's used for thirty minutes a day. Another difference is that technology is now being integrated in to all aspects of the classroom and adapted to suit pedagogy instead of teachers having to adapt their teaching to use technology as an add-on to the classroom experience without proper training or testing.

In order to properly assess how classroom technology will be utilized in the future (and the corresponding architectural requirements), it is important to view historical uses and the effect that had on learning, the classroom experience, and the building.

Note: Technology in education doesn't always imply the computer and so we will use the broader term information and communication technology (ICT). Historically, the term technology by definition could include the chalkboard and other tools (as was done in this introductory section), but this project will focus on electronic devices.

5.1 HISTORY OF USE

The first ICT devices were added to the classroom beginning in the early 20th century. Numerous studies in the 1920s through the 1940s concluded radio and silent films were effective at motivating students to learn. In 1920 the Radio Division of the U.S. Department of Commerce started to license commercial and educational stations.⁴⁶ Implementing widespread radio use in schools had issues not pertaining to classroom usage, like commercial use, upkeep, and federal regulations, but the introduction of radio and films initially was met by educators and administrators with enthusiasm... and some hardware problems.

By the 1940s content was widespread from state departments of education, universities, school districts, and many commercial stations. Price made radio more accessible than film, but saturation rates were often overestimated. CBS' American School of the Air estimated 8-10 million listeners. When returns were tabulated from a survey of Ohio classrooms the numbers showed audiences were more along the lines of 500,000 to 1 million.⁴⁷ In short, the number of radio sets in schools did not directly correspond to the number of listeners or to the number of teachers using radio as an educational tool. Teachers' fear or unwillingness to incorporate new technology in to the classroom has and will continue to be a factor in the adoption rates of ICT.

⁴⁶ Cuban, *Teachers and machines: the classroom use of technology since 1920*, 19.

⁴⁷ *Ibid.*, 23.

A 6 year study concluding in 1943 and sponsored by the FCC (Federal Communications Commission) evaluated radio broadcasts in classrooms. It concluded that: “radio has not been accepted as a full-fledged member of the educational family” and that while radio had permeated the home market, it “remains a stepchild of education.”⁴⁸

It’s difficult to determine why these early products didn’t catch on; some of the effect can no doubt be attributed to novelty value. Having something new in the classroom is likely to gain the students attention and increase motivation. This and other challenges will be explored further in the section CHALLENGES IN IMPLEMENTING TECHNOLOGY.

As would be seen with other technologies over the years, the use of the radio depended on others besides just the teacher for it to be effective. No longer could each individual teacher create, develop, and implement a lesson plan if they also desired to incorporate technology. Now the lesson was developed and implemented by an outside force. This required persons with technical skill to create. In the case of the radio no real expertise was needed to operate it, but maintenance on the radios, receivers, and the batteries was required. If early radios were put on the shelf at the end of the school year and not touched over the summer, they might not work when school resumed in the fall.

Like with other technologies that would come after it, initial problems with technical issues, unfamiliarity with the device, lack of content and high prices for radios, all reduced with time.

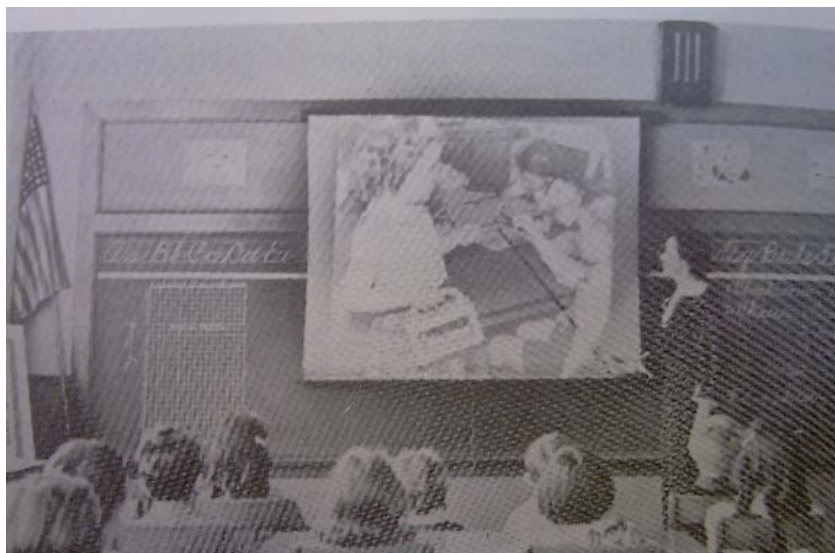


Figure 13: Projected images have been aiding instruction in primary schools for over half a century⁴⁹

⁴⁸ Ibid., 24.

⁴⁹ M. Chen and G. Lucas, *Education Nation: Six Leading Edges of Innovation in Our Schools* (John Wiley & Sons, 2010), <http://books.google.com/books?id=o0as6OnEqDcC>.

Televisions have been a presence in classrooms for the last fifty years. In well documented research in 1960s Samoa, televisions were introduced and used as the primary tool of instruction. Telecasts were used almost in the same method as textbooks. Teachers were instructed both in print and televised explanation on how to lead discussion and activities with the students. It was hoped to be a means of coping with a teacher shortage occurring at the time. Initial results were so successful it prompted a visit from then President Lyndon Johnson. Upon seeing a school there, he said:

“Samoan children are learning twice as fast as they once did, and retaining what they learn... [The] one requirement for a good and a universal education is an inexpensive and readily available means of teaching children. Unhappily, the world has only a fraction of the teachers it needs. Samoa has met this problem through educational television.”⁵⁰

Except that by the time that study concluded in 1979 television had been reduced to a supplemental role instead of the primary source of instruction as it started out. And studies conducted by Schramm and separately Tickton showed that no substantial difference in learning or the amount of information retained existed (as shown by standardized testing) in students taught with a television versus a conventional instructor.

That result shouldn't (and didn't) relegate televisions to the junk pile. Television might not be able to replace a teacher, but no distinction is still an important distinction. Teachers know that a variety of activities is necessary especially at lower grades (ie- primary school level) where that teacher has the same group of students for most of the day. Experimenting with technology is actually more popular at lower grades. In a 1981 survey of Maryland school teachers, 60 percent of high-school teachers said they had never used a television in an instructional role in the classroom; this was true of only 13 percent of elementary school teachers.⁵¹ This result of greater use in lower grades was repeated across national surveys as well. That particular survey is rather old (especially when speaking of technology), but the literature and all the recent articles on iPads being used in Kindergarten classrooms anecdotally bear this out as well.

In 1984, the year this author began Kindergarten, the ratio of computers to students was 1:92. Today that ratio is 1:8 in American public schools and shrinking.⁵² Of course, the computers around in 1984 looked nothing like today's sleek machines. They were often Plato Computers which would have looked similar to the one shown in Figure 3 below.

⁵⁰ Cuban, *Teachers and machines: the classroom use of technology since 1920*, 30.

⁵¹ *Ibid.*, 39.

⁵² “School: The Story of American Public Education,” *PBS*, n.d., http://www.pbs.org/kcet/publicschool/evolving_classroom/technology.html.



Figure 14: Image of a Plato Computer in use⁵³

Over the last couple of decades personal computers have been introduced in to the classroom. Initially, this was as bulky desktop machines and in computer labs and libraries. In the past decade that trend has shifted to laptops and more being introduced in to the classroom itself. This trend will only continue as technology gets better and price points come down. There are many difficulties with the question of how to leverage the fact that many students already have smart phones and could use them in class if directed properly, but that's probably too much too soon for many teachers.

Moore's Law states that the number of transistors that can be placed on an integrated circuit doubles every 2 years. This trend was pointed out by Gordon Moore of Intel back in 1965 and has remained accurate in practice since that point. This rate of change remained relatively consistent, even considering several recessions, and is expected to continue for at least the next decade. Ray Kurzweil has written extensively on the implications if this trend does continue. This will be discussed more in the FUTURES STUDIES AND ASSUMPTIONS chapter.

⁵³ "The Evolution of Classroom Technology - Edudemic."

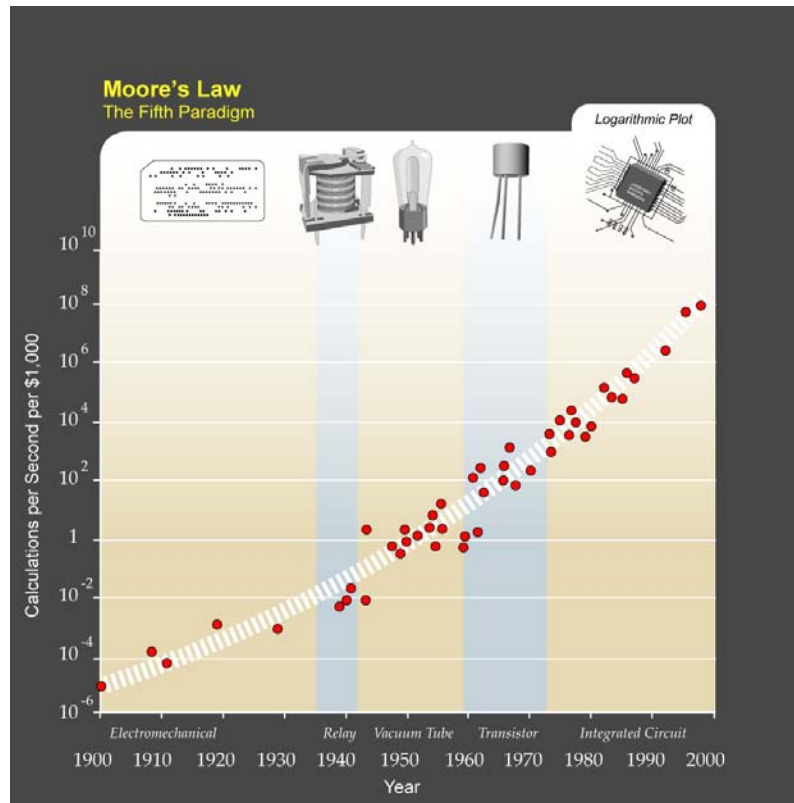


Figure 15: A modified version of Moore's Law as put forth by Ray Kurzweil showing a logarithmic plot of calculations per \$1,000 over the 20th century⁵⁴

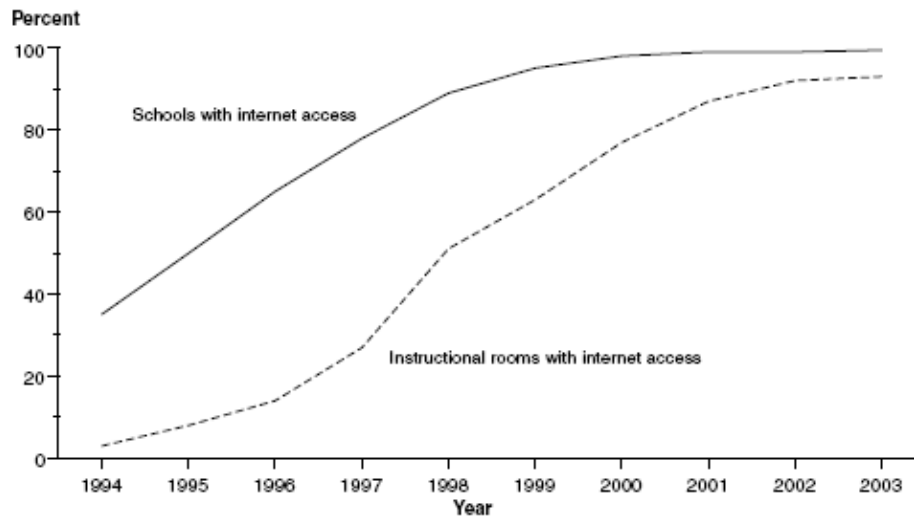
By Kurzweil's calculations computing power as powerful as the human brain will come about by 2020, though he qualifies that by saying he doesn't think we'll have fully reverse-engineered the human brain until 2029.⁵⁵

Another very large addition to the educational environment has been the introduction of the internet. As the graph shown below illustrates, the internet has been in almost all public schools since the turn of this century and is now above the 93% mark in instructional spaces.

⁵⁴ Ibid.

⁵⁵ R. Kurzweil, *The singularity is near: when humans transcend biology* (Penguin, 2006), <http://books.google.com/books?id=9FtnppNpsT4C>.

Figure 29. Percentage of all public schools and instructional rooms with internet access: Fall 1994 through fall 2003



SOURCE: U.S. Department of Education, National Center for Education Statistics, *Internet Access in U.S. Public Schools and Classrooms: 1994-2003*.

Table 2: Internet Access in U.S. Public Schools and Classrooms

Chalk boards and overhead projectors, while still prevalent in today’s classrooms, are now being replaced by the interactive whiteboard (IWB). The interactive whiteboard can be thought of as a touchscreen computer that’s the size of a projector screen in order to be useful to the entire class at once (similar to the transition from slate tablets to full-scale chalkboard).

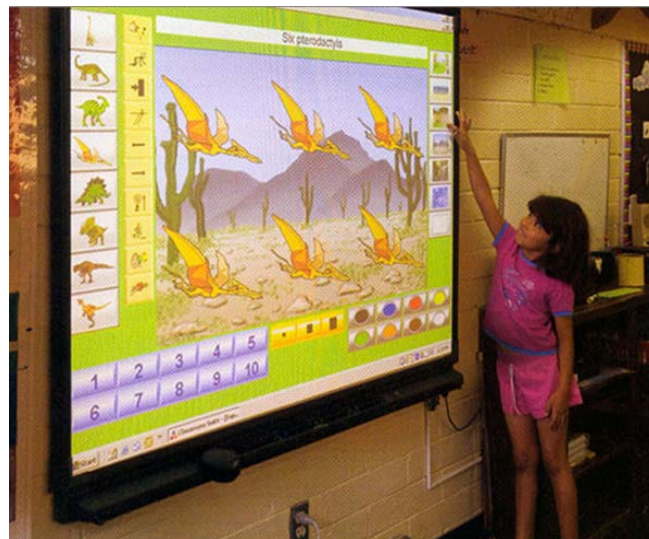


Figure 16: A young girl using an interactive white board⁵⁶

⁵⁶ “The Evolution of Classroom Technology - Edudemic.”

Futuresource Consulting released a market report in 2008 that estimated the interactive whiteboard market at \$1 billion with more than 600,000 installed worldwide with more than 45% of that from primary education (5-11 year olds).

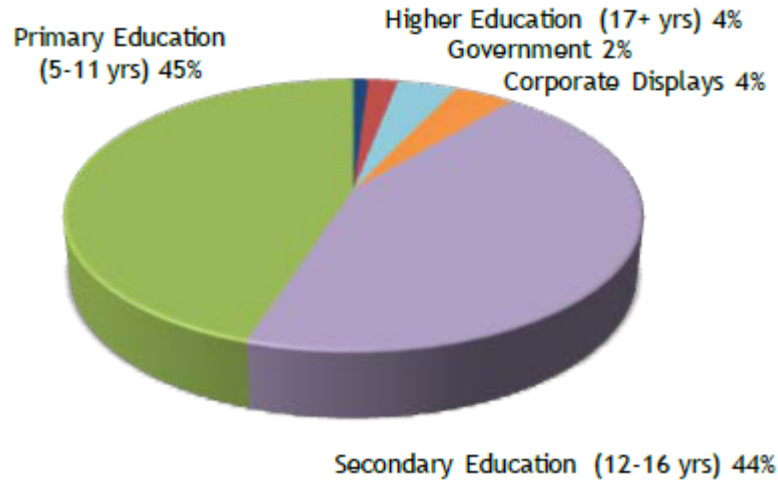


Table 3: Worldwide IWB usage per segment
 (Source: Futuresource Consulting Interactive Whiteboard report 2009 – Figure 1.1)

5.2 BENEFITS

While it may seem counterintuitive to introduce complex machines in to lower grade levels, there are numerous reasons primary schools are ripe for the further introduction of technology even more so than secondary schools. As previously mentioned, having one teacher all day means there's more continuity and clarity to technology's use. Less standardized testing means teachers feel they have more time to experiment. There also tend to be more group activities to encourage socialization in lower grades which can help if the amount of technology is limited by cost or other factors. Also, the teacher in the role of facilitator as often happens with recent uses of technology is more understood by younger students and more accepted by the primary school teachers than those teachers used to lecturing at higher grades.

Technology's use in the classroom can increase student engagement and improve learning in ways that coincide with major child development theorists. Due to the prevalence of technology in the office and the world at large, learning with technology can make formal education more relevant to real world experience and also make the student a more viable candidate for college and many jobs. Those students are then in possession of more needed modern skills such as digital communication, critical thinking,

and information and visual literacy. Then there's also the practical side of being proficient in the latest software and technology.

While the rate of change of technology's introduction in to the classroom may have been slower than initially expected in the 1980s, the direction has remained constant. One would be hard-pressed to find an expert in education theory, information technology, government or child development who thinks that technology should be completely removed from the primary school environment, and most would agree it will play an increased role in the coming decades. The strongest words from critics seem to call simply for reassessment of the assumptions about technology's role (and of course whether it's the best way to be spending large amounts of money).

The past century has provided many examples of technology in early childhood education and looking at these examples can help to show which technologies used in what ways have proven effective in student learning. For example, early technology skeptics thought the use of television to be too passive an experience, but: "cognitive research has shown that viewers observe, interpret, and coordinate all the information in the video to make their own personal sense of what is being communicated."⁵⁷

Sesame Street is one example of a very popular broadcast that's received critical acclaim from educators and children. It effectively utilizes the medium of television and moving imagery to teach basic concepts of language and mathematics. Teachers report those students who watched *Sesame Street* regularly were better prepared for school in terms of relationships with peers and verbal and quantitative readiness. Checking back in with those students has shown the effects last over time with 15-20 year olds who watched *Sesame Street* scoring higher grades in English, math, and science with better overall attitudes towards academics.⁵⁸ Obviously, it wasn't just watching TV, but from these and other studies it's clear that if used correctly television can be an effective medium for teaching. And not "passively", as "cognitive research has shown that viewers observe, interpret, and coordinate all the information in the video to make their own personal sense of what is being communicated."⁵⁹

High-quality classroom learning requires an excellent instructor. Very little research suggests teachers are going to be completely replaced by technology any time soon. It takes a special instructor to be able to hold the attention of their entire class with just a

⁵⁷ "Metiri Group—Commissioned by Cisco Systems, 'Technology in Schools: What the Research Says.' 2006.<http://www.cisco.com/web/strategy/docs/education/TechnologyinSchoolsReport.pdf> (accessed 4/23/2011).", n.d., 5.

⁵⁸ Ball, S. and Bogatz, G.A. (1970). *The first year of Sesame Street: An evaluation*. Princeton, NJ: Educational Testing Service., n.d.

⁵⁹ "Metiri Group—Commissioned by Cisco Systems, 'Technology in Schools: What the Research Says.' 2006.<http://www.cisco.com/web/strategy/docs/education/TechnologyinSchoolsReport.pdf> (accessed 4/23/2011).," 5.

piece of chalk, those that do, do so by engaging the students and make learning engaging and interactive. Television and other ICT can do the same. Video games and some other software actually do this very well. One study by Huston et al showed that middle school students retained more having watched an interactive video than if they had simply read the story as text.⁶⁰

It should be noted that on average 80% of a district's budget goes to personnel. Times of fiscal crisis, such as the U.S. has seen over the last few years, means budget cuts, which inevitably means layoffs. Seniority and tenure probably count more than an ability to adapt, but teachers who can make learning fun and engage the child and parents with the help of technology will thrive in the coming years.

Another popular ICT tool is an interactive white board or IWB (of which SMARTboards are a popular variety). These are now replacing the standard whiteboards, which of course are used often in lieu of chalkboards. They allow a teacher to project their computer screen on to a large whiteboard that's digitally connected to that machine as a touch screen display. The teacher can load videos, move objects, and even get the students to come up and interact with the screen using their fingers or a stylus-type pen.

Mobile devices such as tablets and even Smartphones allow for a similar level of interactivity, but on a personal level. Tablet sales have risen dramatically in just the past 12 months. This has resulted in an explosion of educational software (apps), and many of these apps are freeware allowing for unprecedented options in education for very little additional cost beyond that of the mobile device.

This level of individualization and interaction is beneficial to students if still grounded in proper theory. "Visual learning can result in increased engagement as well as increased complexity, depth, and breadth of experience to improve student academic performances. Results depend on the inclusion of **high-quality content** and **sound pedagogy**"⁶¹ (emphasis theirs). Many children's programs are unwatchable for adults due to simple concepts and repetition of songs and ideas, but repetition appeals to 5 year olds. Adults need to be careful and continue to create content that is developmentally appropriate, especially as the technology and method of delivery gets even more and more complex. It is equally important to do so in an engaging fashion. If children are playing top of the line video games at home, then introducing five year old cheaply put together educational

⁶⁰ Huston, A.C., Anderson, D.R., Wright, J.C., Linebarger, D.L., and Schmitt, K.L. "Sesame Street Viewers as Adolescents: The Recontact Study." Chap. 8 in "G" Is for Growing: Thirty Years of Research on Children and Sesame Street, ed. S.M. Fisch and R.T. Truglio (Hillsdale, NJ: Erlbaum, 2001), n.d.

⁶¹ "Metiri Group—Commissioned by Cisco Systems, 'Technology in Schools: What the Research Says.' 2006.<http://www.cisco.com/web/strategy/docs/education/TechnologyinSchoolsReport.pdf> (accessed 4/23/2011).," 6.

software will have no effect except to further convince students formal learning is irrelevant and out of sync with the world they live in (and they wouldn't be wrong).

5.3 CHALLENGES IN IMPLEMENTING TECHNOLOGY

A survey of 2,000 Ohio Principals done in 1941 allowed respondents to cite the reasons why radios were not used more in their classrooms. The most common answers were no radio-receiving equipment (50%), school schedule difficulties (23%), unsatisfactory radio equipment (19%), lack of information (14%), and programs not related to curriculum (19%). According to Larry Cuban in his book *Teachers and Machines: The Classroom Use of Technology Since 1920*, the reasons given above also generally correspond with answers given to explain why film was also not more heavily used.⁶²

The Metiri Group produced a report for Cisco in 2006 summarizes how technology in the classroom has been oversold as a panacea for issues in education:

“First, in being overly confident that they could easily accomplish the depth of school change required to realize the potential technology holds for learning – not an easy task

Second, in their lack of effort in documenting the effect on student learning, teacher practices, and system efficiencies

Third, in overestimating the time it would take to reach a sufficiency point for technological access

Fourth, in underestimating the rate of change in technology, and the impact of such rapid, continuous change on staff time, budgeting, professional development, software upgrades, and curricular and lesson redesign.”⁶³

This seems a fair assessment; however, it shouldn't come as much of a surprise (in hindsight). The existing model of education (as well as the schedule and structures) have remained mostly unchanged in the last century despite significant changes in the world outside the classroom.

More technology in the classroom is slowly changing the role of the teacher from sage to facilitator. It's also changing the method of delivery and the content being delivered. It's not enough to introduce technology if corresponding curriculum updates, building

⁶² Cuban, *Teachers and machines: the classroom use of technology since 1920*, 25.

⁶³ “Metiri Group—Commissioned by Cisco Systems, ‘Technology in Schools: What the Research Says.’ 2006.<http://www.cisco.com/web/strategy/docs/education/TechnologyinSchoolsReport.pdf> (accessed 4/23/2011).”

infrastructure, and instructor training don't take place as well. Further, those updates need to be grounded in established principles of learning.

5.3A. NOT UNDERSTANDING THE MEDIUM BEING USED

One major issue with the use of technology in the classroom is the desire to use a new tool to simply re-create the existing model of instruction. Computers/tablets should not be considered as substitutes for teachers (at least not yet). They should also not be used in the same way as pen and paper with students simply following along with whatever the instructor in the front of the room is doing.

Charles K. Stallard, one of the authors of *The Promise of Technology in Schools*, states in that book that when creating computer-based training for government employees in the 1980s he found that adults began to tire and lose interest after about 14 minutes of uninterrupted interaction with the computer training. He further states the attention span of children and adolescents is similar and that after 15-20 minutes attention span becomes an issue.⁶⁴ Other accounts have anecdotally put that number as high as 30 or 40 minutes, but the point remains. This is exacerbated by student class periods being of a set length and often several times longer than this. If a teacher reserves a computer lab it's often for an entire period and then it's assumed that period will be used in its entirety. Elementary schools have been slightly more successful as they're less likely to be broken in to discrete periods and a few computers are more often placed in to elementary school classrooms than classes taken to a full computer lab.

5.3B. INFRASTRUCTURE

The use of a computer lab was easier on infrastructure than placing computers in each classroom. By concentrating IT personnel in one or two designated areas in a school, wiring, equipment, and storage can be localized to those areas saving money and making that person more efficient at their job. Wiring and networking a 50,000 square foot building (or buildings) is obviously going to be much more expensive than simply wiring a few thousand square feet worth of computer lab. A happy medium needs to be found with room built in for upgrades and additional capacity. The price to completely network an average-sized elementary school (600 students and 200 computers) in 2001 was \$200,000.⁶⁵

This can be expected to change as wireless (Wi-Fi) has become the preferred method of connecting to the internet. Cloud computing is also becoming much more popular as well. Customers and users were extremely hesitant to store their work or personal data off-site as little as ten years ago. Now with the rise of social networking as well as picture

⁶⁴ C. K Stallard and J. S Cocker, *The promise of technology in schools: the next 20 years* (Scarecrow Education, 2001), 29–30, <http://books.google.com/books?id=oaecAAAAMAAJ>.

⁶⁵ Stallard and Cocker, *The promise of technology in schools: the next 20 years*.

and media storage the cloud has become an accepted method of data storage. Programs like Dropbox and the recently released iCloud have become extremely popular and this will greatly reduce the need for on-site storage and servers.

5.3C. INSTRUCTOR TRAINING

Another concern with effective use of computers in the classroom was instructor training. Few teachers had much experience with computers when they first started to be introduced in to schools. The model of education in the U.S. that's been setup is the instructor as the primary resource of information in the classroom, when that instructor isn't familiar with a complex tool then it's likely not going to be used effectively, and often not used at all.

In 1995, the United States Office of Technology Assessment (OTA) put out a report titled *Teachers and Technology: Making the Connection* detailing the lack of training in technology given to educators both in the schools they teach and in higher education programs. They make the claim that technology: "is not central to the teacher preparation experience in most colleges of education in the United States today. Most new teachers graduate from teacher preparation institutions with limited knowledge of the ways technology can be used in their professional practice."

By this point millions of dollars had been invested in technology in schools with 41 percent of teachers having a TV in their classroom and 75 percent of schools having some kind of computer network. Despite the increased introduction of technology, school districts were devoting only 15 percent of their technology budgets to teacher training. The Office of Technology Assessment recommended a number closer to double that.⁶⁶ It's not just matter of funding. Time needs to be set aside for the instructors to be instructed. According to Mark Hines, the Technology Director at Mid-Pacific Institute, only one hour out of 35 per week is devoted to professional development at that institution. Mid-Pacific Institute is a private K-12 in Honolulu, HI that prides itself on its progressive use of technology to educate its students. Recognizing this isn't enough, Mr. Hines relies on peer learning during non-instructional time and offering additional professional development outside of school hours.

OTA was defunded by Congress shortly after this report was given, though the two don't seem to be correlated. Secretary of State Hillary Clinton and New Jersey House of Representatives member Rush Holt among others has called for the agency to be restored.

⁶⁶ O. T.A.D.P.C.U.S Congress, *Teachers & Technology: Making the Connection* (Diane Pub Co, 1994), http://books.google.com/books?id=12pIYq42_noC.

The average number of years of service for a teacher perpetually hovers around 15 years (14.3 in 2003-2004) with 57.5 percent having worked for more than 10 years⁶⁷. This means that only now is the average teacher someone that has grown up with computers and the internet as part of their daily experience. This increased digital literacy of educators will only aid in technology's continued introduction in to the classroom.

5.3D. SECURITY AND NUANCE

Textbooks can be thought of as subset of information the students will be learning that year. Written for a particular age group they are a very controlled method of determining what information those students will be exposed to. The internet is the equivalent of every book ever written and many more that haven't. It includes opinions most of which are not relevant or appropriate for a classroom. Consequently that stream of information is usually locked down with many teachers unable to access non-educational sites, or those deemed to have questionable content. Unfortunately, many school districts and administrators end up banning popular sites like YouTube which, when used properly, can be exceptionally valuable for educational purposes. Banning YouTube, the video sharing service, because it has many videos that have no purpose in the classroom neglects to see just how many can be instructional. Salman Khan's excellent Khan Academy was initially begun as open courseware on YouTube for anyone and everyone to get additional help on their math homework. It is now being piloted in several California schools. Educators must not overreact in their restriction of content and their fear of new technology. YouTube can even be used to share students' work by having them create and upload their own videos. Given how most comments sections look on YouTube it would probably be necessary to disable that access. Sites like YouTube have begun responding to the call for more educationally focused content with sub-sections like the YouTube Teachers Channel which is a safer option.

Similarly, communities of educators have sprung up to share content and techniques utilizing technology with each other. Dan Meyer, a mathematics teacher who became prominent after a TEDx talk about engaging students by using video and real world situations, runs an excellent blog (blog.mrmeyer.com) with shareable content and many of his videos posted to Vimeo and/or YouTube. There are numerous other examples. Even homeschooling or online schooling websites such as K12.com can provide valuable content for public school educators to supplement their texts. Idaho just recently became the first state in the nation that will require that all students take (at least 2 credits worth of) online courses in order to graduate high school.

⁶⁷ T. D Snyder, *Digest of Education Statistics* (DIANE Publishing Company, 2005), Table A-3.8, <http://books.google.com/books?id=bpCBAAAACAAJ>.

With students' technological literacy higher than many of the educators' it then becomes extremely important for those teachers to become well-versed in proper data storage and encryption methods both on the computer and off (having one's password on a sticky note attached to the monitor sort of defeats the purpose of having a password at all).

Even if the schools have no computers as educational tools, technology in schools cannot be avoided. The majority of students still have cell phones and iPods. And actually, schools are toying with the idea of actually allowing students to use their own mobile devices to cut costs. This has yet to catch on widely, however, as it is difficult to monitor those students, and the number of students with those devices is less in primary schools. Below is an exchange from a student's Facebook wall showing how a teacher with knowledge of technology can keep an eye on students even when they're virtually somewhere else.

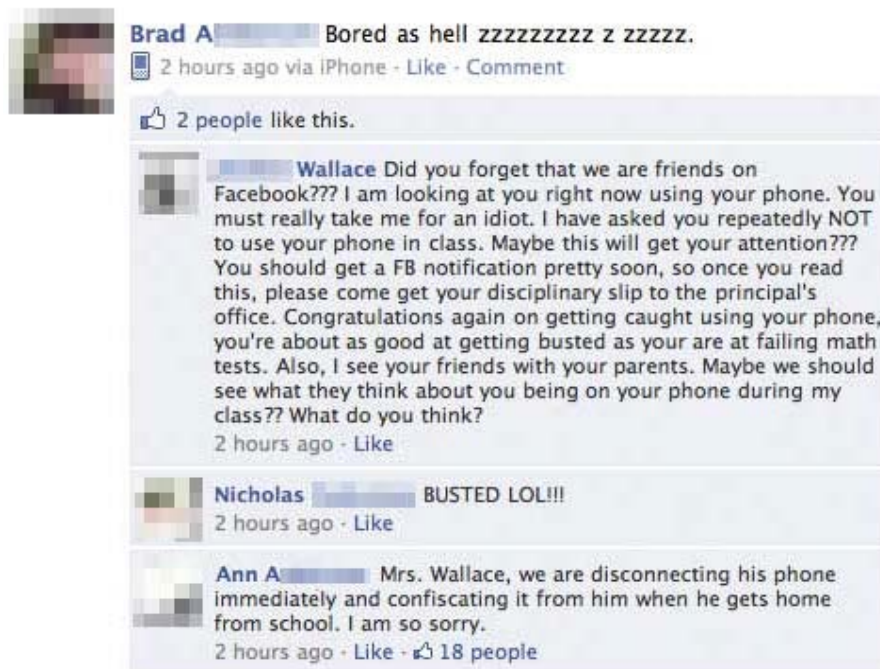


Figure 17: An exchange from a Facebook wall showing a teacher's disciplinary action followed by parental response occurring almost in real time

A student posts online using their phone while sitting in class that they're bored. That in and of itself is fairly remarkable that a student no longer just wistfully stares out the window when bored, but actually connects via satellite with the outside world from (under) their desk. However, that student forgot that due to being "friends" with their teacher, that teacher had the necessary permissions to view that student's thoughts out on the internet. The instructor being up to date on current technology rightfully guessed what

her student was doing and then checked her own Facebook page, likely from her own phone or a computer at her desk. Within moments email notifications have been sent to each and that student's parents whether surfing on the web during lunch or contacted via a separate message by the teacher are brought up to speed and participating in an impromptu parent-teacher conference promising disciplinary action.

The flip side also holds true as there have been several examples in the news recently of teachers getting in to disciplinary trouble for venting about particular students on their blog or Facebook wall. Privacy takes on a very different form in the internet age. Every moment of every day is documented for today's youth. This will only increase and so it needs to be understood by educators.

Policies need to be developed and students, parents, and teachers should be aware of what technology use is acceptable as well as when and where. Other technologies can also be put in place to silence these devices. Many movie theaters, libraries, and government buildings have devices that block those signals to prevent noise or abuse. Schools will need to work with IT staff to determine which areas of the school are "safe" for which forms of technology and then develop specific plans on how to permit use of each.

As technology saturates society even more, parents and employers will pressure school districts to integrate it better in to the curriculum. Issues of internet safety, and nuanced discussion on how to provide students with the most access possible without it being detrimental need to take place sooner rather than later. These issues will only get more complicated with time and so it is important to stay ahead of the curve in terms of creating sufficient school buildings.

6. THE CURRENT STATE OF PRIMARY SCHOOLS

6.1 CURRENT TRENDS IN TECHNOLOGY USAGE

“The biggest obstacle to school change is our memories.”

- Dr. Allen Glenn, professor and former dean of education at the University of Washington

It seems the educational system in this country might be in store for a significant revision in the coming years (history may prove us to be in the middle of it now).

Technology can be used in multiple ways, and in and of itself it is not a cure-all for the problems faced by schools and educators today. Computer labs of the last two decades were attempts to recreate the old classroom with new technology, and they were ineffectual. With the massive amounts of data online, there’s been a recent movement to what’s referred to as “just-in-time” learning. Wikipedia has 3.3+ million entries while a standard Encyclopedia has around 65,000. It’s not possible through rote memorization (just-in-case learning) to internalize even close to a significant percentage of what’s on the web. And frankly, even if it were through years of intensive study, why bother? Computers are much better at acquiring and storing data than humans will ever be. Instead, students should be taught how to search for what they need when they need it.

This isn’t necessarily a good thing as it makes us heavily dependent on technology. Think for a moment if you can recite the phone numbers of your five closest friends; or if you just know where to find your friend’s name easily in your phone to press and have the device dial for you.

What we shouldn’t do is decry what’s lost while ignoring what’s gained. Every time there’s a new technological increase it opens a can of worms about kids losing the ability to <blank>. It is true this generation probably won’t be able to write in cursive – probably not a big loss. It’s also true they may have fewer face-to-face interactions with peers than their predecessors, but they will almost certainly have more social interaction through cell phones, instant messaging, and social media like Facebook. Both what is gained and what is lost should be taken in to account in future design (that is of course we still find value in what’s being lost).

Another reason technology is finally changing pedagogy is the rise of small and inexpensive mobile devices such as smartphones and tablets. These types of devices are very different from bulky desktop PCs and should be treated accordingly. A class in a computer lab used to be about learning about computers. Now students will use technology to learn about all subjects, and do so where they’re most comfortable. In order

for this to be most effective, teachers must adjust their teaching style to best use the mobility and interactivity of whatever device is being used.

Dr. Ruben Puentedara has identified four different ways that technology can be used in relation to a previous task:

- **Substitution:** using technology to do the same task as before, like writing a paper in word processing software versus on paper.
- **Augmentation:** using tools built in to the technology to enhance the outcome. An example would be using Microsoft Word's built-in thesaurus or spell check tools. Other similar features like copy and paste are not available with paper (or at least not in a way that presents a polished final product).
- **Modification:** redesigning the task to make use of available technology. Students after reading a book might be asked to write a 500 word paper explaining a particular character's perspective. Another option would be to ask students to create a short 3 minute film on that character.
- **Redefinition:** design the task with the new technology in mind instead of pigeon-holing old assignments to the new tools. How many times have a four person group presentations become four different Powerpoint presentations strung back to back with different color schemes, fonts, etc. This is because the project is not truly collaborative. New tools like Google Docs and Dropbox allow for multiple users to access and update the same content. Instead of just assigning a 3 minute video, the professor can also ask that it be uploaded to a class website and then ask other students to post their reaction to each film allowing the groups to moderate the ensuing discussion which might include links and other embedded info.

Technology allows the locus of control of the classroom to shift from the teacher to the students. When visiting the Mid-Pacific Institute in Honolulu, Hawaii, I witnessed a student asking their teacher if they could use iMovie to complete an assignment. The teacher responded that he hadn't specified a medium so a movie would be fine, but he didn't know how to use that particular software so they would need to search out online tutorials and check YouTube to see if learning the software and completing the assignment were both feasible in the time allotted. No longer is the teacher the sole repository of knowledge in the classroom; or as the saying goes, the "sage on the stage", has now become the "guide on the side".

Needless to say the above principles of modification and redefinition have not been universally employed by those teachers using technology. Technological integration in to most of America's classrooms has begun, but new teaching methods have largely fallen short and are struggling to catch up. Part of this rests with the fact that school buildings

and the environment in which students learn have not changed much in the last century. This effect will only be exacerbated over time as technology begins to change pedagogy and those districts that built schools without anticipating the change will be failing at their primary task.



Figure 18: Compare/contrast classrooms in operation 71 years apart; not much of a difference⁶⁸

Graham Browne-Martin, the founder of Learning Without Frontiers (LWF) doubles down on the need, not for more technology in classrooms, but to fundamentally change teaching practices and the outdated “industrial-institutional complex”. This will ensure that technology is not a disruption in the classroom, but is integrated in to the curriculum, the educator’s training, and the instructional spaces (as well as the whole campus):

“So are we to go through another cycle of missed opportunity as a result of trying to fit the 21st century into the 19th?”

Are we really going to carry on talking about how we might use clunky learning platforms on mobile and gaming devices? How we might integrate iPads with Interactive White Boards? How the over-priced and over-maintained LMS might integrate with gaming platforms? How we might apply gaming mechanics to tired educational software? How we might enable the teacher with admin rights or other controls on a learner’s personal device?

...

There’s been an on-going industrial-institutional complex at play here for at least the past 30 years that has ensured the continued irrelevance of technology to learning in the formal setting which has been a gift to those in government who would like to opt our learners out of the 21st century and return to back to basic

⁶⁸ “Learning Without Frontiers - Our Blog - The Napsterfication of Learning”, n.d., <http://www.learningwithoutfrontiers.com/blog/2011/4/14/the-napsterfication-of-learning.html>.

teaching practice. This would be fine of course if our learners were joining a back to basics, 1950's world after they leave their formal education.

You know what I'm talking about here, technology designed to replicate and support existing teaching practices and formal learning environments which quite frankly haven't changed a great deal since the mid-20th century. As I've oft said the problem with this approach is that we get the same, often mediocre, results only quicker."⁶⁹

It's not that technology isn't suited for the classroom; it's that the instructors and facilities haven't been setup to use it as would best serve the students. The use of instructional tools and games has been a part of early childhood education for a long time, and will resurface as a backlash to the current model of standardized testing and rote memorization along with the ease of use of apps and tablets. In fact, it's already starting to happen: "A revival of academic interest in Froebel and kindergarten seems at present to be underway, assisted by easily accessible Internet sources." Peter Weston (2002)⁷⁰

Thirteen percent of children in the U.S. are obese, so even if school systems are successful in cramming their heads full of Language Arts and Math all day the child is still being done a disservice.⁷¹ Most people would agree that sitting in front of a computer screen all day is clearly not the proper use of technology for a young child, and so a fundamental restructuring of teaching practices needs to be understood. Some of these fear no doubt stems from the fact that many adults can't get away from sitting in front of a screen all day and long for days out in the sandbox.

No matter your opinion, technology cannot be avoided. Milton Chen in his book *Education Nation* states:

“When considering the importance of every student with a computer many butts enter in to the discussion. But it's expensive. But technology doesn't work. But teachers don't know how to use them. To those doubters I pose three simple questions:

- Do you need a computer?
- Would you give up your computer?
- Would you share your computer with three other people?

⁶⁹ Ibid.

⁷⁰ “The Institute For Figuring // Exhibition:INVENTING KINDERGARTEN.”

⁷¹ “The Institute For Figuring // Exhibition:INVENTING KINDERGARTEN.”

If you answered “Yes” to the first one and “No” to the last two, why do we deny students the same tool we rely on?”⁷²

Even for children who haven’t yet reached school a large number are already online and using computers. For children 5 and under, their parents report 23 percent of them use the internet⁷³ (and of those that do use it, 82 percent access it weekly), and for children ages 2-3 they spend on average 1 hour and 51 minutes per day using screen media.⁷⁴ Whether it’s made it from the home to the schoolhouse and to what degree is another matter. Auburn School District in Maine has recently purchased iPad 2s for the entire incoming Kindergarten class⁷⁵, with the intention of doing so every year going forward. Reaction from the community has been mixed. They’re the exception to the rule as early adopters, almost every school district in the nation struggles with understanding how best to implement new technologies and then balance those decisions with training and costs in a time when school districts are facing drastic cuts across the nation. Regardless of whether a new school is being constructed privately or with taxpayer monies it needs to take in to consideration the role technology will play in the future of education.

6.2 TRENDS IN EDUCATION

Schools are highly institutionalized and resistant to change. Large scale change to pedagogy enacted quickly is a rarity, but change does occur; to get an idea where pedagogy is going one must look at some of the programs meeting with success and some of the institutional hurdles resisting those changes despite their proven track record.

“While many progressive educators have attempted to change teaching and learning by using the conventional tools of curriculum redesign and teacher training, technology enthusiasts believe that computers can provide the kinds of immersive, customized, and adaptive learning opportunities that can reach the children who fail in schools.”⁷⁶

The current generation of new teachers is the first to have grown up their entire lives with the personal computer and technology as a part of it. It seems likely they will be less resistant to the adoption of technology in the classroom and any ensuing change in

⁷² Chen and Lucas, *Education Nation: Six Leading Edges of Innovation in Our Schools*, 87.

⁷³ Aviva Lucas Gutnick et al., “Always Connected: The new digital media habits of young children” (The Joan Ganz Cooney Center at Sesame Workshop, March 2010), http://www.joanganzcooneycenter.org/upload_kits/jgcc_alwaysconnected.pdf.

⁷⁴ V.J. Rideout and E. Hamel, “The media family: Electronic media in the lives of infants, toddlers, preschoolers and their parents.” (Kaiser Family Foundation, 2006).

⁷⁵ “Video - Breaking News Videos from CNN.com,” News, *CNN*, April 8, 2011, <http://edition.cnn.com/video/#/video/us/2011/04/08/dnt.me.ipad.kindergarten.wgme?iref=allsearch>.

⁷⁶ A. Collins and R. Halverson, *Rethinking education in the age of technology: the digital revolution and schooling in America*, Technology, Education–Connections (TEC) Series (Teachers College Press, 2009), 29, <http://books.google.com/books?id=koIkAQAAAMAJ>.

pedagogy. The data doesn't yet bear this out on a large scale, but at a minimum these instructors will have a baseline familiarity with current technology. One important factor related to the above will be to what extent and how fast Education programs at the university level can incorporate technology and expected changes to pedagogy in to their curriculum and certification processes.

As mentioned previously, blogs like Dan Meyers and other online tools like Khan Academy (educational content), and the excellent website Mindshift (educational trends) have proven indispensable for young teachers who are interested in supplementing the standard curriculum. The internet helps to level the playing field of content available to teachers with the motivation to search it out and develop new lesson plans. Khan Academy's meteoric rise to prominence and the near universal praise is not a coincidence. The zeitgeist of the time is ripe for educational change and technology to be at the forefront of that change. Schools were previously limited to teaching what the educators on staff at that particular location knew (for the most part). Now, if a district decides learning Chinese is important, they can collaborate with other districts that already have a Chinese instructor teaching a course online as has happened in Alabama.

Governor Bob Riley introduced a program in 2005 called Alabama Connecting Classrooms Educators and Students Statewide (ACCESS). The pilot project cost \$10 million and brought with it a number of skeptics, but it has proven to be quite successful in increasing equity and access for all of Alabama's students.

“In 2006 students took more than 4,000 courses at 24 schools. In 2008, with ACCESS now in more schools, the number exceeded 22,000. Administrators are finding new ways to liven up the experience. Last year a dozen schools went on a “virtual field trip” to Antarctica, with scientists beamed in by satellite, and a school in Birmingham has been liaising with a counterpart in Wales.”⁷⁷

That penetration rate means that now every one of Alabama's public high schools offers college-level Advanced Placement (AP) courses (that number was around half prior to ACCESS). And as of today any student interested in learning Mandarin Chinese can do so. Beyond the increase in options is real learning, from 2003 to 2008 the number of black students successfully passing their AP subject exam climbed from 4.5% to 7.1%, the largest in the country during that time.⁷⁸

Many programs are available for schools that have the infrastructure to access them. The JASON Project has been operational for over two decades allowing hundreds of thousands of students to virtually travel with and interact with oceanographers on annual

⁷⁷ “Online education: Raising Alabama | The Economist,” News, *The Economist*, July 16, 2009, <http://www.economist.com/node/14034911>.

⁷⁸ Ibid.

expeditions to the ocean floor. Other online programs allow for students to visit zoos through video-conferencing, simulate the stock market without destroying the nation's economy, etc. These programs allow for a sharing of resources increasing student/teacher options as well as reducing costs (there aren't enough Chinese teachers or even Physics teachers in some states for each school to have one dedicated to each location). There are 14,000+ school districts in the country and it's not possible or feasible to have an expert in every possible subject at every location.

Many of these programs are available through video-conferencing technology and have spurred an increase in home schooling and distance learning. There are 37.9 million children in Primary Schools in the U.S. including Kindergarten. Of the students in K – 12 roughly 10% are in private schools with an additional 2.9% being homeschooled. That homeschooling number is up 74% from 1999 when the Department of Education started keeping track.

Religion has always been understood as a major factor for those who decide to home school their children. In a recent 2007 Parent and Family Involvement in Education survey publicized by the Dept. of Education's National Center for Education Statistics (NCES), 83% of respondents listed the desire to provide religious or moral instruction as a reason for homeschooling. The number one reason, however, with 88% mentioning it (respondents could choose multiple answers) was concerns about the school environment (including safety, drugs, and peer pressure).

Those numbers are difficult to track as those who home-school are often very wary of responding to government surveys, but it's clear that the number is increasing and that technology is playing a role.

Up until this point most any student that was homeschooled was in that position because they or more likely their parents decided it was the best option. Now, however, more districts are introducing online or blended (a combination of online and on-site) options. Often times these start as charter schools that can work outside normal guidelines but still receive state funding, as is the case with the Hawaii Technology Academy (HTA) in Waipahu, Hawaii.

The Hawaii Tech Academy began as an online K-12 school for Hawaii public school students. It's comprised of roughly 30% military and about 40% students who were already being homeschooled, but now can do so in a more formal manner. Using software offered through K12.com students originally worked almost exclusively from home (or wherever else they wanted) and would check in through chat periodically with instructors. Instructors (and administrators) can also use built-in tools within the software to keep track of progress and find out whether a student is behind the semester's pace or struggling on a particular unit.



Figure 19: Computer Lab at the Hawaii Technology Academy
Photo Credit: Eric Siwy (2011)

In fall 2011 the school switched to a blended model and now each student has two days a week of on-site instruction (once a week for Kindergartners). Classes meet before noon and then the school stays open for another few hours to allow students to work on their online assignments and receive individual tutoring. Each student in grade 5 and above is given a laptop to use (they pay insurance and only pay a small deductible if the device is lost/stolen/broken). Each student in Kindergarten to 4th grade uses the in-school desktops.



Figure 20: Kindergarten classroom at the Hawaii Technology Academy
Photo Credit: Eric Siwy (2011)

There are almost 1,100 students enrolled at the school with a few hundred coming in on any given day. All of those students are educated using only eight classrooms and roughly thirty full-time instructors (plus about five administrators and IT specialists). In addition, there is a computer lab, administrative offices, an IT/storage space, and (even with the limited space they have) a room dedicated solely to standardized testing. This is well below what a typical school requires as can be seen in the Case Studies section. As a matter of fact there is only one teacher per subject and for some of the younger students, only one teacher per grade level (100+ students).

Their success is encouraging in that it shows the model can work even without a lot of additional money or resources, but it's also a warning that the school environment and facilities can be forgotten about when introducing new technology and even entirely novel educational models. Schools focused on online learning can easily lack what even a deficient school today would consider necessary amenities. In most schools a teacher is assigned to a particular classroom and so that becomes their office as well. Teachers at HTA share classrooms and don't have offices. The closest they have is a small kitchen / break room. There's also no cafeteria, playground, gymnasium, or library. While none of these are absolutely necessary, the lack of all of them means the students at HTA have no space designated for physical activity, recreation, or socialization (they end up in the lobby or stairwell during down time). In terms of size, layout, and overall look HTA's classrooms don't look much different than a typical school. In fact, some are smaller than an average classroom. It should be noted the space is reconstituted from an old office and not specifically designed for HTA or a blended or hybrid model of learning. To their credit, the Hawaii Tech Academy recognizes that their current space is not ideal and, and they're actively looking for a new space that would allow for outdoor activities.

Technology is what allows for this model to be possible, but it's not the only important factor. If students are going to thrive in these newer, very different models of education the environment cannot be overlooked. If the HTA's success is any indication, rethinking what a classroom is or even if it's necessary becomes extremely important in new school design. Architects need to look beyond even the current models to anticipate the pedagogy not yet employed and how that might fit in to a building and learning environment designed today.

6.3 TRENDS IN SCHOOL DESIGN

“The future is already here. It's just not evenly distributed.”

- William Gibson

The above quotation is widely attributed to science fiction author William Gibson (though there's some debate as to when he actually said it). The point is an important one when trying to look in to the future. While it's impossible to precisely predict the future

given far too many variables and a limited understanding of quantum physics, the more that is known about present trends the more plausible the information that is extrapolated.

It should be noted the quote is also somewhat problematic given that it assumes what futurists call a continued growth scenario; that the present will just continue to get bigger and better. The Futures Studies section will go in to greater depth on what that means and why it may not be the case. It will also give future societal context and how that might alter some of these trends, but this next section will show what the present is indicating with regards to primary school design.

The following is pulled from an article put together by KI, an educational furniture provider, that nicely summarizes the work of University of South Carolina Education Professor, Kenneth R. Stevenson, Ed.D.⁷⁹ Though it's almost ten years old, it seems to be a rather fair reading of commonly held existing trends according to the Department of Education, the National Clearinghouse for Educational, Facilities, and others. However, in the past few years some of these have begun to reverse for economic reasons and for others additional research has proven them to be not as important as once thought. Yet most are still commonly held so it is important to address them all and their validity.

Additional trends and caveats are added in an analysis section as the final point for each of the ten listed trends below.

Trend No. 1: Lines of Prescribed Attendance Becoming Less Defined

- Set district boundaries based on similar geographies will change
- 2,400 charter schools operating in 2001-2002 school year
- Each school doesn't have to be everything to everyone (can specialize based on talents)
- **ANALYSIS:** Students will more and more be able to travel outside of their local area to attend schools in other districts that offer services, amenities, and educational models more in-line with the student (or the parents') skills and interests. The number of charter schools continues to increase; as of the 2010-2011 school year there are more than 5,400 of them serving 1.7 million children (half of whom are minorities with 14% having identified special needs).⁸⁰ This trend will likely increase, though probably more so at the middle and high school levels as those schools continue to specialize.

Trend No. 2: Schools Becoming Smaller and More Neighborhood-Focused
Smaller better at:

- improving the academic achievement of students who have not been successful in traditional settings

⁷⁹ "KI Education - 10 Educational Trends Impacting School Planning and Design", n.d., <http://www.kieducation.com/issues.aspx?ar=168>.

⁸⁰ "Facts," *The Center for Education Reform*, n.d., <http://www.edreform.com/issues/choice-charter-schools/facts/>.

- increasing graduation rates
- obtaining greater student involvement in school co-curricular activities
- helping to overcome challenging student behavioral situations
- **ANALYSIS:** After consolidating schools to cut the costs of having diversified curriculum over more numerous smaller schools fifty years ago⁸¹, many school districts began to go the other way in the creating smaller schools with the hope of building community and gaining more individual attention for each student. However, with the substantial budget cuts over the last few years, school districts have had to close many schools creating a forced consolidation. Economics is not the only reason for this trend reversal. Bill Gates one of the largest proponents of this trend has spent substantial amounts of money over the past decade to test it out. His foundation initially found small schools are overrepresented among the highest achievers. It turns out they're also overrepresented among the lowest as well since a small group of good or bad students can more easily skew those numbers. In November 2008 Gates acknowledged: "simply breaking up existing schools into smaller units often did not generate the gains we were hoping for."⁸²

Trend No. 3: Shrinking Class Sizes

- "The current inclination to minimize class size will continue for the foreseeable future (Biddle 2002)."
- **ANALYSIS:** There were policies put in place in many districts limiting class size during the 1980s and 1990s. This is another trend being reversed by the post-2008 economic troubles. Research suggests ideal class sizes are not as small as once thought, closer to 22-24.⁸³ However, designers are asked to create spaces that allow for overflow often up to 27-28. In the near future, however, classes will be substantially overtaxed, but it seems the worst of it will be seen in high schools (Detroit has been considering increasing the allowable class size up to sixty!⁸⁴)

⁸¹ Perkins, *Elementary and Secondary Schools*, 96.

⁸² Staff reporter, "Gates' latest mission: fixing America's schools - Business - US business - Bloomberg Businessweek - msnbc.com," *Bloomberg Businessweek on MSNBC*, July 17, 2010, http://www.msnbc.msn.com/id/38282806/ns/business-us_business/t/bill-gates-latest-mission-fixing-americas-schools/#.Trv-NnL2sm9.

⁸³ Perkins, *Elementary and Secondary Schools*, 29.

⁸⁴ Sam Dillon, "Class Sizes Rise as Budgets Are Cut - NYTimes.com," *New York Times*, March 6, 2011, <http://www.nytimes.com/2011/03/07/education/07classrooms.html?pagewanted=all>.



Figure 21: Overcrowded classrooms have become the norm due to budget cuts
(Source: <http://creekmedic1034.wordpress.com/2011/04/02/seriously/>)

Trend No. 4: Dominance of Technology in the Delivery of Instruction

- Distance learning will be used to offset the costs of smaller, more numerous schools.
- **ANALYSIS:** This is a trend that will likely continue for many reasons outlined in this paper including the continued reduction of cost and size. The Department of Education has made technological literacy a key directive in elementary education. And the numbers support this as the percentage of schools with internet and with advanced technology and computers has continued to trend upwards.

Trend No. 5: Changes in School Spaces

- “According to one viewpoint [Butin 2002], teaching will become more fundamental, driven by the emphasis on school accountability as measured by standardized test scores. The increased focus on academic subjects, in turn, would reduce the demand for music, art and even physical education courses.”
- “In a very different second scenario, standard academic classrooms would be replaced by specialized labs and learning centers (Lackney 1999). However, visionaries contend that segmenting learning into academics, arts, vocational, and other areas is a false dichotomy (Chan 1996). Their perception is that learning is a holistic experience—art incorporated into language arts or math taught with specific job skills or vocations in mind. Under this concept, classrooms must be multifunctional to accommodate a combination of traditional instruction with interactive lab-type exercises that may involve anything from pottery making to drama.”
- “A third scenario maintains an increase in more shared school spaces. Schools of the future will be created or redesigned to allow instructional and support

spaces to be used by outside social and community organizations—or even businesses. For example, a high-school keyboarding space may house a computer technology course in the evening that a local business offers its employees. Or adults in the community may drop by the school health room for a blood pressure check with the school nurse. Such sharing of space is expected to be beneficial to the school and the community.”

- **ANALYSIS:** These three scenarios clearly define the differences in thought currently running through literature on educational pedagogy and school design. The first scenario on school accountability and standardized testing came true during the 2000s, but there is a strong backlash against it. It hasn't changed much yet, but elements of the second scenario have begun to creep in. Technology allows for a multi-discipline approach where students can use different mediums besides pen and paper to solve problems and express themselves. Due to budget shortages there has been little sign as of yet that this will extend to the arts. Some technology proponents may make it seem the iPad can do everything, but it cannot create pottery.

Trend No. 6: Shift in the Organization of Students and Teachers

- Different learner types may have completely different schools. Even within a single school students “may be assigned to a classroom because its design best supports the way they learn”
- **ANALYSIS:** This is an important point. The rise of blended and hybrid schools proves that there is no longer one “typical” school. It is nearly impossible for a space to be flexible enough to do everything that might happen in education. Flexibility gets tossed around a lot as a characteristic of future schools to the point where it doesn't mean anything specific, but it remains a key idea for designers to remember.

Trend No. 7: Students Will Spend More Time in School

- “Schools are under constant demands from policy makers and society. In an effort to comply with educational requirements, school days will lengthen, and the school year will extend to 240 days from its current average of 180 days (Lackney 1999).”
- **ANALYSIS:** There has been no sign of this over the last decade, however, it will continue to be in discussions if learning and graduation rates do not improve. The primary barrier at this point is the additional funds it would require. It seems likely that students will spend more time learning, but not necessarily on school grounds thanks to technology.



Figure 22: Young students gather around a tablet to learn using educational apps⁸⁵

Trend No. 8: Advancements in Instructional Materials

- “School systems of the future will operate virtually without paper... Equally as important, the use of computer resources will affect the visual, thermal, acoustical, and physical environment of the classroom. Maintaining an environment crucial to learning will depend on a variety of technical factors, ranging from controlling the glare from computer screens to providing adequate sound treatment to controlling machine noise.”
- **ANALYSIS:** This is a critical point and will be discussed further later in this project.

Trend No. 9: Modification to Grade Configurations

- “educational facilities will be designed to address the latest findings about when and where students learn best. For example, research indicates that each transition or school change a student makes has a negative impact on learning (Renchler 2000).”
- **ANALYSIS:** The mixing of age levels so that student groups are based more on a student’s aptitude than their birth date is a difficult one to implement as the former has been so ingrained in our educational system. The Gates Foundation’s money will continue to help with identifying what actually works instead of anecdotes. Quantitative data and individualized lesson plans will help to make these assessments and move the educational system another step in this direction.

⁸⁵ Brad Flickinger, “7 Reasons Why the iPad is Going to Change Education | School Technology Ideas,” *School Technology Solutions*, June 24, 2010, <http://www.schooltechnology.org/2010/06/24/7-reasons-ipad-change-education/>.

Trend No. 10: Potential Disappearance of Schools Before the End of the 21st Century

- “Another remotely possible scenario is that schools, as we know them, will disappear (Northwest Educational Technology Consortium 2002).”
- “If technology becomes the main instructional delivery channel of the future, who or what will assume responsibility for the socialization process for which schools have traditionally been held accountable?”⁸⁶
- **ANALYSIS:** The Hawaii Technology Academy and the rise of online and blended schools has made the potential disappearance of schools an option that must be addressed. It seems unlikely on a massive scale, however, as elementary schools also serve as a daycare facility for many students. As technology is stressed and increased the role and importance of socialization in schools must not be forgotten. Technology may become the primary means of instruction, but it cannot be the only means.

It’s telling that many of these trends have not materialized over the last decade, but remain persistent. This reinforces the idea that theorists have known for some time what the problems are, but that institutional forces have remained too strong to change. Technology’s continued introduction will move some of these trends further than others over time.

The following sections will show why the United States has finally reached a tipping point where the problems and pain of not using technology in certain ways in primary schools has exceeded the problems and pain of going with the status quo.

⁸⁶ “KI Education - 10 Educational Trends Impacting School Planning and Design.”

7. FUTURES STUDIES AND ASSUMPTIONS

“Any useful idea about the future must appear to be ridiculous.”

- Jim Dator

The above quotation is University of Hawaii Political Science Professor Jim Dator’s Second Law of the Future. It’s an important dictum and one which the reader should keep in mind during this next section. It may be hard to imagine now, but twenty years ago the idea of a 1 GHz processor device with a touch screen display and access to billions of pages of data containing almost all of recorded human history (audio and visual) in hundreds of different languages probably would have seemed ridiculous. Not only do those devices exist, but they’re about the size of a pack of playing cards, wireless, and relatively inexpensive averaging only a few hundred dollars. They’re also commonplace in the developed world with many households owning one for each family member. It may seem counterintuitive, but seeming ridiculous doesn’t imply that a prediction is implausible. It’s difficult for people to imagine more than five years out, but those individuals who had done some research at the time would have known mobile phones and the internet already existed and could potentially have extrapolated that a confluence of Moore’s Law, high-demand for mobile devices, and the potential of the internet would lead to the situation we have today.

The methods put forth by the discipline of Future Studies are useful for trying to understand the “ridiculous” future that’s in front of us. They’re also commonly employed by large corporations looking to strategize on how best to invest. If an airline can spot trends in oil prices before they happen then they can purchase accordingly giving themselves a competitive market advantage. Governments, including the United States, commonly do the same, especially with regards to matters involving regional stability and national security. If architects are to make buildings that are intended to last many decades, it stands to reason they should make an effort to understand how that structure and its usage might change over the lifespan of the building. It will also give them a competitive advantage when vying for jobs if they can explain the rationale for decisions made to a prospective client to convince them of future savings and increased comfort. In order to do so, an architect must have some familiarity with forecasting and other futures studies methods; if not to do it themselves, than at least to spot good work done by others.

The futurist methods of scenario planning, trend extrapolation, environmental scanning, and cyclical pattern analysis will be explained and employed. The scenarios put forth will be based on past trends, present conditions, and anticipated future events. There will be some commentary, but detailed analysis will be saved for Chapter 8: **REPRESENTATIVE FUTURE LEARNING SPACES.**

Childhood education in the United States is driven by many societal forces including governance, economy, population, environment, media culture, and of course technology; and all will be discussed to some degree in so far as they relate to primary school architecture (e.g. – governance as it affects education policy and budgets, political instability as it affects energy prices, etc.). The following pages are not meant to be taken as a prediction of what *will* occur. There are a near infinite number of possible futures one can imagine for the world forty years from now and so the goal becomes creating robust plausible futures (hopefully probable, not necessarily preferred) that can be defended to outline what should be done in the present in order to best prepare.



Figure 23: Possible futures abound, but this project will attempt to outline a plausible future and not just a preferred scenario
(Source: <http://9gag.com/gag/16718>)

Most views of the future fall in to four distinct categories of scenarios: collapse, sustained existence, continued growth, or transformational change. A collapse scenario implies something fairly cataclysmic has happened to the world causing widespread negative impacts to all of the aforementioned driving forces (think rapid 10 meter sea level rise or a plague that wipes out $\frac{3}{4}$ of the world population). Sustained existence is nowhere near as bad, but implies resource scarcity (think overpopulation and 1 meter sea level rise). Continued growth is fairly self-explanatory and can be seen as what most of the world has undergone for the last half century at a minimum and as an overall arc for much of history. The rate of change can vary from very slight (close to a sustained rate) to very rapid (close to transformational rate). Transformational change, however, implies not just rapid growth per se, but drastic change resulting in new forms of societal organization and behavior. Flying cars wouldn't necessarily be transformational, but true artificial

intelligence in machines or contact with an extraterrestrial species would fit the description.

Since this is primarily a paper on architecture and only secondarily about Futures Studies and the educational system it is necessary right out of the gate to eliminate whole arcs of possible futures that rely on low probability wildcard events. A nuclear war resulting in massive population reduction and complete societal collapse is one possible future; transcendent technology, allowing nanobots to terraform the entire planet thereby solving all resource issues, is yet another. This paper will take an epistemic approach. There are some who believe that we are on a path towards environmental ruin by ignoring greenhouse gases in our atmosphere for so long. Still others believe technology's continued exponential growth will lead to A.I. and other technology that will fundamentally change human existence. Both climate change and technological growth rates are important factors and will be considered, however, given what we know of the world today, neither of the aforementioned scenarios of total collapse or true transformation seem likely enough in the next few decades to substantially impact a primary school being built today, and will therefore not be considered except in passing. As an aside, if either of those scenarios were to happen, whether the world of 2011 accurately designed primary schools for the world of 2040 would probably not be a top concern of that future's citizens.

By looking at current research on climate change, the world economy, education theory, politics, technology, world and U.S. demographics, and several other factors, possible futures will begin to emerge allowing for better design decisions in the present. And, if one disagrees with any of the below (not uncommon to varying degrees with futures studies research), it can at least serve as a framework and jumping off point either to form different conclusions or to adjust when additional information becomes available.

7.1 GENERAL SOCIETAL CONSIDERATIONS

7.1A. FIFTEEN YEARS OUT (2010-2025)

The following section will engage in a process of scenario planning and trend analysis / extrapolation to propose a narrative for the United States over the next fifteen years or so by scanning present day and historical data and media.

Climate change is a very real concern. The science of global warming is overwhelming in its conclusion that current warming trends are anthropogenic. Buildings play a large role and are responsible for 37 percent of all energy used in the United States⁸⁷, more than transportation or industry. Not coincidentally they are also the primary cause of

⁸⁷ USEIA. 2009. *Annual Energy Outlook*. U.S. Energy Information Administration. DOE/EIA-0383(2009), n.d.

greenhouse gas emissions per volume contributing to global warming. The International Panel on Climate Change (IPCC) shows the parts per million (ppm) of Carbon Dioxide at 387 as of 2008. In order to avoid irreparable damage to the Earth (and more importantly its inhabitants), the IPCC has shown that we must keep that level below 350ppm⁸⁸. The graph below shows in red where business as usual will take the country over the next twenty years. It also shows what Architecture 2030 and the Copenhagen Climate targets (buildings portion) would propose in order to avoid catastrophic climate change. The bottom two lines are desired or targeted rates of change.

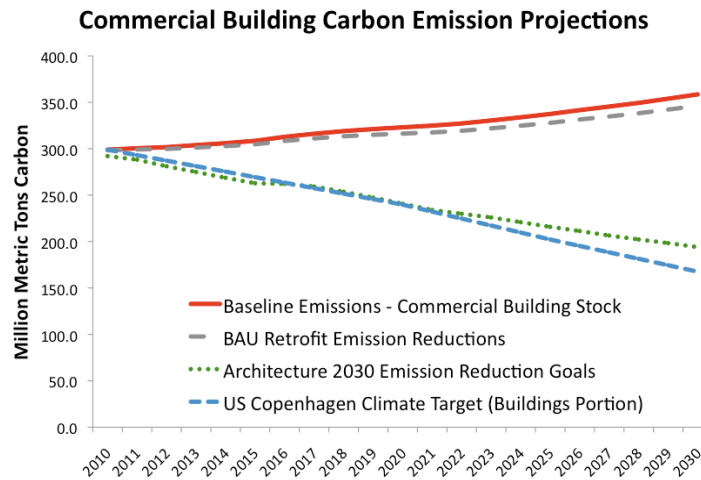


Table 5: Projected carbon emissions for commercial buildings alongside⁸⁹

To give an idea of what would be required to get this nation to those lower lines, Architecture 2030 calls for every new and major renovation to be done at drastically reduced level of energy usage and carbon emissions from the existing ASHRAE baseline resulting in each new building being carbon neutral (using no fossil fuel greenhouse gas emitting energy to operate) in 2030.

All that said, overwhelming scientific evidence has often not been enough to convince the general populace of something if the zeitgeist of the era favors a different story. In a March 2010 Gallup poll, 67% of respondents felt that global warming would not pose a serious threat to them in their lifetime; the split on whether global warming was caused by human activities or natural causes was 50/46 respectively.⁹⁰ This marks a sharp

⁸⁸ IPCC. 2007. *Climate Change 2007: Synthesis Report. An Assessment of the Intergovernmental Panel on Climate Change.* http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf, n.d.

⁸⁹ Olgyay, Victor, and Cher Seruto. "Whole Building Retrofits: A Gateway to Climate Stabilization." *ASHRAE Transactions, Volume 116, Part 2. Atlanta, America Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc. 2010. PDF.*, n.d.

⁹⁰ Frankie Newport, "Americans' Global Warming Concerns Continue to Drop," *Gallup*, March 11, 2010, <http://www.gallup.com/poll/126560/americans-global-warming-concerns-continue-drop.aspx>.

change even since just a few years prior as shown below in Table 4. This trend of disbelief will continue in the short-term.

Current economics in the United States being very unstable have caused a shift in focus for the country's leaders to improving the economy above all else. As a result, the actual rate of change in the above chart will not have a constant slope due to slow adopters and global warming deniers.

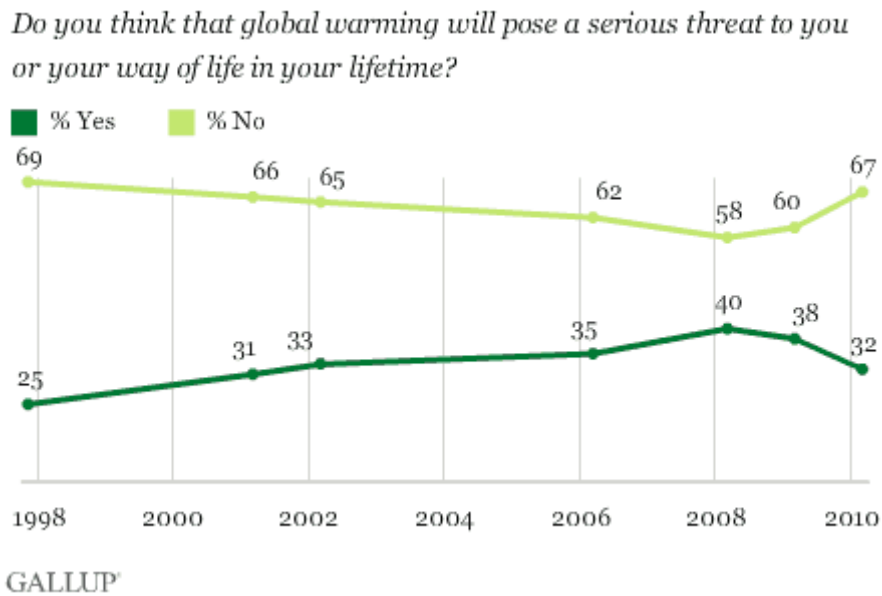


Table 6: Projected carbon emissions for commercial buildings alongside⁹¹

While it may take the better part of the next decade, as the economy improves, polar ice caps continuing to visibly melt more each year, and the parts-per-million of CO₂ inexorably climbing higher will cause the number of deniers to shrink. Though a not insignificant number of people will still be skeptical about whether climate change is caused by human activities, by 2025 no national politicians or mainstream news outlets will be questioning its existence and harmful impacts on the world and its citizens.

Real change will come about for economic reasons. Despite the economy, President Obama will be re-elected in 2012 by a narrow margin as the Republican Party is unable to present a candidate to suitably excite their base and sway Independents. Towards the end of his second term as the world economy begins to recover it will become more and more apparent that the nation's current dependence on fossil fuels is unsustainable. There's some debate over whether peak oil has occurred yet, but even oil insiders like Richard Miller who worked as a consulting geologist for BP up until 2008 and

⁹¹ Ibid.

Christophe de Margerie the chief of French oil company Total believe it will happen within the next 5 years.^{92, 93}

In the 1970's there was a large environmental movement that spread to the general public as a result of the oil embargo and prices for gasoline rising so high. This was a manufactured crisis by OAPEC (the Arab nations of OPEC – the Organization of Petroleum Exporting Countries). As the price for a barrel of oil began to decline, so too did public interest in sustainability. Fossil fuels, however, are a finite resource and the coming crisis will not be manufactured.

The Associated Press ran an article in September 2011 about the decline of the Appalachian coal industry. In it the U.S. Department of Energy is referenced as having projected: “that in a little more than three years, the amount of coal mined here [in Appalachia] will be just half of what it was in 2008.” What’s left is difficult to extract and detrimental to the environment. Out of necessity the U.S. will need to look elsewhere.

U.S. demand for energy continues to increase and China and India are industrializing at unprecedented rates. The next crisis will likely be because demand outstrips cheap supply. Prices will go up as the remaining fossil fuels become very costly to extract. Buildings not designed efficiently will have to undergo costly renovations, operate at sub-optimal comfort levels, or even be shut down.

Historically, the federal government and higher education institutions have set fairly ambitious goals targeting the year 2030 for buildings being carbon neutral or not producing a net positive level of greenhouse gases. This is in part due to the fact that these two institution types are less concerned with a fast return on investment as long as the savings are guaranteed. Municipal levels have been slower to catch on, but many have already instituted required LEED ratings. Efficiency and renewables have very solid return on investments and as the technology improves and installation and efficiency methods become more commonplace this trend will continue and extend down to local governments including schools.

The effect climate change will have on legislation, budgets, and public action in the short-term will not increase dramatically. The effect it will have down the line on those who didn't plan ahead anticipating rising energy costs will be devastating. Budgets are

⁹² David R. Francis, “After BP oil spill, ‘peak’ oil seems nearer than ever - CSMonitor.com,” News, *The Christian Science Monitor*, June 21, 2010, <http://www.csmonitor.com/Commentary/David-R.-Francis/2010/0621/After-BP-oil-spill-peak-oil-seems-nearer-than-ever>.

⁹³ Christopher Helman, “High Friends In Low Places - Forbes.com,” News, January 26, 2011, <http://www.forbes.com/forbes/2011/0214/features-christophe-de-margerie-total-high-friends-low-places.html>.

already tight for public education. That's not a trend that will be reversing any time soon with property tax revenues being so low.

Based on the above another trend that will gain traction over the years is the blended or hybrid model.

The number of privatized schools in the nation will increase. As funds remain low for public schools the increased commercialization of technology ramps up. The success of Channel One News and online retailer Amazon leads other retailers to sponsor content on mobile devices. Channel One is a news-and-commercials television station with a business model of giving free hardware to schools in exchange for being able to show advertisements. It is currently shown in 40 percent of U.S. public schools.⁹⁴ Amazon also recently announced they would offer their Kindle eReader with sponsored screensavers in exchange for a discounted sale price. More and more school districts will move towards digital textbooks. Updated and downloadable content will become more prevalent as well as cloud computing and storing most content on the web. This will create fewer infrastructure requirements at a local level further increasing adoption levels.

Electronics already operating below 100nm continue to go smaller with some experimentation in to nanotechnology and quantum computing. With the electronics industry as established as it is there's not a strong enough reason to contribute large amounts of private capital to delve in to nanotechnology in terms of connecting billions of tiny machines any time in the near future. Quantum computing continues to make strides with small amounts of data being moved, but no major breakthroughs are reported in the next 15 years. Mobile devices continue to increase in power and software offerings and become a key component of educational technology offerings. Budgets do not allow for widespread adoption, but the stigma of young children using technology in an educational setting has been largely eliminated with curriculum development and a move away from standardized testing as it's understood today.

Life expectancy dips for the first time in nearly a century in 2017 causing a renewed interest in healthy eating in media and public school education. A breakthrough in autism research causes many previous special education students to be released in to general classrooms. Many districts realize it has become less expensive to invest in individualized technology and teacher's assistants in general classrooms than continue to operate costly special education programs.

⁹⁴ D. Buckingham, *Beyond technology: children's learning in the age of digital culture* (Polity, 2007), 52, <http://books.google.com/books?id=NFJ1rLv7yIYC>.

7.1B. THIRTY YEARS OUT (2025-2040)

The world population continues to grow reaching near 9 billion people by 2040. China's and India's GDPs continue to rise as they modernize. The increased populations in Asia cause strain on the world's energy and water resources, but also create new markets for U.S. technology.

Water scarcity and resulting crop failures and food shortages have caused major concern for developing nations. The effect on the United States has gone largely unnoticed, but has raised awareness at a local level and resulted in increased military presence in certain key nations to quell resulting uprisings.

The United States hold on being the only superpower has since been lost and they now share the title with China and arguably India. China's continued communism has sparked several diplomatic incidents, but war doesn't seem likely as both countries have too much invested in the economics of the other. The rise of India and China has forced the United States to reassess its role in the world and emphasize creativity and technology. Politicians attempt to legislate this in to the educational system

Back in 2010 the International Energy Agency calculated that to maintain current world oil output through 2030 would require the discovery of six new fields the size of those in Saudi Arabia. This never occurred. Restrictions on deepwater offshore drilling were loosened in the early 2020s, but with little effect. The US Geological Survey estimates there are still massive amounts of conventional crude buried in the world, but it has become far too costly to extract, especially given the increased efficiency of renewables.⁹⁵

Electric vehicles have become more prevalent. The number of 2+ car households has reduced and those that remain often include at least one electric vehicle for short trips. As urban populations continue to grow (near 60% in the United States by 2035), car sharing programs have become popular. In efforts to cut budgets many school districts have encouraged walking and created smart bike programs.

The average size of High Schools continues to decline due to increased home schooling, distance learning, and approved vocational programs. Primary Schools, however, increase slightly in average size growing to 2,200 students. In order to counteract the negative effects of large schools it has become popular for each school to function in small autonomous groups under the umbrella organization while sharing resources.

The percentage of climate change deniers hovers around 10%. There's still about a third of the population that doesn't believe it was anthropomorphic, but as the older

⁹⁵ Francis, "After BP oil spill, 'peak' oil seems nearer than ever - CSMonitor.com."

generations die off and efficiency and renewables figure prominently in the nation's energy generation and usage it becomes easier for people to see the effect mankind has on the planet's environment.

Breakthroughs in renewable energy efficiency have allowed for decentralized energy to become more common and schools must become more aware of their own on-site energy generation devices. Nuclear power still figures prominently though after the 2010 Fukushima reactor problems following the earthquake and tsunami off the coast as well as the terrorist attack on the North Anna, VA plant in 2032.

Space tourism has become big business with many Chinese billionaires taking advantage. At a cost of \$200 million the first private spacecraft trip to the moon happens in 2027 renewing interest in the space program and exploration in the U.S. The event is simulcast to 400 million students worldwide with 3 lucky classrooms that won a contest allowed to remotely drive the rover for a few minutes.

7.2 FUTURES ASSUMPTIONS FOR PRIMARY SCHOOLS

The above sections focused on the external societal conditions under which schools will operate over the next forty years. This section will focus on future technologies that will be developed over the next forty years and have an influence on primary school design. These technologies will be used as examples of how a pedagogical theory incorporating technology might approach various advancements. This then sets the stage of what technology might exist as well as how it might be used. The second phase of this project will illustrate based on current school design theory what factors a school of today needs to keep in mind to optimize for that future state.

The architectural community has less doubt than the general public on issues of climate change. The American Institute of Architects, as well as other worldwide organizations, has come out in favor of sustainability, energy efficiency, and passive design techniques emphasizing a connection to nature and the outdoors.

In the past, learning was equated with schooling. In the information age this is no longer necessary, but the old way of educating has remained. In the dream age students won't need to leave their house to graduate all the way up through college

In 1910, French artist Villemard produced a series of drawings of what life might be like in the year 2000. Below is one that depicts architects and building construction.

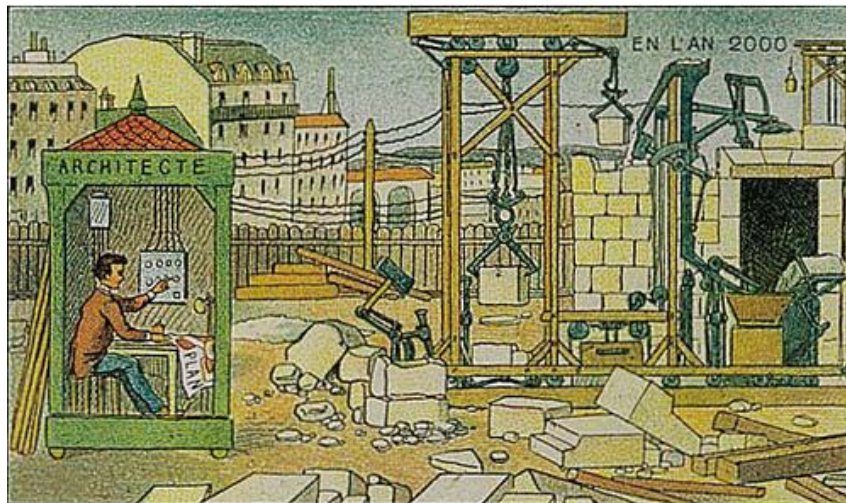


Figure 24: French Artist Villemard's 1910 depiction of the year 2000
(Source: flickr.com user amphalon)

Like many predictions of the future this one seems simultaneously eerily prescient and horribly inaccurate. Towering cranes have been used to build skyscrapers for decades on a scale much larger than this image displays, but mainly for lifting and moving heavy

objects. The complexity of motions that are utilized on an automobile assembly line, for example, is difficult currently to replicate out in the field and at the scale of most buildings.

“If robots are to become an everyday presence, the usual thinking goes, they'll have to be able to function in a completely uncontrolled environment. However, I think the inverse is likely to be true: In the future, we will sculpt our environment to become more robot-centric to accommodate their needs.”

“Such a system has already been reborn at North Carolina State University's new \$115 million James B. Hunt Jr. Library. The school heralds it as "a symbol of the next wave of development" for the institution. One novelty of this new wave is that students will no longer be allowed to wander the stacks, as generations did before them. Two million volumes will be packed into a climate-controlled chamber underground, accessed only via a robotic crane.”

When the Hunt Library is completed in the fall of 2012 students will no longer browse through stacks physically. Instead they'll select a book on the computer and a giant crane will retrieve the book off a shelf inaccessible to the public. Noting that many discoveries in a library are serendipitous while wandering through a particular section of stacks, the computer will display all the books around one's selection on the shelf to see if they might be of use as well.

Technology will also play a much larger role in construction. That is not the purview of this paper, but when considering the future construction of buildings one should not feel limited as if only using the techniques and materials of the present.

The below images are of the Daniel Gantenbein Winery in Flasch, Switzerland designed by Swiss Architects Matthias Kohler and Fabio Gramazio. The brick infill shown, made to appear from afar like grapes, was constructed by a robot. Each brick was laid meticulously by the robotic arm according to previous inputs from the two architects. The effect it has on the interior lighting and ventilation of the fermentation room is quite stunning. They also estimate it was constructed cheaper, faster, and more accurately than a wall of similar complexity would have been by human masons (though obviously slower and more expensive than a flat wall by those same masons). Something in a smaller scale would be a pretty amazing form of Legos for the school of the future.



Figure 25: Daniel Gantenbein Winery

(Source: <http://archidose.blogspot.com/2009/07/half-dose-64-martha-und-daniel.html>)

This is technology that exists today. Couple this with the extensive use of cranes to build today's skyscrapers; and the below image of a Metabolist-like structure, designed by Howeler+Yoon, that can re-configure itself doesn't seem so far-fetched. It actually probably doesn't go far enough to meet the criteria of Dator's Second Law.



Figure 26: Ecopod self-organizing tower competition entry by Howeler + Yoon

(Source: http://www.treehugger.com/howeler-yoon-ecopod-overview_percent20.jpg)

The above building was a competition entry designed as a temporary structure to fill construction sites or vacant lots. It's actually an algae farm and each "ecopod" would be used for research and algae storage being moved periodically to maximize sun exposure and optimize algae growth. This idea could obviously translate to other building types. This might be the school portable of 2030. Couple this with advances in CNC and fabrication machining along with large-scale 3D printing and by 2050 free-form structures will not be as big a deterrent or cost-prohibitive. Optimal dynamic forms can be designed without worry to excessive cost. While the above image is of a rectilinear structure, the existing boxes-within-boxes school design model will no longer be the norm.

An architect might even plan ahead designing modular, interchangeable pieces. This would not increase costs substantially, but might save substantial costs at a later point in time if the design is laid out and constructed for easy expansion or contraction.

Primary Schools will also be much more inclusive of those that were born with or have suffered physical disabilities. The number of people with "special needs" that cannot be addressed in an average classroom will be reduced through improved medicine and technology. As technology becomes smaller and more interactive, those with physical disabilities will more and more have some form of technological enhancement to improve their situation.

“Robotic limbs controlled solely by the mind could be available to paralyzed people within a year.”⁹⁶ That’s the lead for an article in *New Scientist* magazine April 2011. Researchers had already figured out how to surgically redirect nerves to interpret signals from the brain to move limbs for those who have had an arm amputated. This is actually even more impressive as it directly taps in to the brain’s motor cortex for those with spinal cord injuries who don’t have working nerve endings below the neck. Designed by Michael McLoughlin and his team at the Johns Hopkins University Applied Physics Laboratory in Maryland, this would allow someone who’s paralyzed from the neck down to be able to feed themselves with a prosthetic arm that weighs roughly the same as an average human arm (4.5 kg) and has an impressive 22 points of freedom (as opposed to the human arm’s 30).



Figure 27: A man paints using a robotic arm controlled by his mind

(Source: <http://www.newscientist.com/article/mg21028105.000-mindcontrolled-prosthetics-to-help-amputees.html>)

Being that this device is controlled by the mind, it’s interesting to think whether a human being would be limited to having only two of these arms. How many teachers have ever wished for an extra set of arms?

For other disabilities, such as blindness, the iPhone of 2010 already had apps that announce the color being looked at in the viewfinder allowing the blind who once had sight to “see” a sunset or other object.

Haptic responses on mobile devices can already vibrate a smart phone Other augmented reality apps can overlay pieces of information announcing to the user where they are and what’s in a given direction to those without the ability to see or hear. With facial

⁹⁶ Ferris Jabr, “Mind-controlled prosthetics to help amputees,” *New Scientist*, April 30, 2011, <http://www.newscientist.com/article/mg21028105.000-mindcontrolled-prosthetics-to-help-amputees.html>.

recognition software, coupled with miniature hearing aids and cameras someone who is blind can have it announced in their ear who is approaching or speaking to them.

If speech could be visually displayed on a person's retina in real-time (and translated from Chinese at the same time), then the deaf would be able to further integrate in to classrooms with other students. This would increase their socialization and self-confidence, but it also presents some additional design challenges. If this is the case designers might start building in more visual and other sensory cues in anticipation (which would also serve to make school more sense-based for other students).

8. UPDATED DESIGN TRENDS AND REPRESENTATIVE FUTURE LEARNING SPACES

Previous sections discussed mankind's effect on the planet. If increasing population and consumption trends continue, than it's not an exaggeration to say that energy and resource efficiency will have to become the new norm in order for our survival. Many countries around the world have begun moving in this direction with Germany, China, and the United States leading the way realizing that decades of war and strife are the likely future if nothing is done now. As of this document's publication it looks unlikely a major deal will be reached at the United Nations climate talks currently underway in Durbin, South Africa with 194 of the world's nations attending. This failure only further cements the plausibility of the ideas presented in this project.

Any school built today should be designed as a net-zero structure, or at least with the intent and capacity to support renewable systems at some near future date. It is all but a given that a building designed today will need to meet those standards at a minimum at some point over the course of its lifetime. The Energy Independence and Security Act of 2007 is a good place to start in reviewing water, greenhouse gas (GHG), and emissions targets for Federal buildings that should really be used as minimum benchmarks for all buildings. The Energy Design Guidelines for High Performance Schools put out by the Department of Energy is a must-read in this regard as well. The 2030 Challenge website is also a good resource.

There are other constraints a new school faces besides how much fossil fuels are used in its operation. Money is always an issue with regards to education in the United States. Compared to the rest of the world, we spend quite a lot per student (\$9,969 in the 2007-2008 school year), but it's still not enough to meet expectations and maintain competitive salaries and facilities the way it's currently being utilized.

Texas is one of several states that are currently slashing school budgets:

“To balance the budget with cuts alone, the governor and Republican leaders in the Legislature have put forth bills that would reduce the state's public school budget by at least 13 percent — nearly \$3.5 billion a year — and would provide no new money to schools for about 85,000 new students that arrive in Texas every year. School administrators predict that as many as 100,000 school employees would have to be laid off to absorb the cuts.”⁹⁷

⁹⁷ James C. McKinley, “Aid Dropping, Texas Schools Must Scramble to Save Money - NYTimes.com”, February 14, 2011, http://www.nytimes.com/2011/02/15/education/15texas.html?_r=4&pagewanted=1&hpw.

Architects will need to be able to justify every decision and will need to have done their homework on design trends if the cost of a non-specified decision would be anything but a meager cost increase. In this economic climate administrators and politicians will be less likely to take on any additional upfront costs unless solid evidence is presented that those changes will produce savings and high test scores in the future (and possibly not even then).

8.1 FUTURES MATRIX OF EVENTS AND ARCHITECTURAL RAMIFICATIONS

The below table takes the information gleaned from the above futures studies exercises and relates it to specific educational and architectural ramifications.

<u>Year</u>	<u>Future Event</u>	<u>Educational Response</u>	<u>Architectural Response</u>
Technology			
2014	Most educational software and apps are available for free. Content and hardware providers make money through selling devices with streaming ads	This has become the norm for hardware in schools	Large display screens required not just in classroom spaces, but hallways and assembly spaces as well as part of distribution deals
2017	Li-ion batteries last roughly 10x longer due to breakthrough in 2013	Need for long-term storage, charging stations, and even added energy costs alleviated	Pervasive cloud, wireless technology, and excellent battery life means less required on-site infrastructure. Technology personnel less network and more IT with emphasis on professional development for instructors
2017	Real-time translation software now widely available	This makes communicating through distance learning to other students half a world away no problem.	Microphones, speakers, and other audio equipment are equally valuable to screens in future schools that will heavily rely on distance learning and video interactivity
2019	Computers have been able to pass the Turing test for a few years now, but are now used widely for interactive instructional purposes	Increased debate on necessity of teachers	Model of primary experienced teacher plus a few teacher's aides successful and not likely to change

2023	Turing Test computers are mainstream in mobile devices	Students rely heavily on their "mobile AI" for getting around, lesson plans and instructions, as well as conversation practice and home-schooling	Each classroom has an AI assistant teacher. Some have taken on anthropomorphic shapes, but most use holograms. Storage closets for humanoids required. Larger than average energy draw for either method (but still less expensive than an extra assistant teacher) and student : teacher ratios rise to around 40 on average and older 800 square foot classrooms are not accommodating
2028	Minor breakthroughs in quantum computing, but nothing commercially viable	None	No effect as of yet except to slow the rate of change of existing hardware
2033	Price of dual-holoscreen projectors drops making them affordable for the average school	Students are able to experience planetariums in normal 10' height space	Every surface should be considered as a possible projection screen including floor and ceiling
2041	Shortage of rare earth metals brings technology production and some renewable energy generation to abrupt slowdown	Prices are driven way up as demand outstrips supply. Many school districts that haven't already switch to using users' devices	Leads to a further increase in remote learning as parents pull their children to use more advanced home technologies
Governance			
2012	President Obama is re-elected	Common Core standards adopted. Standardized testing still common, but less emphasis	Reinforces constructivist model as viable and slowly more districts willing to make the jump from the traditional primary school typology of teaching the 3 R's to educating students creatively
2020	Congress sets limits on acceptable advertisements on donated technological devices	Hardware donations from vendors become less lucrative and harder to come by	Technology is an integral part of education, but a diversity of spaces and programs will pick up the slack if technology usage or availability wanes

2024	Response to climate change main platform distinguisher in election of 2024. Winner enforces rolling blackouts on evenings, weekends, and holidays	Curbs 24/7 usage, but forces schools to offer some arts courses without technology	A reminder that while technology is primary means of educating, it should not be thought of as the sole means
2036	As the U.S. must start to think of itself as now one of 3 superpowers (and not even the most dominant), Congress realizes our strengths must play to creativity and imagination in the technology sectors	Curriculum is adjusted accordingly	By this point most schools have been designed to accommodate different learning modalities, but this cements a more constructivist approach instead of simply using one's tablet in different spaces
Economic			
2012	OWS continues, student loan debt increases	Fewer kids going to college, will expect public school to prepare them for a career	With fewer kids going to college, parents and society demand high schools meet their new mandate to made students career ready (in addition to college ready)
2014	Real estate prices stay low; budgets remain low. Money stays tight	Kindergarten not mandatory in many states and half days and shorter school years become more common in several hard hit districts	No great change. They'll be back after five or so years. Specific room features not appropriate for older age groups (like a sandbox) should be removable
2023	Oil prices continue to rise; electric vehicle market doing better	School districts and parents demand more bike and walking paths	Treat design as community planning to possibly take advantage of nearby civic resources like parks, libraries, etc. Also, realize students might approach from any direction
Environmental			
2012	"Going green" saves on average \$100,000 in energy costs annually	This money helps to finance additional technology purchases	Focus on passive design and energy efficiency in new school construction as districts realize operational funds will likely be hard to come by for the foreseeable future

2020	Restrictions on deepwater offshore drilling loosened	Little confidence this move will alleviate rising oil prices substantially, but it's still enough to curb widespread change	U.S. generally finds some way to cope, so pervading mindset it still to build to the current day's standards
2024	UNFCCC + COP30 in Dhaka brings about a large change in the global community with almost all nations declaring climate change to be a serious issue requiring concerted and immediate effort	Municipal buildings in the U.S. adopt stringent energy reduction standards	Costly retrofits for those buildings not designed with the ongoing intent of energy reduction
2030	U.S. well below required 2030 levels. New buildings are almost all net zero, but the old are too inefficient to begin reversing the CO ₂ ppm	Civic responsibility and self-sufficiency become stronger themes in education	This carries over to the built environment and all water, waste, and energy must be addressed on-site
2035	China and India leveling off at roughly half the per capita emissions as the U.S., but with 4 and 5 times the population	Continuation of "green" standards better than average building, but still well below what is needed	Designers should not just be meeting standards, but exceeding by as much as possible assuming many others won't be able to
Societal			
2015	Less than 20% of Americans have a child in the school system and are therefore less inclined to pay taxes towards the educational system	Further movement towards community learning centers	Schools now open to general public throughout the day require different layouts and an increased emphasis on security
2017	Life expectancy in the United States dips for first time in nearly a century	Renewed focus on childhood obesity, and overall health and fitness levels	School gardens become more prevalent. Urban schools emphasize green roofs and Microsoft Kinect equivalent workouts
2040	World population reaches 9 billion	Students taught about resource efficiency and the role of the U.S. in the problem and solution	Emphasis on self-sufficiency and community learning center as well as community disaster relief shelter
Educational			
2013	Amazon releases first educational tablet containing sponsored content	Widely adopted	Idea of individualized learning begins to reach public consciousness. Having varied spaces to

			accommodate, follows suit, but isn't as apparent and consequently lags behind
2017	No longer single model for middle and high schools	Online, blended, traditional, along with specialty like arts, vocational, humanities, etc. Not as popular in elementary schools, but not uncommon	If a district or school goes in this direction, then elementary schools will become the community centers and require larger communal spaces. Depending on the district's size, they might also house a blended model of middle and high schools in smaller than normal attached wings or pods instead of maintaining other massive schools that are no longer being used to capacity
2019	Copiers, textbooks, and paper in general used at only a fraction of what it was previous.	These tools have been mostly phased out of schools (definitely new schools).	Additional money can be spent on technology and upfront sustainable design measures
2027	Blended model now accounts for 22% of schools where it seems to be holding steady. Elementary is lower at 13%	No stigma associated with online learning. Still common for some students to opt-out, but even more common for others to opt-in	Public spaces and assembly halls need to be built on different ratio than current 4-5x student body. If possible for larger cafeteria or media center spaces allow for sections to be partitioned off in to additional learning spaces in the future

8.2 UPDATED DESIGN TRENDS

The following is a list of modified design trends taking in to account the best current research and some of the futures studies' conclusions that were documented in the preceding section and previous chapter.

1. Lines of Prescribed Attendance Becoming Less Defined

Students attending school outside of their defined geographic district will definitely continue; in part because certain schools are shutting down and districts are being re-zoned, but more so because of the use of the internet. Geographic boundaries are no longer barriers. If rural students want the amenities of a city school that becomes possible

2. Larger schools will be the norm for the next decade or two thanks to consolidation due to budget cuts

The previously well-entrenched trend of smaller schools being more beneficial is reversing slightly in part due to the Gates' Foundation research and schools consolidating due to budget cuts. However, it now seems like it could make a comeback in another decade or two simply because technology allows for small schools to use the internet to have the resources of larger institutions. However, this will be after a time of consolidation. After initially stating their research showed smaller schools didn't produce the results they were expecting, Bill Gates did qualify that statement by saying small schools do boost attendance and decrease violence: "So we absolutely believe in the small schools thing. Calling that a failure is not fair."⁹⁸ It will also be important to watch the adoption rate of blended schools and homeschooled online learning. If these trends pick up steam due to being far less inexpensive it may lead to the consolidation of schools. The Hawaii Tech Academy is able to get away with eight classrooms for over 1,000 students by only having them come in twice weekly on staggered schedules.

3. Increase in Class Sizes and Rethinking What Constitutes a Class

The trend and desire in the past has been for smaller class sizes. Over the last forty years the average pupil/teacher ratio has looked like this:

1970: 22.3
1985: 17.9
1995: 17.3
2000: 16.0
2008: 15.3

More teachers are being hired. This ratio is not to be confused with average class size which was approximately 20 in the 2007-2008 year for elementary schools.

Current class sizes have been rising. This trend has been felt the worst in high schools with classes up to 30 students, but elementary schools have seen a rise of only a few students on average. New York City, for example has risen to 23.7, up from 21.8 in 2008.⁹⁹ New York bases classroom dimensions on 27 students and so this has remained a

⁹⁸ Staff reporter, "Gates' latest mission: fixing America's schools - Business - US business - Bloomberg Businessweek - msnbc.com."

⁹⁹ Dillon, "Class Sizes Rise as Budgets Are Cut - NYTimes.com."

manageable problem (for primary schools at least). Florida, as another example, recommends 25 for grades 1-3 and most others are in that ballpark.

Massive budget cuts are forcing school closures and layoffs. While the teachers get laid off the students aren't going anywhere (at least not in any significant numbers), which means average class size will increase. It's likely, however, that the dynamic of "class size" will change with the further introduction of technology. Students will work in small groups, but can be in a larger class of 60 and have the primary teacher assisted by several aides. As technology continues to increase and become more interactive and intelligent the number of teachers aides may be reduced, but a school without teachers is a long ways away (if it ever happens, which at this point seems unlikely).

4. Dominance of Technology in the Delivery of Instruction

The Department of Education has made technological literacy a priority, and most students can surf the web before they can even read. This trend will certainly continue, and even when not the dominant form of instruction, technology will always be peripherally involved for the foreseeable future. For example, students can draw on a tablet and play most instruments as well. While not quite the same thing experientially, practice time can be spent on the computer before attempting the real thing saving supplies and not requiring a school to purchase 20 pianos for a class to learn the basics of how to play one. It is of course much less expensive to draw on paper than on an iPad. Purchasing technology makes sense so long as it remains inexpensive and can be used for multiple subjects, because it replaces costs of other current expenditures like textbooks and photocopies of handouts.

5. Changes in School Spaces

"Smaller is better"; this is stressed by several theorists, especially when it comes to technology issues. If this is going to be the case in a resource constrained environment, than other measures will have to be taken to cut costs. Some of this will be from not having to build additional community centers or even town libraries. The primary school will become a Community Learning Center (CLC) with facilities used by all members of the community during certain hours and with certain restrictions.

It also seems likely that as the teacher moves in to more of a facilitator role, larger total class sizes comprised of smaller working groups will become more acceptable with the help of teachers' aides and eventually artificial intelligence. Instead of hiring three fulltime faculty for 60 students they can all be put in to one large multi-purpose

classroom with one well-educated and well-trained primary teacher and 3-4 teacher's aides who can help oversee and instruct the students. From a resource perspective this frees up funds as the aides won't garner the same wages as a full teacher position.

6. Shift in the Organization of Students and Teachers to Different Models of Instruction

This trend will probably affect middle and high schools more than elementary schools, the reason being younger children are also being babysat while they're at school. Regardless, this trend will in fact continue. There has been one primary means of educating young children in this country for the last hundred years. Some students have attended private schools utilizing different educational models, and a small percentage have been homeschooled, but 90%+ have been a part of the "cells and bells" model. This is changing. The internet and small mobile technology allows for individualized lesson plans, distance learning within a school, and online learning from outside of one. In the future there will likely be several different types of schools available and they will have differing space requirements. Understanding the demographics of a district and its intent with regards to growth and technology will be critical in working with them to design a new school.

7. Lifelong learners Will Spend More Time in School and Students Will Spend More Time Learning Outside of School

As community learning centers come to fruition, more and more community members will utilize school (now community) resources to educate themselves, work out, and socialize. On the flip side, students will have access to lesson plans 24/7 through technology. Like workers who telecommute, some online learners will work when is most convenient (for them or for their parents' schedule), which may be outside of normal school hours. If a student is behind they can continue the lesson over the weekend and even watch educational videos from the likes of Khan Academy or other similar sites. Some school districts have extended school hours or reduced summer vacation to fit in more instructional time, but that requires additional money for personnel and keeping the building open and so that trend has not been widespread. Hybrid schools do this more often since the students come in shifts; so some students might be in the building until 5pm, but they don't formally have 8+ hours of instruction.

8. Technology Will Drastically Change Instructional Materials

Actually, this is happening already. The Apple “app” store has tens of thousands of educational apps available for every conceivable subject and the iPad has only been around for two years. Granted some of those were designed with the iPhone in mind, but the iPad is used in educational settings much more frequently. Smart boards are replacing or at least supplementing the typical white board or chalk board.

In November 2011 Pearson, one of the largest textbook publishers in the country partnered with Knewton to bring their content to computers. The point of this partnership is not to simply create e-books out of their textbooks, but to make Pearson’s already burgeoning digital content more data-driven and individualized.¹⁰⁰ They’re interested in creating content for blended learning models. Pearson wouldn’t be even exploring this route unless they felt it was going to be a significant revenue stream in the near future.



Figure 28: A student learns their numbers tracing on an iPad

Source: <http://www.newscientist.com/article/mg21028105.000-mindcontrolled-prosthetics-to-help>

9. Modification to Grade Configurations

This is a trend that seems likely, but not for quite some time, probably at least another decade. Larger classes, individualized learning, and large watering hole spaces will have to precede modifications and any stigma associated with changing grade configurations.

¹⁰⁰ Sarah Kessler, “Pearson and Knewton Team Up to Make Learning Personal,” Technology News, *Mashable*, November 1, 2011, http://mashable.com/2011/11/01/pearson-knewton-data-driven-learning/?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+Mashable+%28Mashable%29&utm_content=FaceBook.

As individualized lesson plans separate students of the same age in to different lesson groups, and as different modalities of learning are also introduced in to the learning environment further separating students in ways other than their age it will become more likely for these modifications to grade configuration to occur.

10. Potential Disappearance of Schools Before the End of the 21st Century

Educating the young will remain a service provided by the government for the foreseeable future. The total disappearance of school facilities even in the next ninety years seems highly unlikely if one allows for the definition of “school” to remain flexible. Primary schools will likely become Community Learning Centers (CLC) with facilities used by all members of the community. However, if schools just become a place for students to take their own iPad and learn through artificial intelligence with freeware apps then something has gone wrong in implementing technology in schools. So instead of thinking about schools disappearing, it seems more appropriate to think about how and where our children will be educated.

9. CONCLUSION

Education theorists have been claiming technology would revolutionize education for the last hundred years, and quite loudly about it for the last twenty. This hasn't happened in part because the tools weren't sufficient yet, partly because it requires a systemic change in administration and instruction and the institutional inertia of the system wasn't up to the task, and largely because the facilities and pedagogy are too rigid to allow for a proper level of experimentation and break from the norm on a wide scale.

The deviation from the status quo that is required to get technology to be its most effective in the classroom can be large. Teachers who are not willing to sacrifice some of their ego to start being a facilitator and not a lecturer will be left behind, but for the moment they still make up a large part of the workforce. Unions are not the problem, but their existence tends to slow the rate of change giving teachers with seniority the first choice to work in new schools that require innovation. Entrenched teachers are usually less likely to embrace change, and newer schools are usually the heaviest involved in experimenting with technology. This was a main reason for the relative failure of the City of Philadelphia and Microsoft's joint "School of the Future".

There is a struggle that goes on every day between administrators and educators, each side believing they know best as to how to educate children. Administrators and politicians tend to lean towards the older industrial model which favors broad strokes to lift up the many at the expense of the few. Many educators understand what is needed to effectively teach children, but lack the necessary resources. The approach of Friedrich Froebel and John Dewey and also Jean Piaget's Constructivist ideas are effective, but are a brand of pedagogy that requires a lot of individual attention and time with each child.

David Thornburg's ideas of Campfire, Watering Hole, Cave, and Life spaces are gaining traction and will allow for greater autonomy and make students who thrive under different modalities (or with different intelligences) better able to learn effectively.

In a resource constrained future it will also be important to plan for full self-sufficiency even if the initial funds are lacking. A designer should take in to account the orientation of the sun and winds to allow for passive daylighting and ventilation as much as possible to reduce energy loads. Lighting should be zoned accordingly parallel to windows so sensors can dim when and where appropriate. The roof can also be sloped to maximize Photovoltaic panel efficiency and/or water catchment even if solar panels or cisterns are not initially called for. Another option, especially in an urban setting is to have a green roof and allow for vegetation or even gardening to expose children to food production and life cycles they normally are not exposed to in an urban setting.

The school can also be a learning opportunity in and of itself. By having exposed systems of ductwork, water from sinks and showers irrigating the grounds students will begin to think of the full lifecycle of their resources and conserve. Real-time displays and interactive energy generation methods like piezoelectric flooring involve students and potentially make a game or competition out of energy generation.

Cloud computing, wireless technology, and increases in battery life will make infrastructure and a “wired” campus less important. It will still be necessary to retain a decent amount of storage space devoted to technology. The Information Technology personnel will spend less time on networks and bug fixes and more time on professional development for the staff.

As technology and its use in the classroom increases so too will the computer’s ability to work directly with a child and tailor the lesson plan and allow for each student to have a unique track and learning experience. This level of versatility will require changes to the standard boxes-within-boxes school design that still remains the norm in too many places. To be effective at teaching, school districts have to lower their costs. This will be done through distance and online learning as well as budget cuts in the near future. Those standard spaces will need to have the flexibility to accommodate new technology as well as new pedagogical methods and different learning styles more easily recognized and catered to through that new technology.

10. BIBLIOGRAPHY

- Armstrong, Sara, and George Lucas Educational Foundation. *Edutopia : success stories for learning in the digital age*. 1st ed. San Francisco CA: Jossey-Bass, 2002.
- Ball, S. and Bogatz, G.A. (1970). *The first year of Sesame Street: An evaluation*. Princeton, NJ: Educational Testing Service., n.d.
- Barseghian, Tina. “Will School of One Expand to a School of Many? | MindShift”, June 21, 2011. <http://mindshift.kqed.org/2011/06/will-school-of-one-expand-to-a-school-of-many/>.
- Buckingham, D. *Beyond technology: children’s learning in the age of digital culture*. Polity, 2007. <http://books.google.com/books?id=NFJ1rLv7yIYC>.
- “Can Sal Khan Reform Education In America?”, n.d. http://www.huffingtonpost.com/2011/04/04/the-khan-academy-and-educ_n_844390.html.
- Chen, M., and G. Lucas. *Education Nation: Six Leading Edges of Innovation in Our Schools*. John Wiley & Sons, 2010. <http://books.google.com/books?id=o0as6OnEqDcC>.
- Coates, Ta-Nehisi. “The Littlest Schoolhouse - Magazine - The Atlantic.” *The Atlantic*, August 2010. <http://www.theatlantic.com/magazine/archive/2010/07/the-littlest-schoolhouse/8132/>.
- Collins, A., and R. Halverson. *Rethinking education in the age of technology: the digital revolution and schooling in America*. Technology, Education–Connections (TEC) Series. Teachers College Press, 2009. <http://books.google.com/books?id=koIkAQAAAMAJ>.
- Congress, O. T.A.D.P.C.U.S. *Teachers & Technology: Making the Connection*. Diane Pub Co, 1994. http://books.google.com/books?id=12pIYq42_noC.
- Cuban, L. *Teachers and machines: the classroom use of technology since 1920*. Teachers College Press, 1986. <http://books.google.com/books?id=uQeEn1vEUSQC>.
- Delacato, Ed.D, Carl H. *The Elementary School of the Future: A Guide for Parents*. 1st ed. Springfield, IL: Charles C Thomas, 1965.
- Dillon, Sam. “Class Sizes Rise as Budgets Are Cut - NYTimes.com.” *New York Times*, March 6, 2011. <http://www.nytimes.com/2011/03/07/education/07classrooms.html?pagewanted=all>.
- Drewes, Paul. “Hawaii Could Set Benchmarks In Education - Local News - Honolulu, HI - msnbc.com.” News. *MSNBC*, October 11, 2011. http://www.msnbc.msn.com/id/44870816/ns/local_news-honolulu_hi/#.TpXud3KH0mE.

- Dudek, M. *Kindergarten architecture: space for the imagination*. Spon Press, 2000.
<http://books.google.com/books?id=PgX0Sr52MRoC>.
- Dvorak, Petula. "D.C. Homeless People Use Cellphones, Blogs and E-Mail to Stay on Top of Things." *The Washington Post*, March 23, 2009.
<http://www.washingtonpost.com/wp-dyn/content/article/2009/03/22/AR2009032201835.html?sid=ST2009032300833>.
- "Embedded: It's a Way of Life" 5, no. 1 (2003).
<http://www.nd.edu/~engineer/publications/signatures/2003/wayoflife.html>.
- "Facts." *The Center for Education Reform*, n.d. <http://www.edreform.com/issues/choice-charter-schools/facts/>.
- Fielding, Randall, Jeffery Lackney, and Prakash Nair. *The Language of School Design*. Revised. Designshare.com, 2005.
- Flickinger, Brad. "7 Reasons Why the iPad is Going to Change Education | School Technology Ideas." *School Technology Solutions*, June 24, 2010.
<http://www.schooltechnology.org/2010/06/24/7-reasons-ipad-change-education/>.
- Francis, David R. "After BP oil spill, 'peak' oil seems nearer than ever - CSMonitor.com." News. *The Christian Science Monitor*, June 21, 2010.
<http://www.csmonitor.com/Commentary/David-R.-Francis/2010/0621/After-BP-oil-spill-peak-oil-seems-nearer-than-ever>.
- Gutnick, Aviva Lucas, Michael Robb, Lori Takeuchi, and Jennifer Kotler. "Always Connected: The new digital media habits of young children". The Joan Ganz Cooney Center at Sesame Workshop, March 2010.
http://www.joanganzcooneycenter.org/upload_kits/jgcc_alwaysconnected.pdf.
- Helman, Christopher. "High Friends In Low Places - Forbes.com." News, January 26, 2011. <http://www.forbes.com/forbes/2011/0214/features-christophe-de-margerie-total-high-friends-low-places.html>.
- Huston, A.C., Anderson, D.R., Wright, J.C., Linebarger, D.L., and Schmitt, K.L. "Sesame Street Viewers as Adolescents: The Recontact Study." Chap. 8 in "G" Is for Growing: Thirty Years of Research on Children and Sesame Street, ed. S.M. Fisch and R.T. Truglio (Hillsdale, NJ: Erlbaum, 2001)., n.d.
- IPCC. 2007. *Climate Change 2007: Synthesis Report. An Assessment of the Intergovernmental Panel on Climate Change*.
http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf, n.d.
- Jabr, Ferris. "Mind-controlled prosthetics to help amputees." *New Scientist*, April 30, 2011. <http://www.newscientist.com/article/mg21028105.000-mindcontrolled-prosthetics-to-help-amputees.html>.
- Johnson, Alex. "U.S. schools in 'category 5' budget crisis - US news - Education - msnbc.com." News. *MSNBC*, March 18, 2010.
http://www.msnbc.msn.com/id/35883971/ns/us_news-education/t/us-schools-category-budget-crisis/#.TpXc93KH0mF.

- Kessler, Sarah. "Pearson and Knewton Team Up to Make Learning Personal." Technology News. *Mashable*, November 1, 2011. http://mashable.com/2011/11/01/pearson-knewton-data-driven-learning/?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+Mashable+%28Mashable%29&utm_content=FaceBook.
- "KI Education - 10 Educational Trends Impacting School Planning and Design", n.d. <http://www.kieducation.com/issues.aspx?ar=168>.
- Kurzweil, R. *The singularity is near: when humans transcend biology*. Penguin, 2006. <http://books.google.com/books?id=9FtnppNpsT4C>.
- "Learning Without Frontiers - Our Blog - The Napsterfication of Learning", n.d. <http://www.learningwithoutfrontiers.com/blog/2011/4/14/the-napsterfication-of-learning.html>.
- Linn, Charles. "The School of One | Architectural Record | Schools of the 21st Century | Features", n.d. http://archrecord.construction.com/schools/09_School_of_One.asp.
- Loveless, A., and B. Dore. *ICT in the primary school*. Open University Press, 2002. <http://books.google.com/books?id=astqQgAACAAJ>.
- McKinley, James C. "Aid Dropping, Texas Schools Must Scramble to Save Money - NYTimes.com", February 14, 2011. http://www.nytimes.com/2011/02/15/education/15texas.html?_r=4&pagewanted=1&hpw.
- "Metiri Group—Commissioned by Cisco Systems, 'Technology in Schools: What the Research Says.' 2006. <http://www.cisco.com/web/strategy/docs/education/TechnologyinSchoolsReport.pdf> (accessed 4/23/2011).", n.d.
- "NAEP Studies - Mapping 2005 State Proficiency Standards Onto the NAEP Scales." *NCES (Dept of Ed)*, n.d. <http://nces.ed.gov/nationsreportcard/pubs/studies/2007482.asp>.
- Newport, Frankie. "Americans' Global Warming Concerns Continue to Drop." *Gallup*, March 11, 2010. <http://www.gallup.com/poll/126560/americans-global-warming-concerns-continue-drop.aspx>.
- Olgyay, Victor, and Cher Seruto. "Whole Building Retrofits: A Gateway to Climate Stabilization." ASHRAE Transactions, Volume 116, Part 2. Atlanta, America Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc. 2010. PDF.*, n.d.
- "Online education: Raising Alabama | The Economist." News. *The Economist*, July 16, 2009. <http://www.economist.com/node/14034911>.
- Paulson, Amanda. "Obama proposes new way of uniformly raising academic standards." News. *The Christian Science Monitor*, February 22, 2010. <http://www.csmonitor.com/USA/Education/2010/0222/Obama-proposes-new-way-of-uniformly-raising-academic-standards>.

- Perkins, Bradford. *Building Type Basics for Elementary and Secondary Schools*. 1st ed. Building Type Basics. New York: John Wiley & Sons, Inc, 2011.
- Perkins, L. *Elementary and Secondary Schools*. New York: Wiley, 2001.
- Prensky, M. *Teaching digital natives: partnering for real learning*. Corwin, 2010.
<http://books.google.com/books?id=BOv6iFWTEAYC>.
- Rideout, V.J., and E. Hamel. "The media family: Electronic media in the lives of infants, toddlers, preschoolers and their parents." Kaiser Family Foundation, 2006.
- "School Design Guide: Los Angeles Unified School District", January 2007.
- "School: The Story of American Public Education." *PBS*, n.d.
http://www.pbs.org/kcet/publicschool/evolving_classroom/technology.html.
- Snyder, T. D. *Digest of Education Statistics*. DIANE Publishing Company, 2005.
<http://books.google.com/books?id=bpCBAAAACAAJ>.
- Staff reporter. "Gates' latest mission: fixing America's schools - Business - US business - Bloomberg Businessweek - msnbc.com." *Bloomberg Businessweek on MSNBC*, July 17, 2010. http://www.msnbc.msn.com/id/38282806/ns/business-us_business/t/bill-gates-latest-mission-fixing-americas-schools/#.Trv-NnL2sm9.
- Stallard, C. K, and J. S Cocker. *The promise of technology in schools: the next 20 years*. Scarecrow Education, 2001.
<http://books.google.com/books?id=oaecAAAAMAAJ>.
- "The Design of Learning Spaces [Book]", n.d.
http://www.google.com/products/catalog?hl=en&safe=off&q=design+of+learning+spaces&um=1&biw=972&bih=652&bav=on.2,or.r_gc.r_pw.&ie=UTF-8&cid=13496626396402408949&sa=X&ei=DYCXTaz0J4SosQPtloDdBQ&ved=0CFoQ8wIwAA#.
- "The Evolution of Classroom Technology - Edudemic", n.d.
<http://edudemic.com/2011/04/classroom-technology/>.
- "The Institute For Figuring // Exhibition:INVENTING KINDERGARTEN." *The Institute for Figuring*, n.d. <http://theiff.org/oexhibits/kindy01.html>.
- Toffler, A. *Future shock*. Bantam, 1971.
http://books.google.com/books?id=D_o1SwAACAAJ.
- Toffler, Alvin. "alvin + heidi toffler {futurists} :: Gallery." *alvin + heidi toffler {futurists}*, 2011. <http://www.alvintoffler.net/?fa=galleryquotes>.
- "United States. Future of Learning: How Technology is Transforming Public Schools", n.d.
- United States. No Child Left Behind Act of 2001*. Washington,: Government Printing Office, 2001. Web. Jan 29, 2011., 2002.
- USEIA. 2009. Annual Energy Outlook*. U.S. Energy Information Administration. *DOE/EIA-0383(2009)*, n.d.

“Video - Breaking News Videos from CNN.com.” News. *CNN*, April 8, 2011.
<http://edition.cnn.com/video/#/video/us/2011/04/08/dnt.me.ipad.kindergarten.wgme?iref=allsearch>.

Walden, Rotraut. *Schools for the Future: Design Proposals from Architectural Psychology*. Cambridge, MA: Hogrefe & Huber Publishers, 2009.

Whitebread, D. *The psychology of teaching and learning in the primary school*. Routledge/Falmer, 2000. http://books.google.com/books?id=MUKPkt_VPjYC.