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Learning Environments

How space can stimulate the learning process

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Philosophical Framework

Spaces for learning should be designed in a manner that helps the brain learn, and stimulates creativity in all types of people and with all types of learning abilities.

The philosophical framework for my research question is based off of subjectivism, because of how the students are situated in the social context and that the factors change around them. The reality of the philosophical framework for this research is the premises that we all believe that human nature seeks to learn and grow and that some environments in this world can support that function better than others. This framework can be validated when working with students in 3rd world countries. The thirst for knowledge is there, and you can see the excitement in wanting to learn new things and evolve, but the lack of nutrition, resources, and built creative spaces to help accommodate their education hinders their development.

Theoretical Framework

When stimulating the brain and its creativity in learning one needs to focus not on how to drive information in, but instead excite and inspire. The premise for this thesis is in focusing on the topic of space and how it can encourage creativity and advance the person in their learning pursuits. In doing this, one must look at different aspects of space such as, acoustics, textures, colors, natural light, spatial organization, the movement through the space, how the student interacts with what is being taught, and other aspects.

The idea for this research topic came to me during the summer of 2014. I had started to ponder about what I was interested in studying during my master's year. While considering my strengths and reflecting at my life, I realized I had a pattern for working with children. I had taught Sunday school for over ten year, and was currently the youth pastor at my church. I had enjoyed reading books on how the mind learns best with different teaching styles, and it lead me to thinking about space and how that could stimulate the learning environment. My own high school was poorly designed, made of all concreate, with small and limited windows to outside. Some classrooms had no natural light at all. We were not allowed to paint the walls or add any variation to the building. This was a mistake. School started to feel like prison, instead of the thriving learning environment it could be.

The audience for my research will be the design community and people working within the education system. I seek to expand knowledge on how space can be designed to help students and to stop thinking of learning as a streamline process that is the same for everyone. This could impact the profession by how we approach learning and the designs for those spaces. We need to stop thinking about what is easy, and start to look at the student's needs and the different environments they might require. Schools and learning facilities from small rural locations to large urban environments could all be affected by this research and start to apply it to their spaces.

My research will focus on the different aspects that affect space. I will research and look at case studies that deal with acoustics and the best designs for different spaces and their activities from quiet libraries to music rooms. Textures and colors can stimulate the mind in different ways, looking at what should appear in the room to help either excite to calm children is important. Many also enjoy textile parts of learning, so having different textures for children to experience might help keep them engaged. Looking at how the room in organized with furniture and the movement through it could also either add or hinder to a student's focus. Last, but certainly not least is how natural light affects the space. Are their windows and views to outside? Can the windows open and allow for free air. Do the students feel closed off or trapped in closed off spaces, or can to much open light be distracting. These are all aspects of space that need to be researched and applied to the design.

History of Education

Throughout history education has been important in our society. Throughout the years the focus of education has changed from preserving our democracy, to providing topics for every student, then during the cold war we focused on keeping the United States competitive, and now we see education as a way to eliminate poverty. But what we forget sometimes is that education is the act of creating thinkers and poblem solvers. The environments that students learn in should not just be a space to hold them for 8 hours a day but a space that stimulates their learning, creativity, and overall wellbeing.

The education crisis that we are in has educations, designers, and others looking for answers in many places. One strategy that is happening is comparing the different types of education throughout the years and the positives that came from each era. In one room schoolhouses we see how students are able to tutor one another at different age levels, all acting at teachers for someone else. In these simpler times students generally walked to school and had time to play outside during the day to allow for fresh air and blood flow to the brain. As schools develop over the years, in the 50s we see the style of wing schools that had gardens and windows providing daylight on both sides of the wings. In the 70s the pods were a popular solution, thought these offered great common spaces for students daylighting was less of a priority. Today, those with a passion for educational spaces are studying these examples and attempting with new research available as well to create hybrid schools.

Strategies (General Methodology)

1.Qualitative Research- reading physiology books to better understand children and the learning process.

2.Case Studies- to look at previous work on acoustics, textures, colors, movement, organization and how it effects the learning environment

3.Correlation Research- to see how learning might be effected by demographics in the area, and how test scores might correlate with room specifications.

Tactics (Specific Research Methods)

Tactics for Qualitative:

a. Reading materials that explain how children learn and what they need in that environment

b. touring elementary schools to gather information on their learning evironments

Tactics for Correlation:

a. Typological analysis; looking at the education spaces and the neighborhoods surrounding them

b. Factor analysis- looking at data of testing scores and what might be affecting the learning process; creating a computer simulation model of a real classroom with it specifications and comparing them to the test scores of that room to try to identify a pattern.

Methodology for Correlation and Qualitative

1. Select research to focus on and conduct research

2. Collect book, articles, and case studies to research

3. Collect Research on the following topics:
   a .Acoustic Level
   b. Daylight
   c. Indoor Air Quality
   d. Furniture and classroom layout
   e. School layouts

5. Create computer models of classrooms that will be used for simulations

6. Run simulations on the models using acoustic and lighting software
   a. Acoustic use EASE software
   b. Daylight use Revit Daylight Plug in

7. Create correlations from test score data and simulation information

8. Create graphic charts to represent final results

9. Write Article based upon results

Acoustics

Background Noise

Acoustics can have a great impact on the learning environment. Some aspects that one should look at is indoor and outdoor background noise and reverberation time which both influence the speech intelligibility within the room. Frist we will focus on background noise.

There are many outdoor noises that can become distracting in the classroom such as vehicular traffic, aircraft flying above, industrial noise from construction, and the schoolyard or nearby park. Taking readings of the sound levels from these disturbances will indicate how you should design for your particular setting. With a lower setting of <55dBA, you can stick with normal building construction, but as you move into louder settings such at 71-75 dBA you should increase your wall OITC rating to not less than 28 dB and pay close attention to the construction as the building technique might not be your typical assembly. Now indoor noise can cause about just as much trouble.

Classrooms can be bothered from noise coming from nearby restrooms, adjacent classrooms, mechanical rooms, and people moving through the hallways. When you have identified how loud the surrounding spaces are then there is a variety of wall construction types to choose from that range from STC (Sound Transmission Class) rate of 36 to 53. The STC 36 wall consists 3.5” wood study or heavy gauge metal stud with 5/8” gypsum on either side, with a STC 53 wall gets more elaborate with 2-5/8” gypsum, 3.5” light gauge (25 gauge or lighter) metal stud with fiberglass blanket, 2-5/8” gypsum. Applying the correct amount of sound proofing for your room will help keep students focused on what is happening in the space and will increase their ability to understand both their teacher and each other.

Background Noise Level		Design Solution
<55 dBA	→	Typical wall construction; OITC rating not less than 30 dB
55-60 dBA	→	Typical construction with emphasis of external walls having OITC rating not less than 25 dB
61-65 dBA	→	Construction must be detailed orientated with an OITC rating not less than 26 dB
66-70 dBA	→	Construction should be monitored carefully and external wall should have an OITC rating not less than 27 dB
71-75 dBA	→	Similar to 66-70 dBA except OITC rating not less than 28 dB
76-80 dBA	→	OITC rating not less than 29 dB but not greater than 50 dB.
>80 dBA	→	If greater than 80 dBA consider another, quieter site

Effects of Poor Acoustic Conditions

Teacher Health**:**
•**32%** of teachers have problems with voice fatigue and **20%** of them miss work.

Teacher Absenteeism:
•Teachers take at least one sick day a year from voice fatigue.

Design Goals and Techniques

•Background noise should be at a maximum level of 35dBA with the speech level 15dBA higher than that.

•Some levels or HVAC noise can be used as white noise, but avoid small diameter ducts with high velocity for this process.

•Some techniques to help control background noise within the building is layering drywall to increase the mass, having sound attenuation blankets (insulation) to absorb sound, staggering stud construction, and last separating the top and sole plates to prevent the transfer of sound.

•Another technique to limit vibrations to be transfered into sound is to use resilient pads and springs and install resilient connections to spring, pad, and flex connector machinery.

•Separately fiberglass or gypsum wall board are not effective as sound barriers, but in layering the two products Acoustical Society of America found that they were an effective solution to reduce noise between interior spaces.

Reverberation Time

Reverberation is created in classroom where sound is able to bounce off hard surfaces such as walls and furniture. This movement of sound through the space causes words to become garbled and for young students to have problems distinguishing the true message.

•Lowering reverberation in the room will increase the intelligibility of speech.

•Using softer surfaces such as carpet, acoustical ceiling tile, and wall panel treatments will help achieve this.

The graph pictured compares the phrase “breakfast is ready” in non-reverberation conditions to moderately poor conditions.

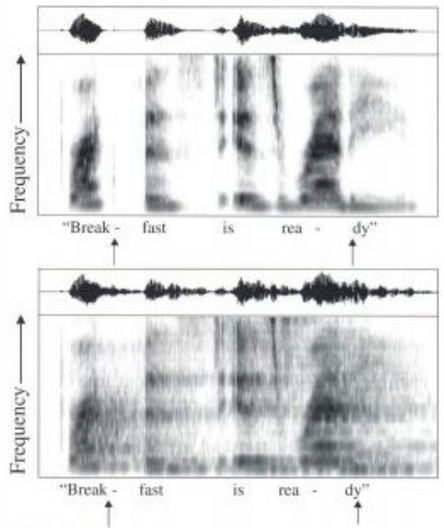


Figure 5. An example of a phrase (“breakfast is ready”) in non-reverberant (upper graph) and in simulated moderately reverberant (lower graph) conditions (RT=1 second). Each graph shows the time waveform at the top of the panel, and the spectrogram, or change in frequency of the sound over time, at the bottom. Darker patterns indicate more intense sounds; light areas indicate silence or quiet sounds. Note that even with moderate reverberation, many of the temporal patterns of the speech are smeared. The quiet /k/ (shown with an arrow) is apparent in the upper graph but masked in the lower one. The second syllable in “ready” (shown with an arrow) is also masked by the reverberation.

Reverberation Chart

Learning Space	Max Reverberation Time (in seconds)
Core learning space with enclosed volume (≤ 10,000 ft3)	0.6
Core learning space with enclosed volume (> 10,000 ft3 and ≤ 20,000 ft3)	0.7
Core learning space with enclosed (>20,000 ft3) and all ancillary spaces.....	No Requirement

*Above data is for unoccupied, furnished learning spaces.

Speech Intelligibility

Speech intelligibility is effected by background noise and reverberation time. By achieving a reverberation time of 0.6 and controlling the amount of background noise in the space you can increase the percentage of words that young children hear. Since young children do not fill in the blank as well as older students and are more likely to have a lower understanding of content if they are missing part of the message. Students that speech English as their second language or have any hearing or attention disabilities will have even a lower understand of content. Creating high speech intelligibility is especially important for young education environments.

Student Learning Conditions:

•**One in six** words is not understood by the average first grade student because of poor reverberation time.

•20% of students speak another language at home and are learning English as a 2nd language, this puts them at a further disadvantages in environments that have poor speech intelligibility.

•Ear Infections are common among children as well, and these can cause partial hearing loss for up to a month.

Design Strategies for Speech Intelligibility

•Using a sound system can help boost a staff’s voice, but if dealing with poor reverberation this will not improve the conditions, and if attempting to achieve a 15dBA level higher than the background noise, be careful that you are not making the level of sound uncomfortable.

•Absorbent Surfaces such as acoustical ceiling tiles, fabric-wrapped panels, manufactured acoustical panels, soft seating, drapes, carpeting, blinds (some blinds are designed for sound absorption), can all help with sound absorption and can help increase speech intelligibility.

•Diffusive Surfaces can help break up large painted hard walls and absorb sound. Try insetting windows, using columns and filled bookshelves inside a space to “soften” the sound in the room.

•Sealing leaks around windows and doors will not only help reduce heating and cooling but will help prevent unwanted sound from entering the space.

The acoustic simulation was tested on a basic 25’ by 30’ ft classroom with one entrance and student seating where the teacher is positioned in the front of the class for student lectures. The classroom model was loaded into EASE software where materials were assigned to more closely give accurate readings and then the speakers and audience in the room was placed.

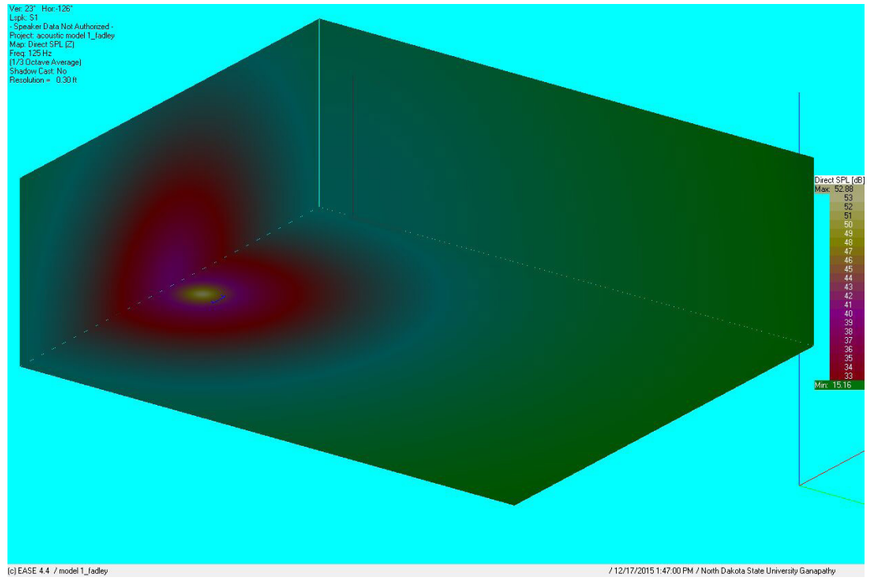
After the model was set up and checked for any inaccuracy, the model was ready to be run though the speech intelligibility software. The following limits were given in the simulation based off the previous ideal research.

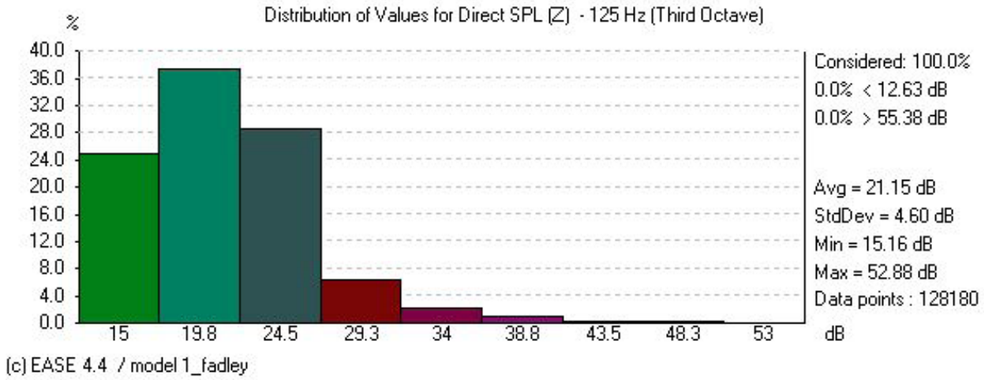
Background noise level: 35dBA

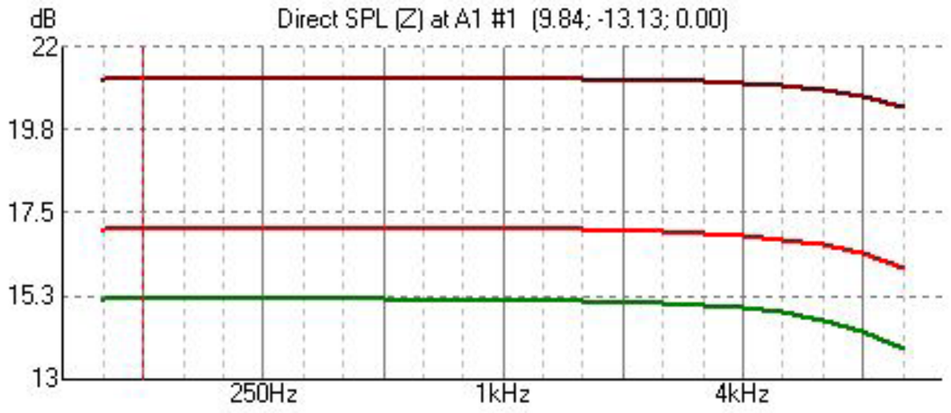
Teacher audio level: 125 Hz

Reverberation Time that was calculated in the room at those settings was:

0.36 seconds, the time was below the maximum recommended of 0.6.







(c) EASE 4.4 / model 1_fadley

Daylighting

For years people have believed in the power of natural light but recently we have started seeing studies being conducted to see just how much daylighting helps our students.

•Classrooms with maximum window coverage providing large amounts of daylighting had **7% to 18%** increase in test scores than classrooms with minimal daylighting.

•Students with most daylighting progressed **20%** faster in math tests and **26%** in reading tests.

•Students with the largest window area progressed **15%** faster in math and **23%** in reading tests.

•Students located in classrooms with skylights that diffuse light evening were shown to progress 2 points higher in reading and 2.3 points higher in math than classroom without skylights.

Daylight is also know to illuminate surfaces evenly in rooms, compared to typical lighting which focuses on horizontal features. In classrooms you want light casting on the faces of people and the wall for the extra resources they provide. Exposure to daylight also helps us produce Vitamin D which is healthy for the body and in recent years has helped treat seasonal affective disorder which is common condition where people become more depressed in the winter months from lack of sunlight exposure.

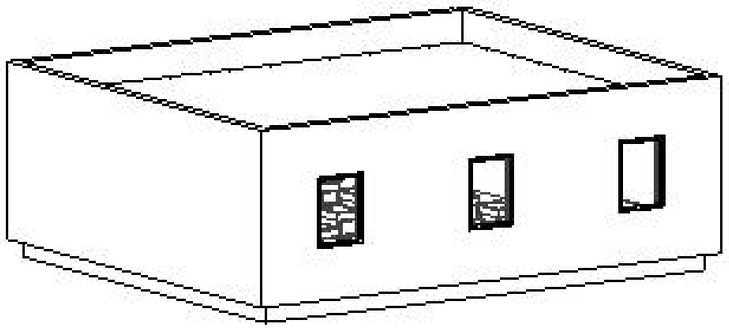
Window Specification

“The energy efficiency of the window can vary with glazing selection, window type (casement, double-hung, etc.) and construction (thermal break, aluminum-clad, etc.). Window properties are critical to energy performance and visual satisfaction. Specify low U value to reduce winter heat loss and summer heat gain. Windows on the west and east sides experience maximum solar gain in summer and should have a low Solar Heat Gain Coefficient (SHGC). Low SHGC is achieved with selective glass, tinted glass, or reflective coating. Specify selective glass for clear appearance or when high visible transmittance is required for daylighting goals. South side glass may be protected from summer sun by an overhang and have a high SHGC if winter heat is useful. Specify a low SHGC for south-side glass if the building is dominated by internal heat gain and solar heat is unwelcome even in winter. North side receives very little sun and requires no special treatment.” (Enhance Indoor Environmental Quality (IEQ). (n.d.). Retrieved October 12, 2015.)

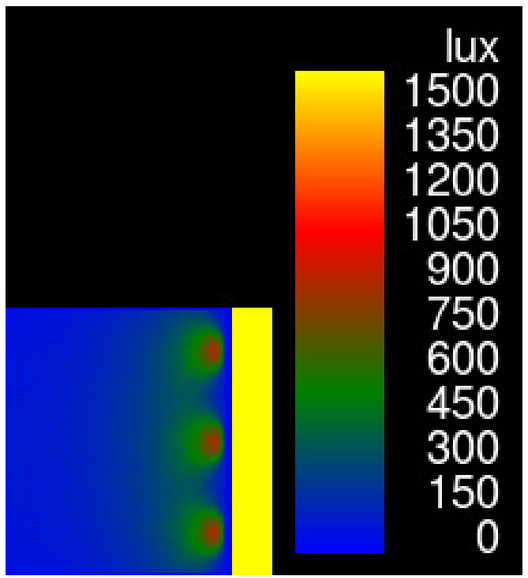
Windows-Daylighting

• All classrooms have large windows exposing students to natural light.
• The windows on the first floor are also located about 4 feet off the ground to allow for safety if a vehicle were to crash into the school.
• There are interior blinds that allow each room to adjust the amount of sunlight needed throughout the day.

Daylight Simulation 1



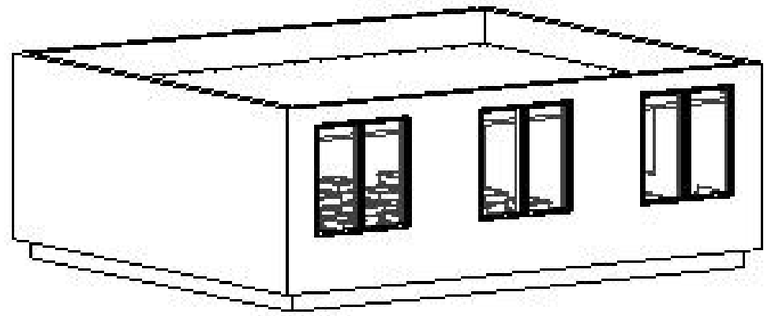
Classroom is 25’ x 30 x 10’



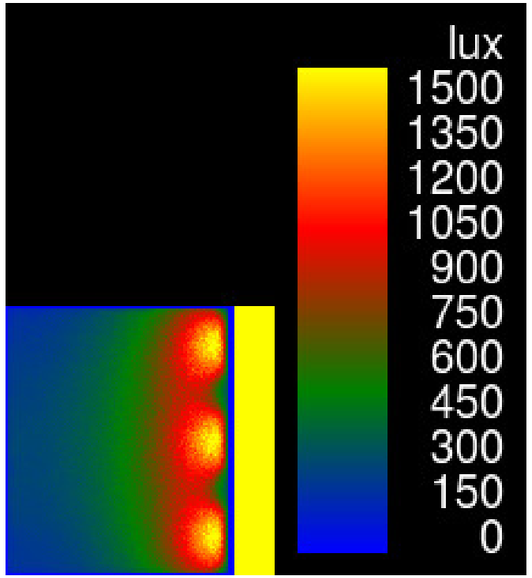
This first daylight simulation shows the effects of having three windows; 3’ x 4’.

What might appear from regular observation as a significant amount of windows, we can see in this graph does not offer much daylight for the internal users of the space.

Daylight Simulation 2



Classroom is 25’ x 30’ x 10’



In the second daylight simulation, I increased the window size to 3’x 6’ and double the amount of windows to six.

This increase in window size brought significant growth to the amount of daylight in the space. We see now that about half of the room has some increase in light levels from the daylight coming in from outside.

Indoor Air Quality

IAQ Health Concerns

Many occupants complain about feeling sick at work or school, this condition is known as sick building syndrome, and is caused from when the indoor air quality is so poor that you start to have physical health problems while in that environment.

Health problems caused from poor indoor air quality:

•Headache, fatigue, shortness of breath, sinus congestion, coughing, sneezing, dizziness, nausea, irritation of the; eye, nose,throat, and skin.

•Asthma from poor indoor air quality causes **14 million** missed school days a year.

Effects of High CO2 Levels:

•A 1000 ppm increase in the elevation of the indoor CO2 concentration above the outdoor concentration was associated ($p < 0.05$) with a 0.5% to 0.9% decrease in yearly attendance, corresponding to a relative 10% to 20% relative increase in student absence."
[Associations between classroom CO2 concentrations and student attendance in Washington and Idaho.]

IAQ Benefits

Student Benefits

•Improving school IAQ conditions showed a **13-14%** increase in math and reading test scores.

•An elementary school in Oregon began an indoor air quality management plan and had a **15%** decrease in absent students.

Facility Benefits

•Improving school environments with sustainability like IAQ increases teacher retention by 54%.

•IAQ also brought about a 20% improvement in attracting new teachers.

Building Strategies

VOC's

•Limit the amount of VOC's (volatile organic compounds) emitting from products. VOC toxins are found in: paint, adhesives, cleaners, carpets, particle board, caulk, sealants, furniture, and etc. Formaldehyde is a harmful product that is found in wall panels, cabinetry, and carpet and should be avoided, chemicals should also be stored properly and office equipment should emit minimal odors. Standards for low emitting materials can be found in Green Seal, SCAQMD, CRI Green Label Plus, and Floor Score.

Entryway Systems

•When designing entryways, using systems like grates, grills, and mats, can help dirt and dust from shoes that can hold toxins from being tracked into a building. They also cut down on the amount of cleaning necessary in the building. [1] Mats should be 18 to 20 ft long to acquire the optimal IAQ benefits of decreasing dirt by 80%.

Ventilation Systems

•Separate exhaust ventilation should be used in rooms containing copy machines, printing, break rooms, and food preparation Improve air movement by using energy efficient or variable drive fans and increase fresh air brought into the building. [1]

MERV Rating

•MERV (minimum efficiency reporting value) is a system to measure the effectiveness of air filters from a rating of 1 to 16. Higher numbers indicate a denser filter which is more efficient at removing small particles. But a denser filter does require more energy to push the air through. [1]

Tobacco Smoke Protocol

•ETS (environmental Tobacco Smoke) is harmful to everyone. By banning smoking within a distance of any entrance of a building, and installing separate HVAC systems to isolate smoking areas you can achieve a better air quality. [1]

Spatial Design

Another way to increase the space that students learn in is in the layout and form of the room. New sources such as Children's Spaces by Mark Dudek are calling to break away from the traditional rectangular classroom shape and to start exploring new layouts. They suggest trying an L Form which breaks into different spaces more easily but still gives teachers the visibility they need. Dudek also points out the need for quiet small spaces for children to work in.

In an event held by Accent Environments the speaker Mark Osborne talked about how designing with irregular shapes adds interest for students and starts to create these different space from large group to individual study time. The use of glass walls to block off an area can be great as well. With new technology, the glass can be sound proofed to create a quiet environment but still allow the teacher visibility into the space. Glass can also be used as a white board, with new types or markers and chalk, every glass surface can become an easy writing surface for students to work on and have group discussion. Standard separated desks have always been popular in school, but having tables or grouping desks, shows to save space to allow for other uses in the room and encourages students to help on another. Mark Osborne quoted statistics that teachers tutoring was about just as effected as another student doing the tutoring, so we should be encouraging classmates to corroborate and work together.

Having communal spaces or pods that connect the classrooms so that students have a space to flow from the classrooms and work with each other on projects and activities in a larger space is also an idea that is growing in popularity. These pods can be connected to restrooms, so that each unit has their own facilities to prevent students from wandering around the school. Discover Elementary School in Grand Forks, ND does a great job of utilizing these communal spaces in their new school.

The Smith System has a varity of funirture that is designed for Ergonomic spaces. Ergonomic spaces are designed to accommodate the body's comfort in hopes to reduce stress and strain. Things that can be done are height- adjustable desks that are free to move, adjustable chairs, monitor arms, keyboard trays, footrests, and document holders.

The Smith System Flavor Chair lets the student move side to side and backward. They can also sit on the chair forward, sidewards or backwards comfortably. Utilizing systems like this gives students better outlets for energy and enhances health.

Discovery Elementary School Case Study

Discovery School Communal Room

Discovery School Break-Out Room

Conclusion

With all the new research happening in the design of school spaces, we as designers should be able to help with the education crisis by creating schools that help create the thinkers and problem solvers of the next generation. While others are more trained to revise curriculum or teaching practices, we hold the power to set standards as to what the design of school environments should be. The problems we face today are growing in complexity and we need to create individuals ready to solve these problems in creative ways.

Future Projection

This research can help in the designing of future school projects, including my own personal thesis project coming this spring. It is important for the future of our schools and its students that we stress the importance of this information and spread it to as many teachers, administrators, and city officials as possible. By creating interest in this area of study, we can stimulate more research to be done in schools to better improve the information we already have.

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