Comfort Analysis of Differences in Classroom Designs between Socioeconomic Statuses

by

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Abstract

Classroom design has been ever changing, attempting to keep up with the new ideas about education and learning. As we learn more and more about how children learn, we adapt our learning styles with this new knowledge. Architecture is something that is meant to last for a while since construction costs of buildings are so expensive. Because our buildings are changing slower than our learning styles, we are currently having to spend large amounts of money on retrofits to buildings that aren't the best fit. This thesis is a look into the history behind how schools have changed in America and an analysis of a few schools in San Diego that are stuck thirty years behind the times. It takes the pros and cons of these schools and proposes a new way to look at school design for the future.

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1. Introduction

Schools in an architectural sense should be the most academically positive buildings they can possibly be. They should be inviting; places where students want to learn and teachers want to teach. The schools should have features that are most conducive to productivity and learning. Based upon prior research, some of the features necessary for productivity and success are ample daylighting, effective artificial lighting, proper ventilation, and for the layout of the classroom to promote functionality of the classroom. The architecture of the school, purely as a building can help to serve as a vessel of learning, even when one takes people out of the equation. Part of the way to accomplish this functionality might be to model new schools after offices that have shown to have high productivity and tenant liveliness. One office design that works well in terms of productivity is Google. At Google, there are plenty of relaxation and transition rooms as well as conference and office spaces. This idea applies to classrooms, since a classroom acts both as a social medium and as a working medium. Therefore, the classroom should have aspects of an office space, social space as well as home setting since students spend so many of their waking hours in school.

The architecture of schools in low- and high-income areas differs drastically and the resources available in each of these areas also differ. In higher income areas, there is typically more parental support, financially to the school and students, so high-scale

renovations and fancy equipment can be put in place. However in lower income areas parents may be working multiple jobs and may not be able to give back to the school or even help students as much after school with their homework. Why is there a discrepancy in the resources and support available to students based upon socioeconomic status and can we come up with an architectural solution for this problem?

The second chapter of this thesis will serve as a history and background of classroom design and school structure from America's founding to today. Chapter 3 will then discuss the methods used to delve deeper into classroom design within a school district with a predominantly socioeconomically disadvantaged community. Chapter 4 is an analysis of the positive and negative aspects of the schools studied and a proposal for a new perspective to approach school design.

2. History of School Site Design in America

A. Background

Since the United States was founded and the first schools were implemented, schooling in America has evolved: we have changed the amount of time our children go to school in a year, and the amount of time they spend in the classroom daily (Snyder 1993). Schools have grown from one classroom to multiple classroom or even multiple building campuses. We have also changed our views on what items are necessary to include in a classroom, and how they should be set up. Teaching styles have changed: there have been so many changes in all areas of education. Why have these changes occurred? What sparked the transitions?

Because of these enormous changes in education, ascertaining the best educational system for students is a challenge. The school changes that are currently implemented originated in a growing need for larger schools to accommodate the influx of students into education. Societal views have changed in terms of who should be getting an education and how much education everyone should be getting as a baseline.

This paper will focus on students and what affects their success in the classroom. The focus of these buildings should be on the students: they are the ones that will be tomorrow's leaders. If the classrooms we have for students are not conducive to learning, these students are not going to succeed.

This review of literature is meant to trace the history of elementary classroom design in America and also show a case study schools that was built recently. Education has grown from the one room schoolhouse to the schools with multiple classrooms all off of one hallway back to a large open classroom onto a sustainable classroom with features that are currently thought to be the best for student learning. This thesis will give an overview of the different stages of classroom development through the years, focusing on the successes as well as the downfalls that contributed to classroom designs developing into what they are today.

B. American Education: The Early Years

In colonial New England, children were either taught in their homes, in one-room school houses, or in homes of neighboring families. Colonists felt it was acceptable for teaching to happen at home because it enabled the parents (typically mothers) to teach them about the morals and culture of their specific family life. It also allowed for these children to learn what they needed to know about the family trade and also about the religion that the family followed through the Bible (Tanner & Lackney, 2006). It was an all-encompassing education that resulted in little mainstream or standardized education being taught to the kids. The illiteracy levels of the time were

extremely high, but because of this, it was acceptable for children to also be brought up illiterate.

In the 1600s, the English created Latin-based schools and colleges in the thirteen colonies, such as Harvard University in Massachusetts. In 1647, the government of Massachusetts mandated a more formalized school system and put in effect a statute that created more structure and order around the facilities where kids were to be taught (Tanner & Lackney, 2006). This made it necessary for construction to occur in the colonies, in order to erect the buildings and facilities necessary for teaching.

Many of the initial schools were one-room schoolhouses commonly associated with the times. These were sometimes built as part of a church, or were made to be used also as a community center. The schoolhouses were commonly built in smaller villages that allowed for the limited number of students in the village to be taught locally.

Students went to school for a significantly shorter amount of time than they do now. Boys only went during the winter, when not much farm work had to be done; girls went during the summer when less housework had to be done (Sloane, 1972). Many times the classrooms had desks and chairs that were fixed in place so the students couldn't move around and the teacher couldn't personalize the classroom. Typically the classes were segregated by gender, with boys on one side of the classroom and girls on the other side. There were also typically separate entrances.

Lancasterian schools emerged right around the same time, but unfortunately failed. These developed as part of a school system that developed in the cities, and are closest to modern free public education system. Students were in larger classrooms, with few teachers and many teacher's assistants. These failed at the time because of the economic impact of not having the families paying for the student's education. (Tanner & Lackney, 2006)

C. American Education: The 1900s

It wasn't until the 1900s that the one room schoolhouses started to be phased out. In 1913, more than half of the nation's students were enrolled in these one room schoolhouses. In the first quarter of the 1900s, the increased number of students going to school on a full-time basis then required more places to put them. The governments and communities had to figure out how to house all of these students. This was also a period when vocational education and high schools began to emerge – this type of education made it possible for students to learn their trade but also get a general baseline education, which in turn led to a higher literacy rate. High schools developed as extensions of the elementary school. More jobs emerged, family trade became less popular and students were able to think of a whole range of jobs they could have when they grew up. To accommodate for this, more school facilities were added and new

styles of educational buildings, other than the one room schoolhouses were introduced.

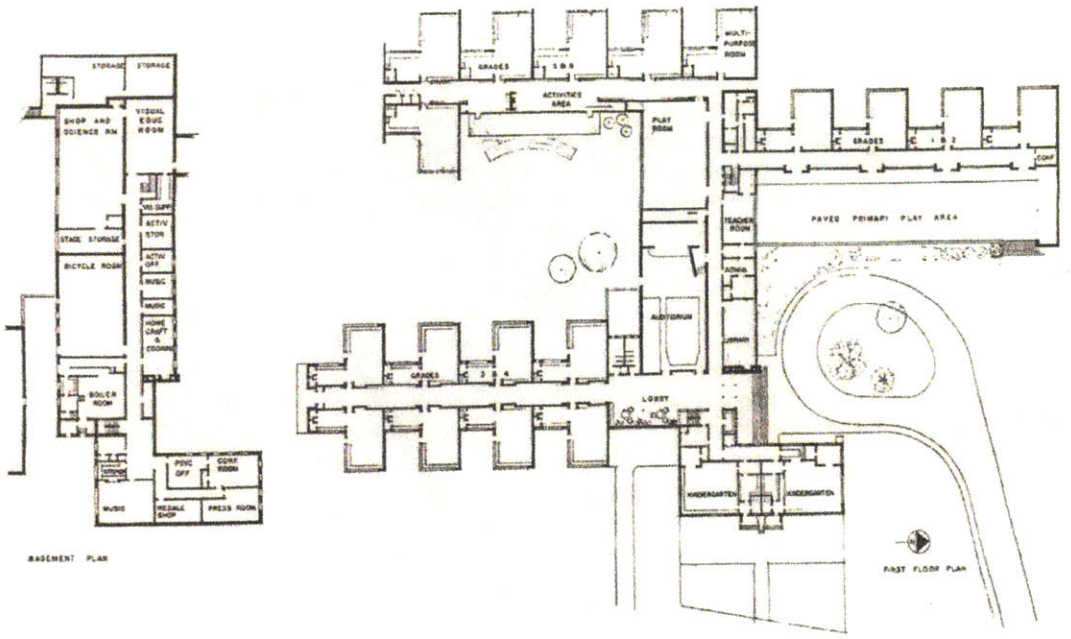

Figure 1. Finger Plan school. Each classroom includes the room, a laboratory area, mudroom, bathroom, outdoor play area. (Tanner & Lackey 2006)

One of the plans that emerged was dubbed the finger plan (Figure 1.): this included long interior hallways that connected all of the classrooms, which were like fingers that branched off the hallways. This permitted the classroom to be attached to a workshop or craft area, a bathroom, storage area, and an outdoor play area.

The baby boom occurred shortly after World War II and there was suddenly a large influx of school aged students requiring education. This was a time when standardized education for all was becoming the status quo. Since the number of people being born around World War II increased compared to previous years, the number of

students reaching school age shortly after that increased as well. Schools had to expand to accommodate this occurrence.

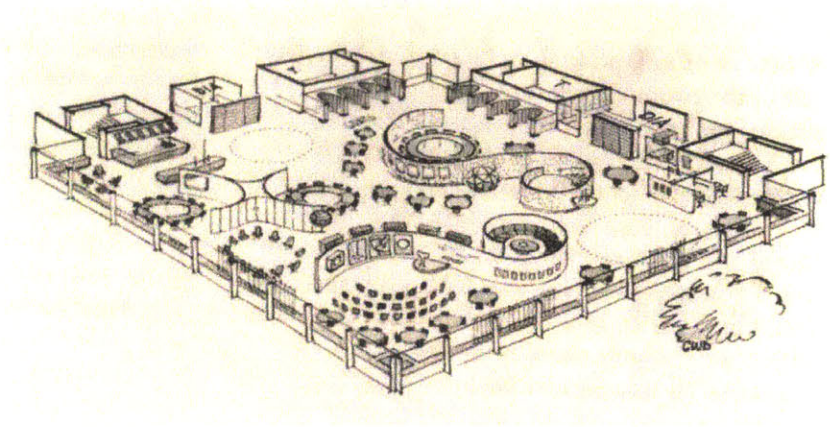

Figure 2. Perspective view of an open classroom. The non-permanent walls separating the various areas are visible. There is a focus on group tables rather than individual tables. (Tanner & Lackey, 2006)

The finger-plan style was a very popular educational facility type until the 1960s, when the open plan of classrooms and campuses was adopted. The idea behind the open plan classrooms was to permit the room to be moveable and allow for personalization. To accommodate for this, the classrooms were much larger than they had been previously in order to fit more people into one space. They would be the size of multiple classrooms all being held in one space. Non-permanent walls were erected, to section off different areas, hypothetically enabling different levels of students to be studying in the same environment. Seats were not connected to the floor or to the desks and so the entire classroom was able to be personalized to an extent. When kids started school continuously, there was a range of academic levels even within one grade level.

Open classroom design ultimately failed due to the noise and visual distractions of having so many people in one place all doing different things. As studies came out condemning this kind of classroom, permanent walls were erected to keep the classrooms separated in terms of sound.

However, it has taken a long time for open classrooms to be completely phased out. Many schools and districts were not able to finance the costs of putting up permanent walls, and many schools across America today still have an open floor plan, with temporary walls between various classrooms.

D. American Education: Now

Technology controls not only our everyday lives but also the educational system. We have things like Khan Academy[1] and Open Course Ware[2] for various universities and schools that allow for younger students to get help and get exposure to a variety of topics that they wouldn't otherwise have access to. Today's classrooms have significantly more electrical outlets for computers and other multimedia teaching devices than they used to (Perkins & Bordwell, 2010). Technology is more prominent in

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[1] https://www.khanacademy.org/
[2] http://ocw.mit.edu/index.htm

teaching through online assignments, PowerPoints, etc. Another aspect that designers focus on in today's time is sustainability. Designing and building for low energy and low impact is becoming popular.

New styles of teaching are more interactive and are based on interactions with the teacher, the technology and peers, and have enabled the student to move away from the fixed seating of the past and progress towards a new seating scheme that allows for movement. (Perkins & Bordwell, 2010) Desks and chairs used to be permanently in one place in the classroom or permanently attached together; now we have moved away from this permanent seating into more flexible seating.

One of the up and coming ideas that designers are focusing on today is sustainability. Studies show that buildings account for a significant portion of energy and environmental effects that we have on the world today, arguing for the design and construction of more sustainable educational facilities. However studies that have examined test scores of kids in these kinds of classroom settings versus older not sustainable classrooms reveal that academic progress occurs at about a 20% faster rate in sustainable classrooms than those that are not. Specifically, in rooms that have better daylighting than other, darker, more artificially lit classrooms, students test scores are higher by 20% (Gelfand & Freed, 2010). Overall, students perform better in classrooms

that are quieter and/or more day-lit than in classrooms that are noisy and/or artificially lit.

E. Next Steps

Classrooms in America have changed shape, size, structure and more between the 1600s when formal education was first established on American soil to now. While one room schoolhouses were popular in the 1600s, they are no longer the best and greatest thing because times have changed. The number of students going to school is significantly larger so the one room schoolhouses are not adequate in size to accommodate everyone that is going to school. Students are going to school for longer periods of time (both daily and annually) and they are staying in school to pursue higher education in most of the situations now. The idea of what classrooms should look like has changed drastically throughout the years because of these factors and is sure to change even more in the coming years.

Low-income areas are unable to provide the funding to upgrade their schools as new ideas emerge about how schools should be built. Because of this, their schools are years behind in terms of architecture and the students in these schools may have the opportunity to get as far as the high income areas where these renovations are more readily able to be implemented. However there should be relatively cheap "quick-fixes"

that can be implemented to help these schools better their performance and help students feel better about their schools.

3. Methodology and Context on San Diego Schools

A. Methods

The planned methodology of conducting comparisons, measurements and analysis is listed below.

I. Comparisons

a. Different Typologies (portables, open plan, individual classroom)

b. Design Attributes (Daylighting, Acoustics, Glare, Comfort)

c. San Diego

d. Low income areas of varying student performance levels

II. Measurements

a. Observations

b. Illuminance

c. Acoustics

III. Analysis

Table 1. Table showing the comparisons that will be made

	Sustainable School	*Mediocre School*	*Not Sustainable School*
Portable Classroom	X	X	X
Open Classroom	X	X	X
Individual Classroom	X	X	X

I. Comparisons

One of the comparisons that will be made is between a few different classrooms typologies (portables vs open plan vs individual classroom). There will also be a comparison of different design attributes such as daylighting, acoustics, glare, comfort, etc. These comparisons will be made in order to determine a qualitative difference between comfort, and performance of schools. Metrics used for this will be described in the next section. Comparisons will also be made between schools of high-income areas and low-income areas.

II. Measurements

Measurements will be made in a qualitative and quantitative manner in order to compare the various schools in the best possible way. The qualitative measures will be mainly through observations and speaking with students and teachers about their experience in the classrooms. The quantitative measures will come from glare, illuminance and acoustic measurements.

Through classroom observations, I will take notes of conditions during quiet work time, noisy work time, teaching time, as well as make notes of when or where there is glare and high noise conditions.

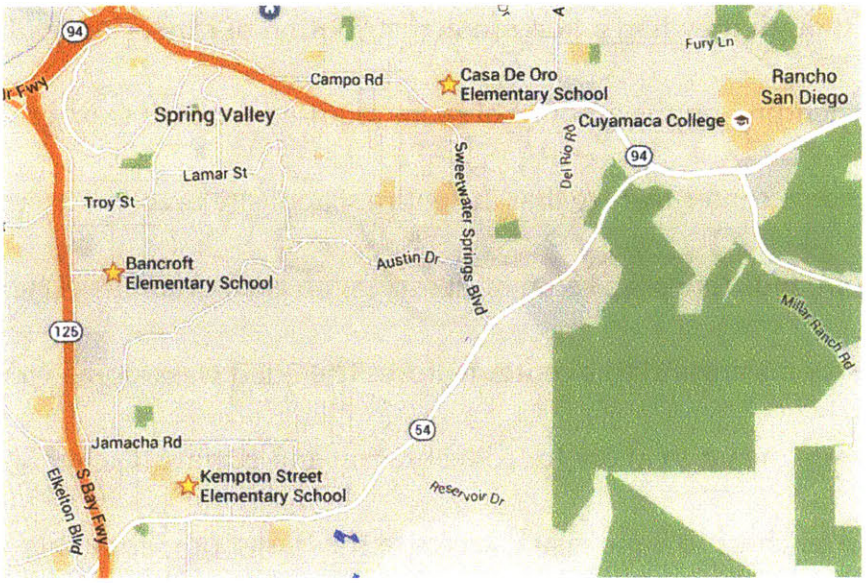
The quantitative measures will be made to balance out the qualitative measures and give conditions to make more robust comparisons with. Using an illuminance meter, we will be able to take measurements of the illuminance off of different objects in the room in order to make comparisons of the lighting coming into the room at various points in the room. The acoustics will be measured by taking measurements of the decibel levels at different work times in the room: noisy or group work, quiet or individual work, teaching, etc.

III. Analysis

Analysis will be conducted by cross-comparing various measurements and conditions present in the classrooms observed. I will be comparing the different classrooms to each other as well as compare them based upon income area and metrics from the School Accountability Report Cards (SARC) reported for the last year.

B. Background on Schools in San Diego

After much deliberation and analysis conducted on schools across San Diego County, I narrowed my search of schools that I would visit to a few in the La Mesa-Spring Valley School District. This was the school district that I was most familiar with since I grew up in the area and it was also one of the few that allow undergraduate students to visit campus for research. Their website had a very clear listing of the amenities for each campus as well as SARC. The three schools I visited were Kempton Elementary, Casa De Oro Elementary and Bancroft Elementary. Each of these is Kindergarten through 6th grade and is in a lower income areas of the school districts region. Map 1 shows the location of each school and I will go more in depth on the background of each next.



Map 1. Stars represent Schools Visited (credit to Google Maps)

The schools from this school district that I focused on all came from a slightly different style of classroom. This district has sites with four distinct styles of classroom layouts: lofts, pods, quads and what one might consider a traditional modern classroom. Most sites have portable classrooms alongside one of these primary forms of classroom. The schools that I visited were of the quad and traditional variety of classrooms but I will briefly describe all of the styles. The loft form is a remnant of the open plan style classroom that was discussed previously in this paper with many classrooms in a large space with temporary walls if any. These classrooms were turned into loft classrooms by putting up more permanent walls to divide the large building into multiple classrooms however these walls are still of a temporary fashion and don't allow for total noise or light blockage from neighboring classrooms. These were

considered lofts even though they had a horizontal distribution of classes instead of vertical. They were depending on the amount of room required for each teacher. The pod school sites have some center feature that the entire school site revolves around (typically an auditorium, multipurpose room or library) with each grade level having its own cluster of classrooms around this center feature. The quad classrooms were unique because they were meant to allow for collaboration and private teacher areas while still allowing the teachers to have visual access to the classroom while they are in this separate area. An image example of this will be presented with the information regarding Kempton Elementary. Lastly, the traditional classrooms are your typical classroom with large windows and one or two doors to the outside and a teacher's desk at the front. I will also go more in depth with this typology during the Casa De Oro and Bancroft sections of the background.

I. Kempton Elementary Background

Kempton Elementary School is statistically the worst school in the district. It has the lowest average test scores of any of the schools in the district and has the highest number of students coming from socio-economic disadvantaged backgrounds. There were less than 50 percent of students through each of the grades scoring proficient or advanced in all of the subjects tested at an elementary school level (English-Language Arts, Math and Science). Their overall Academic Performance Index (API) score was a

754 out of a 1000 point scale which is on the lower end of what schools are expected to perform. An 800 is the goal for all California Schools, and any school under 795 is expected to improve 5 points per year. To go along with these statistics, the number of socio-economically disadvantaged students going to the school is reported around 86 percent. California policy requires that schools performing at this level must inform all student families that the school is underperforming and the students have an option to get bussed to a better school in the area. School principals at the school said no one has taken them up on this offer.

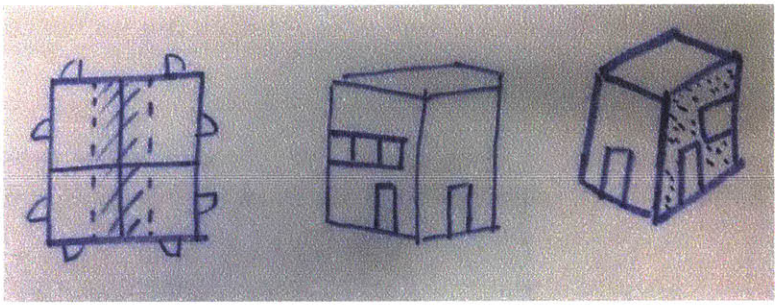


Figure 3. Sketches of classroom layout (Sketch by Author)

During the visit to the elementary school, I found the layout to be quite unique. There were clusters of four classrooms together with a work/office area for the teachers in the middle. This teacher office area had windows to overlook the classrooms and maintain a sense of control being in a private area to work on report cards or sensitive work. The illuminances of the classrooms were fairly low, along the low to mid 100 lux range and sound levels were nothing out of the ordinary. The biggest issue throughout

these classrooms was that the windows were not operable at all. None of the windows could be opened for ventilation so the teachers had to open the door(s) in order to get fresh air into the classroom. Because of this, many of the classrooms we went into had a mix between a muggy and stuffy feel to them. Another big issue that was general across all the rooms was how dim the projector bulbs were. They made it so students could barely see what was being projected so all of the lights needed to be turned off in order to see some of what was being projected. This made it so students were unable to take notes during lecture or teaching time that included projected material.

The second kind of classroom that was associated with the campus was a portable style classroom. These were meant to be temporary classrooms for an expansion once the 6th graders made the move back to the elementary school sites, however they stuck around and are still being used. These classrooms had one wall of windows that were operable however they were tinted so the room relied almost solely on the electric lighting for the classroom. There was very little storage for the teachers and students and many materials were stored in the library, which was also in a portable on the far end of the campus.

After talking to the principal after the tour and visit of the school, the three main takeaways for fixes in the classrooms would be operable windows, electronics that work better and more color. The entire campus was an off-white color with little

landscaping so it looked almost prison-like. This was not a place where people would want to go to school every day as I stated the ideal would be at the beginning of the paper.

II. Casa De Oro Elementary Background

Casa De Oro's academic statistics were very similar to Kempton Elementary with lower state testing results (around 50% at proficient or advanced for each subject). Their API was slightly higher than Kempton's at 771. Their demographics are around 72% of the student body coming from a socio-economically disadvantaged background.

Casa De Oro Elementary is set up in the traditional classroom style pictured below. This style consists of long rows of classrooms with overhangs covering the entire corridor. This school in particular clumps grade levels based on the classroom row as depicted in the image.

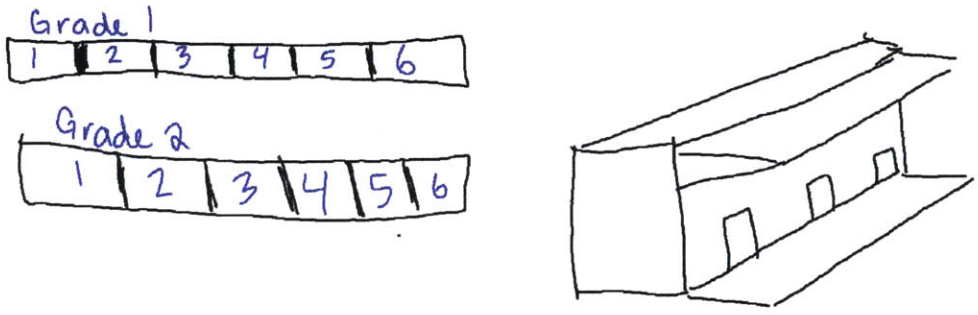


Figure 4. Sketch of classroom and site typologies (Sketch by Author)

This was also a school with a primarily off-white color scheme though there was more of a spruce of color throughout the campus. The teachers had more displays of art and classwork on the exterior of their classes since they were protected from the elements by the overhang. There were lots of windows in each classroom, which typically would have allowed for plenty of light to reach the classrooms. Instead, many of the classrooms had student classwork plastered all over the windows, preventing much light from entering. Even with this, the lighting was much brighter in these classrooms as compared to the previous school and the illuminances were almost identical from classroom to classroom.

III. Bancroft Elementary Background

Bancroft Elementary School is the best academically out of the three schools visited with exactly 50% of the students reaching Proficient or Advanced on all of the CST subjects. However it has a higher rate of socio-economically disadvantaged students as compared to the other two schools visited, at nearly 83 percent of the student body under these qualifications.

This is also the school that had been renovated the most recently. The initial design of the school did not have air conditioning so this was put into the school within the last 10-15 years. In order to put this in, there were dropped ceilings installed, blocking some of the windows. This campus layout was similar to Casa De Oro's

however it had more windows and overhangs. There were windows on both sides of the classrooms as shown in the image but one side of the windows started about halfway up the building and continued to nearly the ceiling. The other side of the building had a large work level window that was able to bring air and light in from both sides of the building. The principal expressed concern over glare that enters the building. He indicated the orientation of the building as the primary cause of the large amounts of glare entering the building. Because of this, there were overhangs installed to counteract the glare. Once the air conditioning was installed and the drop down ceiling incorporated, the amount of light from the windows decreased dramatically and the classroom had to turn to the electric lighting for its necessary light intake.

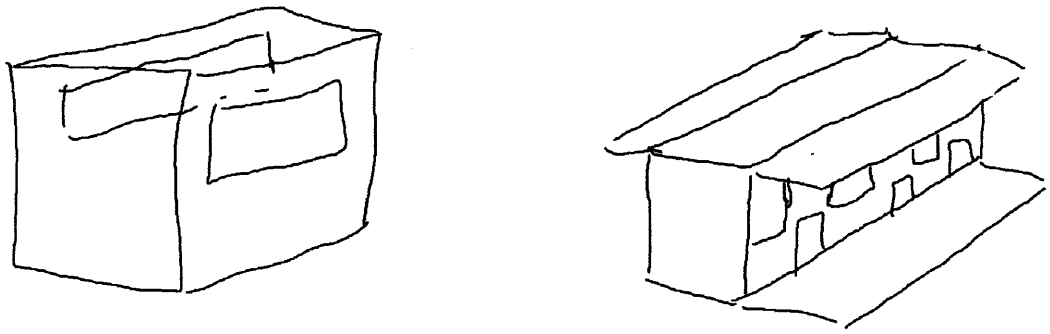


Figure 5. Sketch of classroom and site typologies at Bancroft Elementary (Sketch by Author)

The other modern feature of the school was the ability to control different sets of lights with different controls. This helped when teachers were using overhead

projectors or wanted to allow more natural light into the space. One downside of this campus was the lack of teacher storage within the classroom. Typically traditional style classrooms have plenty of room for storage. This was also a campus that had plenty of wall space for teachers to hang student work, which was unique in the sites visited for this thesis.

4. Analysis on Schools in San Diego

From the visits to each of the schools, I found typologies of each of these school sites had their pros and cons. No school is perfect and these schools were far from perfect but I acknowledge that they still function as schools. These schools can produce students that go on to do great things in the world but with how these schools are designed, this is very difficult to achieve.

A. Positive attributes of San Diego schools

Each of the electric lighting schemes provided for plenty of light for the students to use though each site used this differently. Some had user control lights based on light grouping others were controlled altogether.

Though not always able to be used properly, each of these sites had lots of windows available for students and teachers to get a nice outside view. These also theoretically would be able to bring in more light for the students.

B. Negative attributes of San Diego schools

The cons of each of these school sites and general cons of these schools are easier to ascertain from the various metrics of performance I was measuring. Overall the

window schemes of these sites were dismal at best since the windows were either not functional or covered up with school work.

These classrooms also were not centered on student learning and teacher support as we know it today and were instead the up and coming designs for the education system back 50 or more years ago. Because of this mentality, these classrooms were not setup to be able to handle the technology of today. There are very few electric outlets per classroom not allowing for the multifaceted technological learning we have today.

These school sites were also very bland and lackluster in their exterior design scheme with the off-white and color-less exteriors which the principals of the schools expressed concern over. This is more of an aesthetic concern that was made rather than one based off of measurements made.

C. What can be changed?

There are many things throughout each of these schools that could be changed but the four major changes that need to be made based upon what I saw and what principals said are color and character additions to the site, better technology access, improvement of electric lighting quality and control, and functionality of windows. These play into both aesthetic, technological and architectural characterizations of

change for these classrooms. Each of these proposed changed will be discussed in depth below.

I. Color and Character Additions to Site

Color, though an aesthetic feature, is an important part of the persona of a site and the atmosphere it creates. Color adds to the character of a place and can make it feel lively and vibrant or can also make it feel dull and boring. These school sites that were visited had little to no color to them, which was compensated for by decorating with student work. However, the principals I spoke with felt that the campuses having more color would add to the character and help facilitate more school pride within the students. Classrooms or blocks of classrooms being colored differently would be something for them to associate with.

II. Better Technology Access

The schools that were visited were advanced in their technology usage in some ways but not in others. All of the schools in the district visited has iPads for each of the students or nearly every student. On these iPads are testing apps as well as other academic enrichment applications that the students can use during certain times throughout the day. However, with increasing electronics in the classroom, there is more need for support for these electronics such as outlets for charging and ports for

projections. The projection device needs to be able to accommodate these new changes and that isn't always the case.

III. Electric Lighting Quality

Alongside technology access is electric lighting. Previously, all electric lights were on the same switch and lights were either all on or all off. Some of the schools visited are still on this style. There needs to be more user control over the lighting. Some of the classroom activities today (especially those being projected) have a need for some lights to be on so students can see what is happening on their desk but also see whatever is happening on the screen or elsewhere in the classroom.

IV. Functionality of Windows

Overall, none of the windows in the classrooms were functional to the point I would have liked them to be. The windows were completely fixed and unable to be opened or were able to be opened but rarely were. Since each of these classrooms are air-conditioned, sometimes there is a misconception that the classroom needs to be sealed so the air-conditioner can do its job without wasting energy. However, in the San Diego climate, many times just opening the windows instead of turning on the air-conditioner will cool the classroom just as well. It is very important for fresh air to be getting into the classroom.

D. The ideal classroom

The changes laid out in the previous section can cumulatively come together to make the ideal classroom. The idea classroom would be one that would be almost completely malleable and customizable depending on the students and teacher. There would be acoustic panels in the ceiling that would be able to be moved around depending on the need of the students and teachers each year. The plugs and outlets would be able to easily be interchanged or changed out for whatever the newest thing is. For example, recently USB ports have been starting to be integrated into wall outlets. Rather than having to rewire and area, outlets should be able to be easily changed out to a different plug style by the janitors or custodians of the school site. The walls should also accommodate storage and teaching opportunities as well as display of student work. The electric lighting system should be able to be customized based on each teacher. Whether this be track lighting that is able to be rearranged as well as dimming or some way to reset and customize light settings on a semi-frequent basis, customized electric lighting is crucial.

5. Conclusion

With the fairly new knowledge that everyone learns and teaches differently, a classroom should help to facilitate a multifaceted learning experience for students of all ages and learning styles. Children (and teachers) spend roughly half of their waking hours in school. Since they spend such a majority of their time in this one place, students and teachers should look forward to being at. It shouldn't be a place they have to put hours and hours outside of work hours to customize and make into a classroom functioning for their purposes.

For this reason, we need to revamp the way we approach classroom design. Rather than focusing on the past or whatever the new teaching techniques are (because these will quickly go out of style), we should be designing classrooms for tomorrow. While schools are in the functional shape they are in today, we should be retrofitting to keep up with the ideals and teaching methods used today, however when designing for new classrooms we should have tomorrow in mind. They should be able to adapt to whatever new teaching styles we find are best tomorrow and in the future to come. Since construction, new or remodeling has high costs, schools should be designed for minimal remodeling as they adapt to the newest technologies and teaching strategies.

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