ON PERMEABILITY – THE BIOLOGY OF ARCHITECTURE

What will the spaces and structures for undergraduate science, technology, engineering, and mathematics (STEM) look like in ten years, and what are your reasons for making such predictions?

Contemporary science education is dynamic and flexible. The traditional distinctions and boundaries between scientific disciplines continue to erode and evolve. Several developments of our time affect the design of spaces for science:

- Increasingly facile and ubiquitous technology liberates us from the limits of traditional classroom or laboratory walls.
- Pedagogy has moved from lecture-based teaching to discovery-based learning.
- A growing awareness of the fragility of the natural environment prompts us to consider how we can design, construct and use buildings to be “sustainable.”
- Much of the scientific research of our decade will focus on biological and genetic discoveries.

These factors propel us towards a future where the limitations and boundaries of the past are replaced with new, interactive and experimental techniques and approaches. An even greater degree of collaboration between disciplines will require buildings to be flexible at a level that we have not yet experienced; continued development of building technology will allow buildings to interact with nature in a manner that is more sensitive to ever changing climatic and environmental conditions.

As we look towards the future, it is useful to evaluate the boundaries we currently see in the built environment and reflect on how we may choose to change the nature and limitations of these boundaries. For centuries the creation of architecture has been about creating enclosure and shelter. In essence, the physical aspect of architecture is the creation of or definition of spatial boundaries. The spiritual aspect of architecture is how the space boundaries transcend the pragmatic, evoking emotional and aesthetic reactions and prompting intellectual discourse. In thinking of future facilities for STEM, there are ideological limitations and physical boundaries to consider and define: flexibility, sustainability and permeability.

Flexibility

Flexibility in building design and space quality is a reflection of how much adjustment must be made to accommodate a change in use or function over time. Highly flexible spaces are most useful and desirable when change is expected to occur frequently. Spaces benefiting from a highly flexible design would include teaching laboratories that have little fixed cabinetry, have electrical, ventilation and plumbing services arranged such that demonstrations or experiments can be conducted in a number of different locations, and have room dimensions and proportions allowing for groups and teams of varied sizes to learn in diverse ways.
Highly flexible spaces do not exhibit the same degree of specialization that would have been the norm for teaching spaces a generation ago. Adaptability has replaced old typologies of rigidly programmed layouts, and reflects a changed pedagogy that will continue to evolve with time. In fact, planning highly flexible spaces for tomorrow’s uses today, is as much about what not to include in the spaces as it is about providing appropriate infrastructure. The teaching laboratory of ten years from now will reflect an understanding of the psychology of learning and will provide the appropriate physical setting for intellectual development.

Flexibility in architectural design extends beyond the adaptable nature of an advanced teaching laboratory. In a sense, the flexible STEM building of the future will reflect the continuously evolving boundaries among the traditional disciplines. These flexible buildings must be organized to support the complexities of the various disciplines and their particular infrastructure requirements while simultaneously removing the physical barriers of isolation and segregation so long associated with technologically sophisticated buildings.

STEM buildings will reflect this changed dynamic of increasing interdisciplinary interaction in many ways. First: the strategic placement of highly flexible teaching spaces that can be utilized by more than one discipline. Second: creation of larger, flexible and adaptable faculty/student research spaces that are grouped together rather than isolated as individual cells. Third: the creation of functional zones and circulation systems such as stairs, elevators and corridors to maximize opportunities for personal interaction. This is not to say that a sense of privacy or seclusion will be precluded in such buildings, but that the pathways linking different parts of the building are designed to create and enhance a sense of community.

**Sustainability**

The STEM building of the future will not only be flexible in its internal organization, but will also reflect an understanding of the complex interaction of people, architecture, nature and climate that we call sustainability.

Since the 1960’s, developed societies have been struggling to find an appropriate balance between the consumption of fossil fuels (and the consequent pollution and depletion of resources) and the quest for a comfortable, healthy and sustainable environment. Architectural and industrial reactions have been driven by the desire to maintain comfort and quality of life while reducing the environmental costs associated with increased energy usage. The results of these efforts have been mixed.

Manufacturers continue to improve energy efficiency of building products such as heating, ventilation, lighting and electrical equipment. Architects and engineers, along with governmental agencies and legislators, have worked together to improve the energy conservation of buildings, reducing heat gains in summer and reducing heat loss in winter. Among the unfortunate results of these pioneering efforts is a generation of buildings without operable windows and with inadequate mechanical ventilation. This can contribute to “sick building syndromes” and can create a feeling for occupants that they are trapped in buildings whose environments are not only unhealthy, but also cannot be controlled or readily adjusted to respond to the natural range of variance in temperature.

More recently, increased awareness of the value and scarcity of natural resources has propelled society to consider the environmental impact of materials and products that we use to make our buildings while also considering the quality of the air inside these buildings.

These considerations have made architects, building owners and builders begin to try to reduce the impact of buildings on the environment by such steps as increasing the use of recycled materials, designing new products for recycling, limiting the use of scarce resources and continuing to focus on energy efficiency.
While a step forward, these advancements have not yet significantly changed our concept of how buildings relate to our environment or climate. The very fact that buildings have been designed “green” but operate and appear just like any other building begs the question: Is sustainability something to hide or would we be better served to celebrate our respect for the environment in a more tangible and visible way? The STEM building of the future will move beyond our current thinking regarding “greenness” and begin the advancement of sustainable design that is sophisticated and reflective of our increased understanding of the complexity of nature as well as its impact on scientific discovery.

Nature provides us with many examples of efficiency and beauty that are inspiring in design and fascinating in function. To advance beyond our current limitations, our buildings must begin to reflect nature’s intricate and individualized response to environment and climate. By designing buildings that are not simply barriers to sun, rain, wind and snow, but rather as organisms that use materials, engineering and technology to adapt to the climatic conditions, we begin to evoke a new relationship between buildings and nature.

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This will mean, for instance, that the exterior wall of a building will be less a permanent barrier and more a filter that can open and close as conditions demand. Building HVAC systems will take the energy nature provides — light, heat and wind — and adapt or store it to provide for the comfort of the building occupants. These buildings will be developing towards an open, adaptable and variable envelope suggestive of the membranes and enclosures of plants, animals and our own bodies.

In such future buildings, sophisticated technologies will be used to allow the ventilation, lighting and weather protection components to be adaptable and flexible, responding and changing with nature’s varied seasons and conditions. The output of these buildings will not be waste that requires disposal, but will be a resource that can contribute to the life cycle of the future. The result of this open and sophisticated building system will be an environment for learning and living reflective of our own natural biological systems, and co-existence of the building and nature will be comfortable and natural.

The advancement of technology will allow future STEM buildings to mimic the sophisticated energy management systems of nature and allow the building to change its enclosure and ventilation systems as required to respond variations in temperature, wind, daylight and moisture conditions. This is an increase in design and technical complexity, but such advancements will allow the building to respond in more useful ways to both internal and external influences.

In addition, sustainable buildings of the future will reflect the local climate conditions and building materials in ways demonstrative of our own values about us as social creatures. This will reflect an increased respect for our planetary biosphere and our conscious recognition of humanity as a biological element in this natural order. In the future, the rigid architectural solutions of the past that imposed alien orders and generated formal reactions (or even outright defiance) to the natural environment to give expression to the concept of man’s dominion over nature will be replaced by an architecture reflective of our participation as members of a complex ecological system.

Sustainability will then enter a new age, one more fully cognizant of the sophistication of nature and simultaneously demonstrative of our increased understanding and appreciation of natural systems.
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The sustainable STEM building of the future will not only reflect our changed values, but will also serve as an educational model, adjusting and adapting with the forces of nature and providing a living testament of our quest for knowledge and understanding the world around us.

Permeability

The STEM building of the future will not only prove more flexible and sustainable than the buildings of the last century, but will ultimately serve as physical representations of the issues of our time: intellectual openness to new ideas; analysis and filtration of the influence of stimulus; and boundless discovery.

One might even suggest that we are moving from the Industrial Age where buildings were designed to be more machine-like for strength and efficiency to a new way of designing buildings to be more biological for flexibility, productive interaction with the environment, and catalytic connection to their users.

We refer to these qualities as permeability, and many efforts in the last decade, especially those of Project Kaleidoscope, have questioned the traditional academic pedagogies and the physical aspects of building designed to support such educational ideologies. As is the nature of intellectual inquiry, members of institutions call into question methodologies and approaches of the past and have abandoned obsolete teaching models for learning based on discovery and inquiry. It is the quest for intellectual openness and reception, experience and remembrance that compels us to ask how our physical environment impacts the learning process and what we can do to provide the best setting for STEM. The challenge for designers is how to create architecture of permeability.

Architecture of permeability is one that embraces boundaries that function as filters rather than as confines, boundaries that simultaneously establish domain and yet allow those within and outside the domain to be aware of the world around them, physically and spiritually.

These permeable filters may be found both inside a future building where the boundaries among STEM disciplines are blurred, but also between the building and nature and between the building and the surrounding community. This architecture is open to the suggestions of the natural environment and develops from an understanding of the forces of nature and evolution. A permeable building is one that moves beyond enclosure from the elements and enters the domain of interaction with the environment as a living organism. In this way, biological architecture can also be a living educational experience for STEM students and teachers.

The greatest role architecture can play in the future of STEM buildings is to provide settings that allow students to learn collaboratively in a set of diverse, complex, interconnected and ever-changing fields of study while connecting the student with nature, providing protection when needed, and allowing the buildings themselves to be living laboratories for Science, Technology, Engineering and Mathematics.