ARIZONA SCHOOL DESIGN PRIMER

The Basic Elements of School Design

Marlene S. Imirzian, AIA

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PREFACE

The idea for the Primer came from my experience selecting a school for my child. I was surprised to find that the schools I visited, in different areas of Arizona, with different socioeconomic populations, were some of the most disappointing buildings to be in. As a practicing architect I know that the built environment has a significant effect on achievement and productivity. Yet many of our schools have little daylight in classrooms, unwelcoming spaces, poor finishes, and appear closed to the surrounding community. I could not imagine sending my child to spend hours in such places. I started to ask questions to the administrators & faculty such as: Have you noticed there are no windows in the preschool classroom where you have children for hours at a time? Have you noticed that we don't expect one in an office to stay in such places, but for some reason we expect children to? The answer was always the same – this is just the way it has to be done.

All parents, faculty and administrators I spoke with wanted the best for children but were unaware of the negative impacts of the school buildings their children attended. Lack of funding was used as an explanation – but better environments don't have to cost more. I became convinced that lack of basic information regarding the effect of the built environment on children and on learning is a factor in what was built. Lack of knowledge is driving low expectations which are resulting in poor quality schools.

I developed this Primer as a first step to provide basic school design considerations. These basics can be applied to every new or renovated school construction project and budget. It is my hope that understanding the basics will lead to higher expectations and better schools for learning.

Marlene S. Imirzian, AIA

PURPOSE & FOCUS OF THIS PRIMER

Raise the level of communication and expectations of school design in the state of Arizona at the level of the key decision makers (school district superintendents, school board members and key facilities personnel)

OVERVIEW

Every school day, 54 million children and 6 million adults — that's 20% of the total U.S. population — spend their days inside school buildings.

Arizona currently has a public school inventory that totals approximately 122,000,000 square feet of academic space (Arizona School Facilities Board). This space represents a replacement value of 14.6 billion dollars. As Arizona grows, we will have to virtually double that inventory over the next forty to fifty years. Unfortunately, too many of our schools are little better than above-ground basements that hinder learning and harm health. Today, clear and convincing research shows that improving building design quality improves academic performance, attendance, and productivity.

Especially in such hard economic times when construction budgets are tight, doing smart design to create schools is a necessity. This Primer explains the most basic concepts in school design that have been often overlooked. It uses research from many groups that study school design to show how the design of schools can improve the learning and productivity of every person who experiences that space for years to come. It does not include all the numerous topics of design for education that require analysis. Its focus is on the initial building decisions that, once made, are almost never correctable. It is the hope that, going forward, these first decisions can be made with better knowledge leading to improved buildings for learning.

Well designed schools improve student performance, are easier to maintain, retain better teachers, and cost less in the long run.

Empower the key decision makers for school design and construction in the state of Arizona with fundamental information needed to make informed decisions regarding school design based on current research and project case studies

Inspire Arizona's decision makers to improve the learning environments of Arizona schools in order to enhance educational outcomes

Students utilize a flexible break-out space while under supervision from the adjacent classroom. (Thurston Elementary School, Springfield, OR; Mahlum)

THE MYTH OF COST

MYTH OF COST

If you construct a school building to expend the least possible cost on initial construction, that is the best way to minimize overall cost for the public.

The cost of operating schools has become one of the most problematic funding issues facing Arizona school districts. The fact is that in many school districts, energy costs are second only to salaries, and exceed the cost of supplies and books.

REALITY OF COST

Viewed over a 30-year period, initial building costs account for approximately just 2% of the total cost of a building, while operations and maintenance costs equal 6% (Fuller).

Life Cycle Analysis (LCA) must be a key tool for making building design decisions to compare system performance, energy cost, and net savings in order to build schools that cost less in the long run. LCA is the calculation and evaluation of a building's total cost of constructing, owning, and disposing of a building system. In a nationwide study, Davis Langdon (Matthiessen) showed that incorporating energy efficient and sustatinable elements in school construction can be incorporated with no significant difference in construction cost. LCA will help determine the reduced energy cost of elements such as high-performance Heating, Ventilation & Air Conditioning (HVAC) systems or incorporating glass for daylighting. Such energy saving elements may increase the initial cost but result in dramatically reduced operating and maintenance costs.

LCA uses projected utility rates, cost of construction, and number of years of use to evaluate the cost of inclusion of energy efficient and sustainable elements early in the design process to show how quickly the initial cost is offset by saving in operating cost.

20x

"The life cycle pay-back from the investment in life cycle cost reducing elements can be expected to return net financial benefits to the school disctrict that are on the order of twenty times the cost of those elements" (Kats, 2006).

SUGGESTED APPROACHES

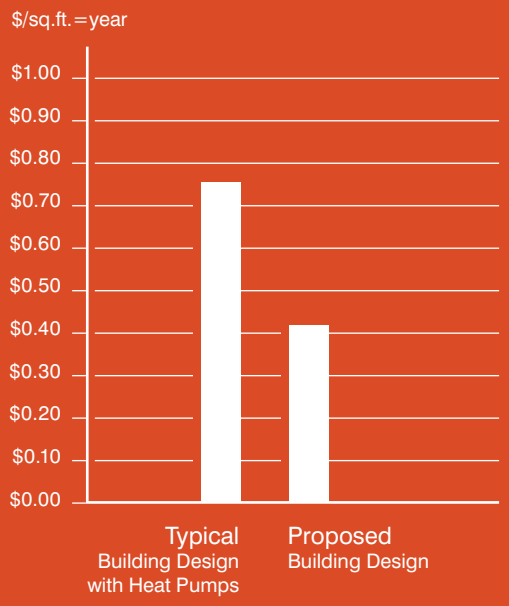
Perform Life Cycle Cost Analysis on all major building system alternatives that calculate the number of years required to pay back the initial investment in a system or component

Evaluate the cost of maintaining and replacing low cost systems versus investing in better performing and lower maintenance systems and finishes

A Life Cycle Analysis was completed for Benjamin Franklin Elementary School early in the design process informing many key decisions. Refer to diagram on right. (Benjamin Franklin Elementary School, Kirkland, WA; Mahlum)

ENERGY COST **COMPARISON**

This illustration shows the projected dollars spent per square foot each year on energy cost. The selected system has half the energy cost of the typical system shown. (Benjamin Franklin Elementary School Energy Cost Analysis - courtesy of Mahlum)



LIFE CYCLE **ANALYSIS**

DPR Construction's 52,000 sf new office building was completed in 2008. They performed a life cycle analysis as part of design decision making.

- **The upfront premium for energy efficient design was 11%**
- **The payback period was 3 years**
- **There is a savings of approximately $50K in energy/utilities every year**

SUSTAINABLE DESIGN AND ENERGY EFFICIENCY

The operational and maintenance savings allow schools to reallocate the additional funds towards the purchase of much needed educational materials, resources, and teacher salaries.

Sustainable design creates developments and buildings that meet the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable designs incorporate systems that need less energy to operate, use less water, use materials that have long life, and reduce use of non-renewable materials.

Design of buildings that use less energy requires that all elements of a building — walls, roof, mechanical, electrical, technology and landscape — be considered in evaluating the most cost effective and best performing solution. This is a comprehensive whole-building approach to design which reflects the reality that every system affects the others and energy efficiency must be based on real dollars of total building operation. To evaluate energy efficiency, all building projects should require a "whole building analysis." A whole building analysis utilizes computer modeling that will show the amount of energy used by alternative systems and construction.

Commissioning is a procedure that verifies that fundamental building systems are designed, installed, perform, and operate as expected. Commissioning should be done for every building. If commissioning is not done, the majority of new construction will not perform as designed, not provide the air quality required and use more energy over the lifetime of the building.

Kiowa County Schools utilize many sustainable strategies such as rainwater collection, natural daylighting, low operable windows for natural ventilation and a low maintenance native landscape that provides shade in the summer and light filtration in the winter. (Kiowa County Schools, Greensburg, KS; BNIM Architects)

33%

"By integrating energy efficient and low maintenance solutions into its design, a school can use an average of 33% less energy than conventionally designed schools" (Kats, 2006).

SUGGESTED APPROACHES

Use Energy Modeling and Whole Building Analysis software to model the mechanical heating & cooling, lighting, passive heating and cooling, daylighting, and alternative power to establish the most cost effective and comprehensive design of systems and distribution

Design building orientation and site design elements to minimize heat gain from east and west direct sun penetration

Limit heat generating surfaces - use exterior paving surfaces that are permeable wherever possible, install heat reflecting roof

Select exterior and interior finishes that are non-toxic, require little maintenance and have long life

Reduce water usage through appropriate low-water use plant and plumbing fixture selection, and capture rainwater for on-site irrigation use

Implement water retention through use of roof collection or greywater systems

Use daylighting to limit lighting energy need

Select renewable energy devices whenever possible

Improve insulation in walls and roofs to limit heat gain

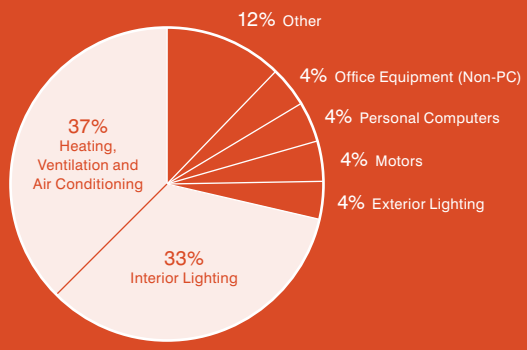
Install an energy management system for heating, ventilation and cooling to operate most efficiently at varied times of the year and day temperatures

Choose energy efficient heating and cooling systems, incorporating digital controls and commissioning to ensure that all systems work as designed

Sustainably designed schools create better learning environments and can be living laboratories that will enhance the educational experience to last a lifetime.

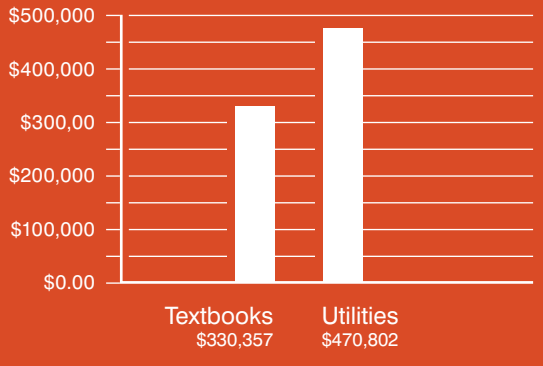
TYPICAL ELECTRICITY END USE **BY PRIMARY & SECONDARY SCHOOLS IN ARIZONA**

Incorporating daylighting and more efficient HVAC systems can result in significant savings. Every year schools are paying 37% of their utility cost for heating, ventilation and air conditioning systems and 33% for interior lighting – 70% of the total electricity use every day, every year, for the life of the building (APS Energy Answers for Schools)



SPENDING COMPARISON: **TEXTBOOKS VS. UTILITIES**

At the Grandview School District in Missouri, utilities represented the largest area of expenditure after personnel in a report of the U.S. DOE (Myths about Energy in Schools). Many districts, like Grandview, spend more on utilities than they do on textbooks.



Data provided by: U.S. DOE

DAYLIGHTING IMPROVES LEARNING

Daylighting is free, and when appropriately placed for solar orientation and shading, it is the most energy efficient source of illumination (Nair & Fielding, 2005).

A large study by Heschong Mahone Group, Inc., (1999) analyzed over 21,000 elementary school students (grades 2–5) and 2,000 classrooms from three districts in Capistrano, California; Seattle, Washington; Fort Collins, Colorado; and Johnston County, North Carolina — four districts encompassing very different curricula, teaching styles, building designs and climate. Despite these notable differences, this study revealed statistically compelling connections between daylighting, views and student performance. The longer the student has exposure to natural daylight, the greater the student's performance proved to be (Nicklas & Bailey).

A further study by Heschong Mahone Group, Inc (2003) of the Fresno Unified School District supported the idea that "an ample and pleasant view out of a window, that includes vegetation or human activity and objects in the far distance, support better outcomes of student learning." Generous and interesting views have consistently been found to increase student performance because they allow students to relax their eyes, which is particularly important for young children working in a room for an extended period of time (Collaborative for High Performance Schools).

Students in classrooms with the most daylighting were found to have 7–18% higher scores than those in rooms with the least, and progressed 20% faster on math tests and 26% on reading tests in one year than those students with the least exposure to daylighting (Heschong Mahone Group, 1999). Students in classrooms with the largest window areas were found to progress 15% faster in math and 23% faster in reading than those with the least.

Daylighting is directly associated with higher test scores, better work habits, and decreased mental fatigue (Nair & Fielding, 2005).

Classrooms incorporate windows, a light shelf to bounce light, direct/indirect pendant light fixtures and allow for views to a distant landscape. (Issaquah High School, Issaquah, WA; Mahlum)

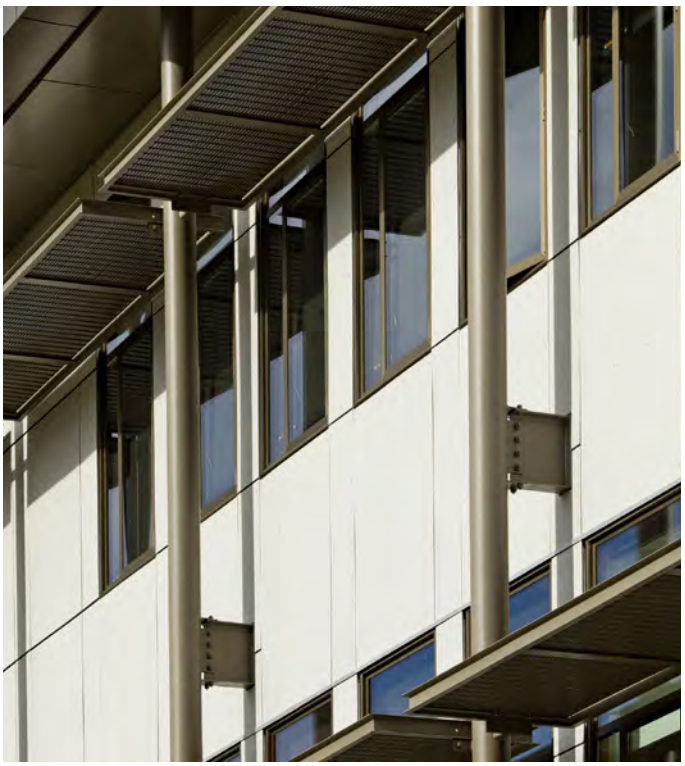
SUGGESTED APPROACHES

Provide daylighting at all occupied spaces: classrooms, lunch room, library, gymnasium, specials, etc.

Use Daylighting modeling programs to establish light levels at desks and workstations and to determine the effects of glare reducing elements for maximum efficiency

Limit direct sun penetration through careful placement of windows and provide shading in order to minimize glare and thermal discomfort

Provide an ample and pleasant view out of the window to the outdoor environment, or into occupied areas of the building



Exterior horizontal shade canopies are provided above the windows to reduce glare and direct sun penetration to the classroom. (Issaquah High School; Issaquah, WA; Mahlum)

21% *The elementary school students in classrooms with the most daylight showed a 21% improvement in learning rates compared to students in classrooms with the least daylight* (Heschong Mahone Group, 2001).

COMFORT IMPROVES LEARNING

"Children breathe higher volumes of air relative to their body weights and their tissues and organs are actively growing. Children also spend more time in school than in any indoor environment other than the home. Adverse environmental effects on the learning and performance of students in schools could have both immediate and lifelong consequences, for the students and for society" (Heath & Mendell, p. 3).

Comfort is achieved when classrooms have proper ventilation with fresh air, the right temperature, good lighting, acoustics that allow students and teachers to hear each other, and when teachers have control over their environment. Heschong Mahone Group completed a study on the indoor environment that compared the performance of over 8,000 3rd through 6th grade students in 450 classrooms in the Fresno Unified School District (FUSD) in California. The following general conclusions were drawn about comfort: "Poor ventilation and indoor air quality are correlated with lower student performance. However, in FUSD these issues are almost hopelessly intertwined with thermal comfort, outdoor air quality, and acoustic conditions. Teachers often must choose to improve one while making another aspect of the classroom worse" (2003, p. 109).

Heating, ventilation and cooling systems need to have appropriately sized distribution ducts and digital controls to provide the appropriate temperature and fresh air without compromising the acoustic performance of the room. A teacher should not have to choose between keeping the mechanical systems running or having the students hear the lesson.

Low operable windows for natural ventilation provide the teacher control over the classroom environment. (Kiowa County Schools, Greensburg, KS; BNIM Architects)

When students, teachers and staff are comfortable, teaching, learning and productivity are optimized!

"Fresh air impoverishes the doctor."
–Danish proverb

Sealed concrete floors requiring no finish, no toxic cleaning materials, and no finish replacement over time are incorporated in both the classroom and public spaces. (Kiowa County Schools, Greensburg, KS; BNIM Architects)

SUGGESTED APPROACHES

Ventilation provided at all times with fresh air supplied by mechanical systems or operable windows. Allowing natural ventilation through operable windows gives users greater power over the quality of air in the room, as well as providing a sense of connectedness to the outdoors

Achieving thermal comfort through well-designed heating, ventilation and cooling systems create environments that are not too hot, cold or humid. Pay careful attention to noise from improperly sized mechanical ducts or placement of equipment

Ensure dryness of site and building materials to help prevent mold by mold-resistant building techniques

Use lighting designed to make visual tasks such as reading and following classroom presentations easier. Minimize glare which strains the eyes and makes seeing presentations and computer use difficult

Acoustics allow students and teachers to hear each other in order to communicate and learn. Minimize noise from mechanical systems, exterior sources, and adjacent rooms from reaching the classrooms

Allow for individual teacher control of heating and cooling temperature and ventilation systems

Utilize low-emitting, nontoxic, chemically inert materials: some materials can off-gas enough toxins to cause health problems from indoor air pollutants (and to which children are more susceptible than adults)

Select materials that do not require toxic cleaning materials

IDENTITY OF PLACE IMPROVES LEARNING

A school with a strong identity of culture, such as a unique school spirit, raises the self-assurance of students — especially at the high school level. Such a level of engagement is evident at Civano Community School in Tucson where the sustainable design of the small elementary facility contributed to a high level of environmental awareness and personal commitment to sustainable choices exhibited by its student body. The school includes a community garden that highly engages many outside the traditional school family to engage and contribute to its success.

Arizona has very distinctive land forms and climatic conditions. This unique environment can provide a design direction that will result in a distinctive signature identity and purpose for a school. A visual expression of the values that are the basis of the shared vision statement for the school will give its students pride in the place where they learn and grow. Having that, they will more easily develop the self confidence they require to do their best.

The value of an identity is that it can instill purpose. A school building that reflects its unique identity, culture, or spirit can help infuse a heightened motivation in its students to fully engage in their own education and strive for their personal best.

SUGGESTED APPROACHES

Establish community aspirations for the school that can inspire its design

Evaluate opportunitites from the site's immediate surroundings and community for ideas about appropriate image

Identify signature programs or components of the school's mission that can become part of the school's design image

Identify land forms or water systems that provide a strong sense of place that can be featured in the design

Identify the role of the school and its community to identify community connections that may be primary design elements

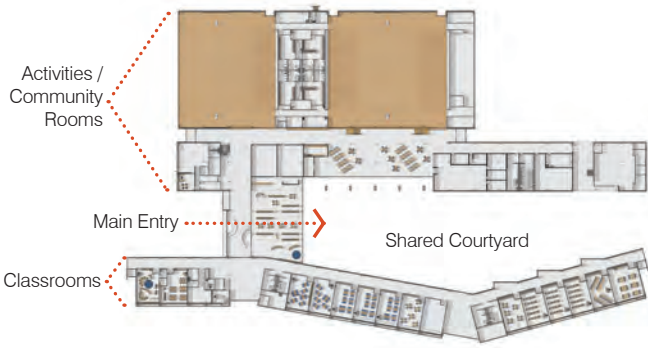
A unique design image responsive to its beautiful site & climate. (Ventana Vista Elementary School, Tucson, AZ; Antoine Predock Architects in association with Burns and Wald-Hopkins Architects)

Strong identity is provided in a renovation of a former retail commercial building for an alternative high school. (Desiderata Alternative School; Phoenix, AZ; Jones Studio, Inc)

"We shape our buildings and afterwards they shape us."
–Winston Churchill

SCHOOLS AS CENTERS OF THE COMMUNITY IMPROVE LEARNING

In order to create schools as centers of the community, architects, educators, designers, local officials, and residents need to think differently about our schools and create more highly useful and flexible spaces that reflect a new understanding of the school building intended for both students and the community. Many local school districts in Arizona have embraced this concept and have created examples of wise management of public resources.



Floor plan. (Kiowa County Schools, Greensburg, KS; BNIM Architects)

Chandler, Deer Valley, Anthem and Casa Grande Unified School Districts have incorporated county branch libraries in new high school projects with great success. The Wickenburg Unified School District joined forces with local patrons of the arts, the Wickenburg Foundation for the Performing Arts, and the Del E. Webb Foundation to fund, construct, and operate the Del E. Webb Center for the Performing Arts. Holbrook Unified School District recently completed a similar project, the George Gardner Performing Arts Center, on the campus of Holbrook High School.

BOULDER CREEK HIGH SCHOOL SITE PLAN

The North Valley Regional Library is located at the center of the High School campus with convenient public access. This allows shared access between the public and the students while still maintaining security on the campus. (Boulder Creek High School, Anthem, AZ; DLR Group; image courtesy DLR Group)

WHY IT MATTERS?

Research done by the American Architectural Foundation (2005) as part of their Great Schools by Design initiative has shown that when schools are integrated into their communities, there are dramatic benefits for both the community and the school. This integration can lead to positive differences in four key areas:

STUDENT LEARNING
Demonstrated gains in student achievement

COMMUNITY VITALITY
Increased community pride in surrounding neighborhoods, improved sense of security, better rapport among students and residents, and more intensive use of school facilities

SCHOOL EFFECTIVENESS
Stronger parent/teacher relationships, improved teacher satisfaction, a more positive school environment, broader community collaboration and support

FAMILY ENGAGEMENT
Greater family stability, more involvement with school activities, greater sense of responsibility for children's learning success

SUGGESTED APPROACHES

Evaluate potential community partners for building and operating facilities

Evaluate community needs that may be able to be provided with shared school facilities

Develop potential for community education programs that could use school facilities after school hours

Consider a design approach that incorporates zones of the building and site that can be separated for alternative uses by the community

Shared courtyard. (Kiowa County Schools, Greensburg, KS; BNIM Architects)

School facilities that are shared with other public uses maximize the return on the public investment they represent. In the process, they enrich the learning experience of the students at those facilities.

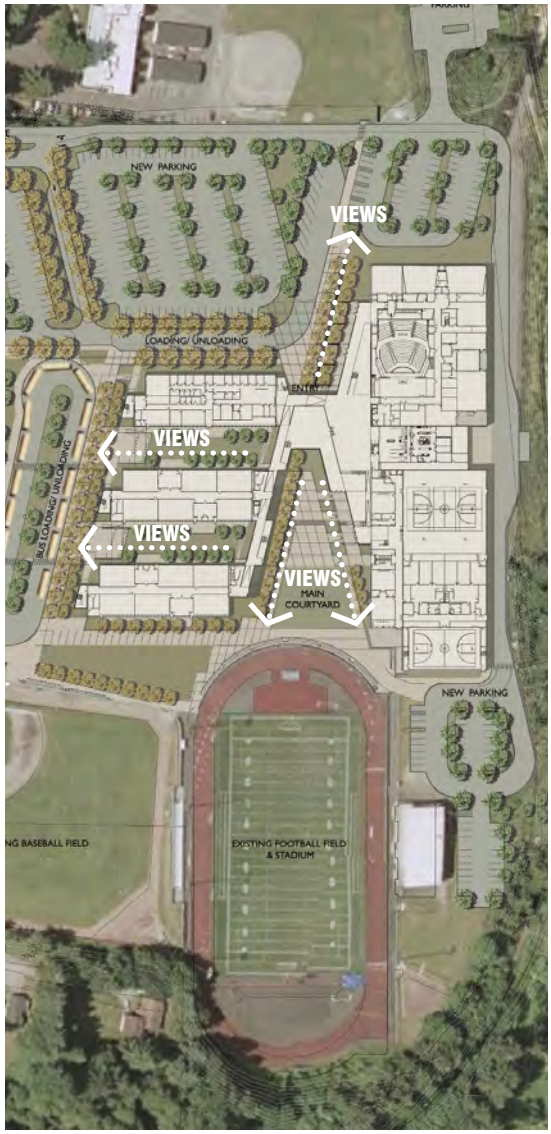
SAFETY IMPROVES LEARNING

One of the most pervasive misconceptions I discovered is that schools must be like a fortress in order to deter crime and limit vandalism. This seemingly reasonable goal has resulted in the simplistic approach to eliminate windows, block views, and make the primary image a high fence. The alternative approach used by Police agencies around the country for decades is CPTED.

Criminologist C. Ray Jeffrey, Ph.D. of Florida State University coined the term, CPTED (pronounced “sep-ted”), in 1971 when he wrote the book entitled: Crime Prevention Through Environmental Design. He defined the term as, “the proper design and effective use of the built environment that can lead to a reduction in the fear and incidence of crime, and the improvement of the quality of life.” While CPTED is primarily focused on ways architectural and site design can help prevent crime, understanding the key strategies defined by the CPTED concept can also help school officials convey a sense of safety and security for students, teachers, and staff while simultaneously providing visually open and inviting schools. There are numerous design attributes and facility characteristics that can enhance a school’s safety and security performance. These attributes were highlighted in a report entitled, “Arizona Safe Schools,” issued by the Arizona School Facilities Board (2007).

Visibility, activity, and design are the best ways to create safe environments—none of which requires eliminating windows and designing fortress schools.

Crime Prevention Through Environmental Design (CPTED)



The building is designed to allow views of all primary exterior areas using visibility and natural surveillance to create a feeling of safety. (Issaquah High School, Issaquah, WA; Mahlum)

SUGGESTED APPROACHES

Use landscape and architectural design devices to clearly define borders of controlled space — not necessarily a fence

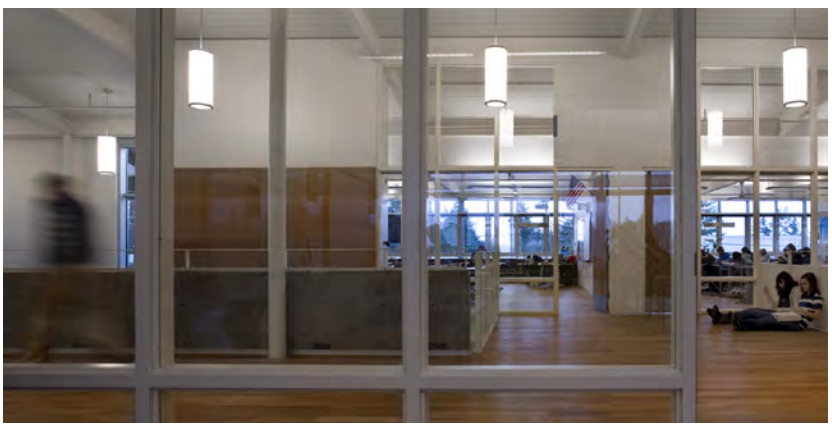
Use design elements to demarcate the transition from public to semi-public to private space. Placing the primary entry and administrative offices at the front of the building promotes natural surveillance, helps eliminate wandering visitors, and provides general access control

High activity uses deter nefarious individuals who want to evade scrutiny or intervention. Therefore, scheduling the productive and active use of spaces will reduce the perception of risk to intended users and will help control the behavior of ill-intentioned individuals

Locate unsupervised spaces such as restrooms and stairways near supervised areas or high use spaces

Design schools that take advantage of natural visibility and that increase the perception of visibility and natural surveillance, creating an overt feeling of safety. Sidelights in classroom doors allow teachers to keep an eye on corridors or adjacent student activity areas and to observe quickly who is entering or very near the room

The courtyards at Issaquah High School provide natural surveillance through increased visibility. Landscape also clearly defines borders.
(Issaquah High School, Issaquah, WA; Mahlum)



Visual transparency.
(Bainbridge High School 200 Building, Bainbridge Island, WA; Mahlum)

TECHNOLOGY AND FLEXIBILITY IMPROVE LEARNING

Develop design of buildings that allow modifications of use and changes without major adjustments to expensive building systems. Modular design of space and systems allows for similarly sized structural and service systems to accommodate a variety of uses — classrooms, offices, specialty instruction, etc. These can include innovative spaces that support many educational functionalities: lecture space, room for projected images, space that allows students to gather and work collaboratively in small groups, and work spaces that permit sharing images and files from laptops.

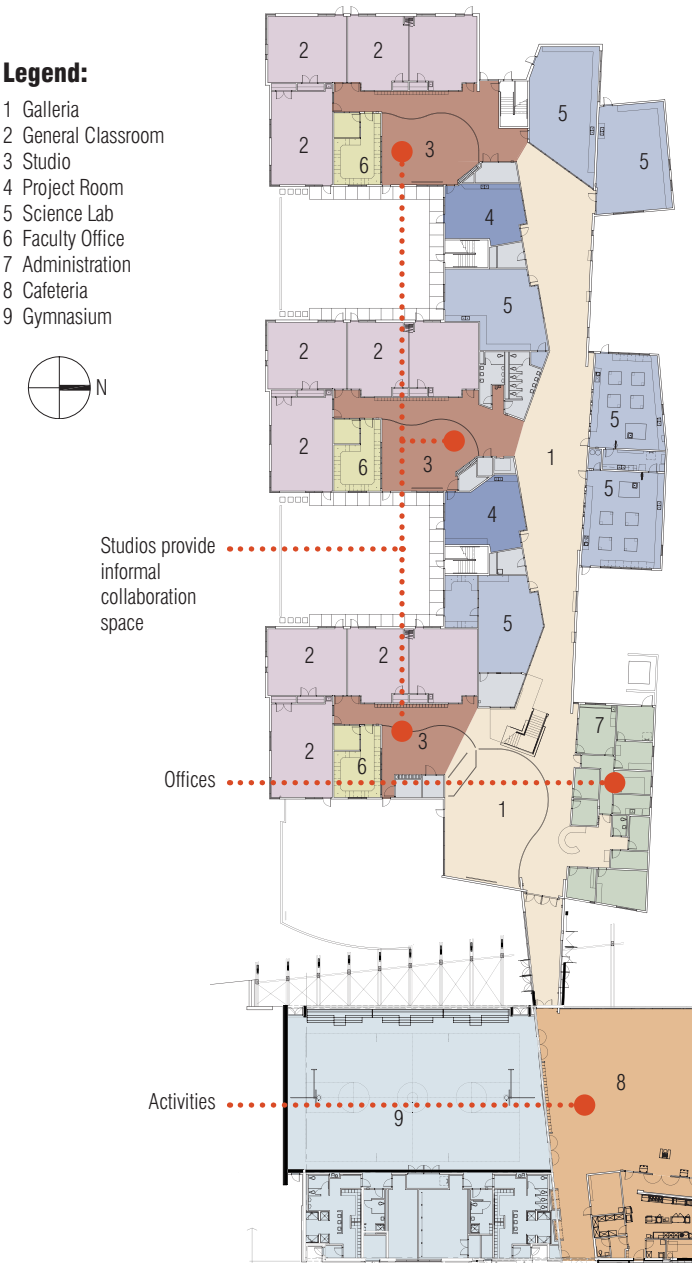
Classroom designs for the 21st century must provide the flexibility to accommodate the array of teaching and learning configurations that are proving to be instrumental in improving student achievement.

Informal learning spaces, indoors and outdoors, are key to providing personal learning opportunities for the students in our schools. These provide areas for collaboration, the sharing of knowledge and discussion which is important to innovation and comprehension. These "out of the ordinary residual spaces" can be catalysts for "out of the ordinary thinking" contributing to making Arizona's 21st century schools true "incubators of innovation."

Loose fit = long life:
Create schools that can adapt and evolve over many years due to their design of spaces and systems used to improve learning opportunities and reduce the cost of future changes.

The lobby was designed for multiple uses such as an informal gathering space, group learning or presentation space, and an informal area to study or socialize. (Indian Community School, Milwaukee, WI; Antoine Predock Architects)

DENVER SCHOOL OF SCIENCE AND TECHNOLOGY



Floor plan showing modular classrooms and flexible learning spaces. (Denver School of Science and Technology, Denver, CO; klipp; image courtesy klipp)

SUGGESTED APPROACHES

Create reasonable classroom flexibility that can be adapted to the wide range of alternative learning and teaching methods

Develop a zoning of mechanical, electrical and communication systems that allow for easy modification and access for modification

Design offices and specialty activity rooms **that can be easily modified** in the future for instructional use

Incorporate spaces that can be used for small group instruction, large group meetings, displays, performances, and demonstrations to support achievement

Provide a variety of flexible spaces for personalized learning, project-based learning, and group learning

Design circulation to be informal teaching/collaboration space — interior and exterior

Employ modular design of services/technology (HVAC, electrical, communication) to allow future space use modification

Design space that will be flexible enough to accommodate future learning-based Information Technology advances and devices

SUMMARY

As we rapidly approach our statehood Centennial and begin Arizona's second century, we need to be mindful of our legacy and future.

Nothing can ensure a bright and solid future more than the education we provide our children. If we expect our generation of Arizona schools to match the rhetoric of offering an educational experience that will make our students competitive players in the global economy, schools must be designed to support that goal. Knowing what makes for the best school, we would be foolhardy to ignore that knowledge as we plan, design, and build new schools.

In this era of public school frugality, the importance of smart school design is more imperative than ever. The concepts in this Primer must be central to the design and construction of new schools and the renovation of existing schools. The best examples of quality architecture have been, more often than not, constrained by limitations of site, schedule and budget. The current limitations on resources available to fund public schools do not constitute an excuse for ignoring the useful and prudent design concepts reviewed here.

We can build more with less. It just takes imagination and determination. These were the very qualities of those who founded Arizona 100 years ago. Let's employ those same qualities as we approach Arizona's Centennial in the 21st century schools we are building now.

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NOTES

Your own notes for questions you may want to ask your architect as you begin the design process for your new school or for the renovation of an existing school:

What is your approach to Life Cycle Cost?

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What is your approach to Sustainable Design?

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What is your approach to Daylighting?

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What is your approach to Comfort?

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What is your approach to Identity of Place?

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What is your approach to Schools as Centers of the Community?

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What is your approach to Safety?

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What is your approach to Technology and Flexibility?

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WELL DESIGNED SCHOOLS

Improve Student Performance

Are Easier To Maintain

Retain Better Teachers

Cost Less In The Long Run