Ordering Chaos: "Computerism" versus "Humanism"

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Overview

Current trends in high profile Architecture, offer forms and structures that are well beyond the basic comprehension of most human beings. In fact, the rationalization and eventual construction of the structures that are presented as initial sketches are likely beyond the personal technical abilities of those who design them. This is not meant with any disrespect, but with simple observations based on examinations of early napkin sketches, architectural massing models, renderings and representations of steel with little pieces of balsa wood where it is represented – intriguing visions – absolute lack of technical detail. Such proposals present a frenzied vision of massing and structure that requires an intense use of cutting edge computing technologies and advanced human intellect. The chaotic steel structures that characterize the current work of Daniel Libeskind and Frank Gehry have driven enormous changes in the way that such structures are designed, fabricated and constructed. They have altered the tools that are used and largely shifted the architect's technical dependency from the Engineer to the steel fabricator and detailer.

Is technical architectural education keeping up with such changes? Are our teaching methods and tools too deeply entrenched in detailing practices that have been relegated to the mass construction of "Big Box" stores, and are rarely to be found in the projects that our students design? How do we criticize their work if we don't understand *if it could* or *how* it is to be built. Is it visionary? Is it impossible? How do we process, root, and respond to this shift in technical culture? How do we continue to assist in the design and detailing process?

Shifting Centers: "Man Vs. Computer"

There has been such a remarkable centric shift in architecture and technology, which critics may argue displaces "man" from the architecture of chaos. Reconciling current thinking about the design, detailing and construction of purposeful disorder, with minds that remain faithful to the beauty of classical forms, is challenging. It pushes those who teach design, and challenges those who teach construction and structure. With such apparent disparity in form, it might be questioned whether experience in the field will help or hinder in solving problems that arise in detailing such chaotic forms.

Humanism marked a point in history where "man" was deemed to be at the center of the universe and was considered to be the measure of all things. Humanist architects, from Leon Battista Alberti through Andrea Palladio, strove to create a definition of architecture that was based upon human proportions, historic successes, and that permitted a rationalized repetition of forms and elements that were derived from the perfection of nature and sacred geometry.

> "Both our organs of perception and the phenomenal world we perceive seem to be best understood as systems of pure pattern, or as geometric structures of form an proportion. Therefore when many ancient cultures chose to examine reality through the metaphors of geometry and music, they were already

> very close to the position of our most contemporary science."[1]

As nature was "of God", and man was made in God's image, so should architecture achieve a more perfected state of being if it were to be created aligned with human proportions. Man positioned with a view from the center could clearly comprehend this view.

> "…Renaissance architecture, like every great style of the past, was based on a hierarchy of values culminating in the absolute values of sacred architecture."[2]

Sacred Geometry was able to clearly assist in the derivation of the Pythagorean Triangle, visualize square roots and define the Golden Proportion and the value phi and the Platonic Solids. Scientific and mathematical developments towards the end of the seventeenth century finally developed treatises that began to use practical geometry as a means to solve the actual problems of building and construction. Philibert de l'Orme's Architecture (1567) devoted several chapters to illustrate the use of horizontal and vertical projections to determine the measurements of complex parts of a (stone) building. Such invention in the fields of stereometry and mensuration allowed for the development and subsequent construction of accurate and more complex structures in stone. G. Desargues is credited with using stereometry to reduce the art of stone cutting to universal and methodical principles.[3] Where such applied mathematical invention was landmark at the time, is has become the drudge basis for all drawing and CAD systems in contemporary culture. Such systems did not necessarily continue to reflect human proportioning, but they were intellectually accessible by humans. Books addressing the "Science of Art" document a rational system, where perspective and regular orthographic methods assist in representing ordered spaces.[4]

Fractal – Meet Architecture…

Modernism and the International Style may have stripped architecture of symmetry and ornamentation, but still adhered to the use of simple, regular geometry in buildings. Le Corbusier, in "Le Modulor" strove to re-infuse modern architecture with human proportion in an effort to make it more beautiful. Building upon existing geometric theories, Le Corbusier unsuccessfully sought to reinvest buildings with a modular design theory based on the Golden Proportion.

Various trends in architectural design, from Russian Constructivism to Contemporary Deconstructivism, negate any requirement to acknowledge human shape, form or size in the generation of their architectural designs. Early proposals, such as the Tatlin Monument, were only ever realized as models, never having to endure construction. Similarly, early explorations into chaotic deviations in architectural form during Daniel Libeskind's tenure at the Cranbrook School of Art, resulted in drawing and model based designs, not construction.

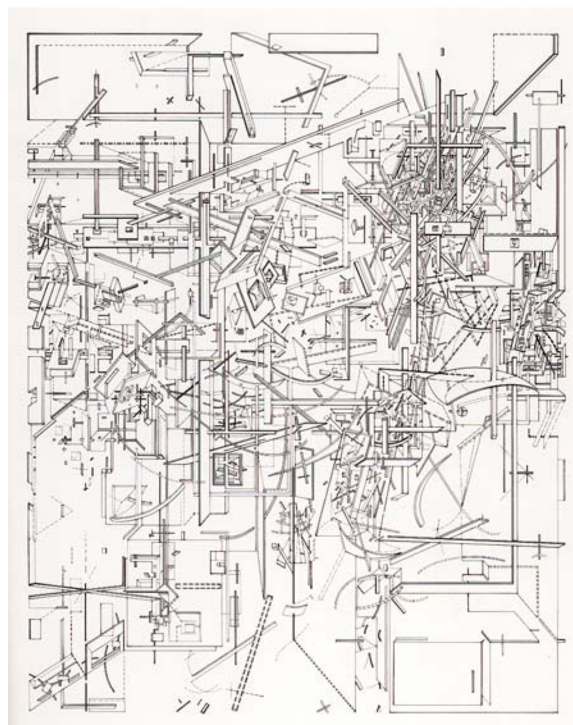

Figure 1: Little Universe. Daniel Libeskind. 1979.

Libeskind writes in "From Zero to Infinity" in 1981:

> "Architecture and architectural education reflect more accurately perhaps than any of the other arts, the order of society, the ideology of formal configuration and the limits beyond which forms become unacceptable and are simply considered irrelevant and disorderly."

Although Libeskind's "architecture" of the period might have caused a stir, and influenced less ordered design ideals in students and a small selection of practitioners, the absolute chaos that permeated the renderings was not possible to religiously translate into built form. The renderings lacked materiality, scale and physical connections that would have allowed them to exist full scale.

Charles Jencks in "The Architecture of the Jumping Universe", 1995, begins to explore the impact of Chaos Theory on architecture. Where humanistic proportioning systems were based on the geometries of nature that could be seen, Chaos theory is based upon the geometries of nature that evaded our view, that is, until the invention of high powered microscopes – i.e. fractals. Jencks does maintain that fractalian architecture (at least that based upon spirals and hexagons) was invented by Bruce Goff and Frank Lloyd Wright before the science was actually discovered.[5] However, architecture based upon spirals and hexagons is still governed by regular rules of geometry, if more complex to translate into built form.

Much of the star architecture today, in its deference to affirming either fractalian architecture or cosmic views of chaos, negates all of the basic principles of humanism. The ideas behind the buildings, the technology to create the buildings and the spaces generated have little, if not nothing, to do with human scale or capacity. They cannot be easily described in drawing or via the use of orthographic drawing methods. They cannot be hand calculated for structural sizing. They seem to have infinite pieces and views. This is quite in keeping with the nature of fractals, upon which much of this architecture is supposedly based. Fractals are shapes that are *independent of scale*; no matter how far you zoom in you will always observe the same degree of '*roughness*'.

"In the mind's eye, a fractal is a way of seeing infinity"
James Gleik. Chaos 1988.

Even before modularity was a keyword in design, repetition of elements was the norm for classically derived buildings. Symmetry, patterning, inter-columnation and the use of like-sized components (bricks or stone slabs) preceded even Durand's Précis de Leçons or French Beaux Arts style. Even modern architecture, which for the most part ignored rules of symmetry, at least looked to the repetition of elements for economic results. Chaos based design results in drawing files and quantities of unique components that lie beyond the grasp of our understanding of most contract document "sets".

Renaissance architecture, and indeed most building up to the invention of modern cranes, was limited by human capabilities in lifting and placing the components of a building. Much of the scale we see in architecture has been a function of the amount of weight one or two workers can reasonably lift without mechanical assistance. Modern cranes make the precision lifting of steel trusses in excess of 50 tons a manageable task. This has also drastically changed the design and construction of complex buildings.

Intellectual Capacity: Man vs. Computer

Man's intellectual capacity and ability to process complex thought, as well as perceive and understand space, has grown exponentially in the past 1,000 years. This is clearly evidenced in advances in drawing and painting even from the Middle Ages to early Renaissance treatises, such as Alberti's 1435 treatise "On Painting". The perspective method set out in this treatise established the viewpoint, horizon line, picture plane and combined a centric view of man with a non-Euclidean view of geometry in the adoption of a vanishing point for supposedly parallel lines. It is conceptually difficult, for the developed mind of 2005, to appreciate Medieval representation methods, with their perspectival inaccuracies. Even small children of this century can develop a better sense of perspective in drawing than is represented by the most advanced frescoes of Giotto.

Hand drawn perspective renderings for hundreds of years would routinely apply a scientific underlay to validate the positioning of objects in a painting. Where early perspective renderings were only possible if the artist clearly understood the scientific application of the process of "seeing", current computer applications do not necessarily require that the user fully understand the process, only be able to see the output as correct. In this way the complexity of any architectural project or structure is no longer limited by human intellectual capacity.

Perspective is to the viewer. Axonometric is to the object. This cannot be done by hand….

Computer programs that are used for architectural design, rendering, modeling, as well as structural design and modeling, all use data input based upon the Cartesian coordinate, x, y, z axis system. Even the points in the most complex of buildings can be defined and physically located by this rudimentary system. What this has allowed is the ability to translate abstract points in space to fixed points in the 3-D building grid, and via extrapolation, infill and manipulation, generate wire-frame bases from which to derive architectural and structural images by which to understand and detail the building. Such drawing data can then be used by the steel fabricator, via software programs such as X-Steel, to completely define the structural elements, with bare millimeters of tolerance, to the last bolt.

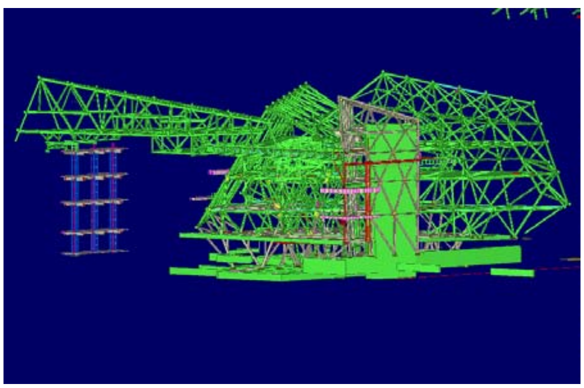

Figure 2: X-Steel Computer Snapshot of the "whole job"

Beyond the God-like skills of the software engineers who design such programs, lies an incredible ability for a detailer to appreciate the interconnectedness of "the whole job". Working with fractalian notions of infinity, the ability to rotate such detailed 3D models allows for unlimited views, zooming and extraction of all details and connections. With respect to the ROM project, except perhaps for floor framing plans, traditional elevation and section images resulting from normative orthographic projections would yield unintelligible webs of receding lines and unmeasurable data. For actual dimensions and material take-offs, only projections taken normal to any surface are of value, and more easily done via computer than by hand.

What just happened here was a jump from the Architect as master builder, in control of all design aspects of the project, to the steel fabricator (also engineer) as the only team member with the capacity to not only manipulate such design programs, but also to fully understand the ramifications on the detailing, fabrication and erection of the structure. Unless one is fully immersed in the design and detailing of such a structure, so as to be personally involved with each connection and its detailing, how does either the architect, and sometimes even the structural engineer, have any basis for objection or query, if their intimate knowledge of the structure is well beneath that of the fabricator?

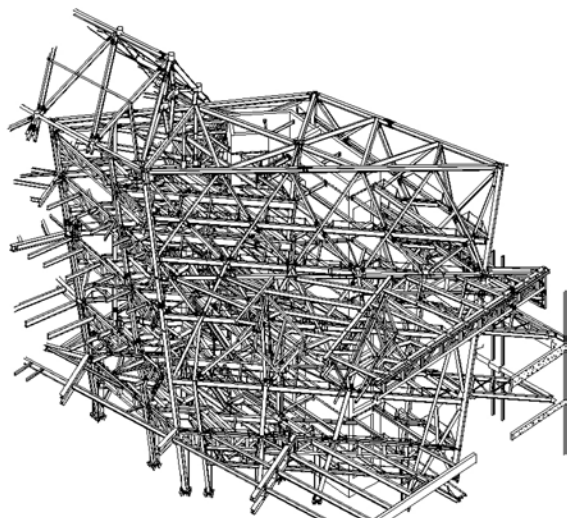

Figure 3: ROM: Axonometric of Crystal 4

What is intriguing about the axonometric of the "Whole Job" is its ability to be pulled apart to show the individual "Crystals", and then by the detailer to define specific erection sequences. What appears as a tangled mess of steel by most is seen by the steel detailer and site supervisor as a defined series of distinct pieces that must be installed in a particular order, as a function of their nearness to the ground, need to support or brace other members, and to be kept clear of other lifts as not to impede crane access.

That is not to say that more rudimentary methods are passed over when examining and understanding the structure. The steel floor framing is shown below in a rough model that looks at the floor plates in isolation, and the exterior diagrid planes are isolated to be able to visualize each crystal's face without the added confusion of interior framing.

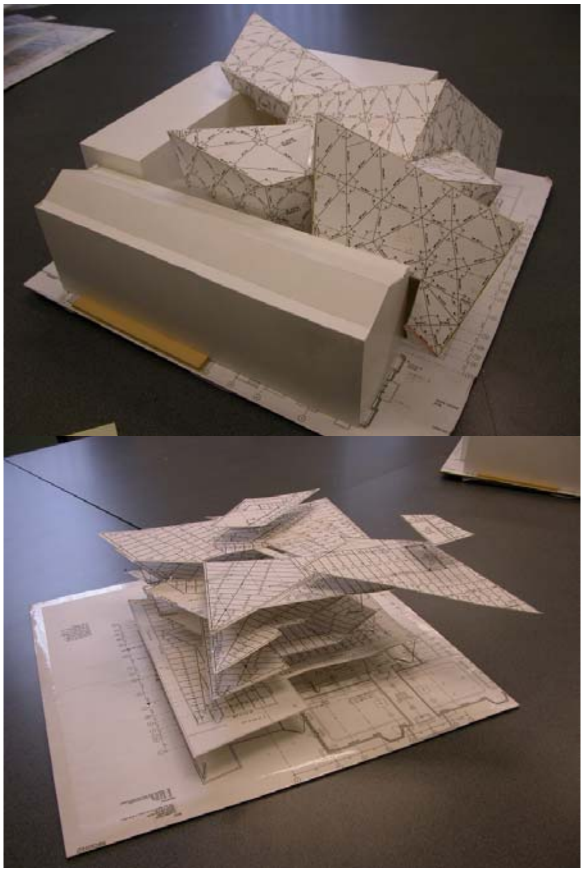

Figure 5: Working models made from information extracted from the axonometric

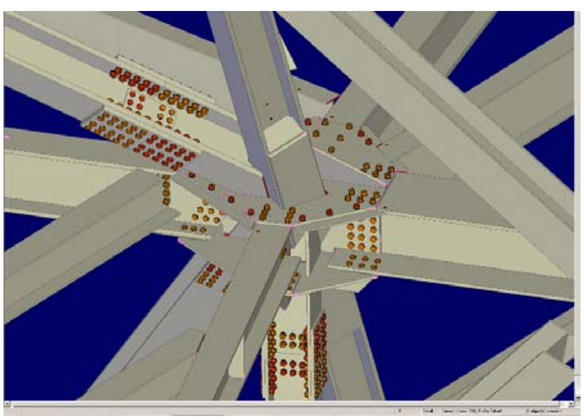

Figure : A single connection isolated in X-Steel

With technological advances in computer technology, both for processing data/calculations, as well as in drawing and detailing complex structures, the level of complexity and detail is no longer limited by basic human intellectual capacities. The scope and possibility of architecture is no longer limited by human capacity for thought, accuracy, construction or lifting. The computer centric design and construction process allows architecture to step well beyond human capabilities in all areas.

Fabricating And Erecting Complex Shapes: Continuances In Basic Geometry

From the concept as a whole, to the eventual breakdown to unique disparate parts, even chaotic systems are measured and ordered by traditional geometries and systems of measurement. This marks a significant connection between the traditions of humanist derived mathematical systems of understanding and drawing architecture, to modern, chaos generated elements. So in understanding, and in teaching, the basics can be reduced to comprehensible theories and practices rooted in accepted concepts. As we rotate and dissect the axonometric view, each piece may be extracted and its characteristics, dimensions, thickness and connections recorded in standard notation.

Figure 6: A drawing using standard orthographic projections sits aside the steel whose accuracy is checked with a carpenter's square, pencil and tape measure.

It is intriguing to notice that the problem solving skills of the detailer and the ironworker have kept pace with the challenge of the question, perhaps to a higher degree than their architectural counterparts. A better sense of gravitational centers, balance and constructability is evident in the way that the oddly shaped steel members are handled. It is relevant that trial and error still prevails as multiple attempts may be made to position an irregularly shaped steel piece. The human touch and interpretation of the situation still grounds the construction in historic normalcy. Computers are to be found more often on the job site as the complexity of the project requires three-dimensional checking that is beyond the printed contract document and shop drawing set.

Construction as a Spectator Sport: Learning by Watching

If architecture is intended to be occupied by and appreciated by humans, then there must be means to bring such complex projects to a point where they can at least partially be understood and appreciated. The observation of construction process is one means to be drawn into this arena. It is also key to developing a keener understanding of the transition from "mass of tangled steel" to assembled connections. If one does not necessarily "like" the building, it can still be appreciated for its "process". And the process of this particular building, and others like it, has much to offer in the way of learning about steel construction and detailing. There are many who do not agree with the Addition to the ROM, for reasons both architectural and cultural. But it is still an engaging piece of architecture that can well be used as an instructive piece for both the public and students of architecture. This particular building is situated at the main intersection of Toronto. It is on the "route" of all sightseeing tour buses and is passed by hundreds of pedestrians each day. The increase in the numbers of webcams that oversee public building projects like this one makes it simple to keep track of progress from a distance as well.

Order must be achieved in terms of the scheduled delivery of components – relating to the erection sequences on a crystal-by-crystal basis. With so many disparate parts, this also orders the fabrication of the members. The steel members were fabricated in Walters Inc.'s shop in Hamilton, and then transported 100km to the Bloor and Avenue Road site in downtown Toronto, to be delivered as much as possible in avoidance of traffic congestion. The staging area on the north edge of the site was extremely tight, so the steel was offloaded and laid very compactly on a "to be erected" basis. Trucking restrictions limited the size of components, so many of the larger angled pieces of the diagrid were shipped as essentially straight members with their palm like heads attached in the shop, and assembled into larger configurations in the staging area prior to erection. As the erection proceeded through the fall and nonstop through the harsh winter of 2005, the staging area steadily shrunk as building displaced the free area of the site. This made sequencing and placement of deliveries even more critical.

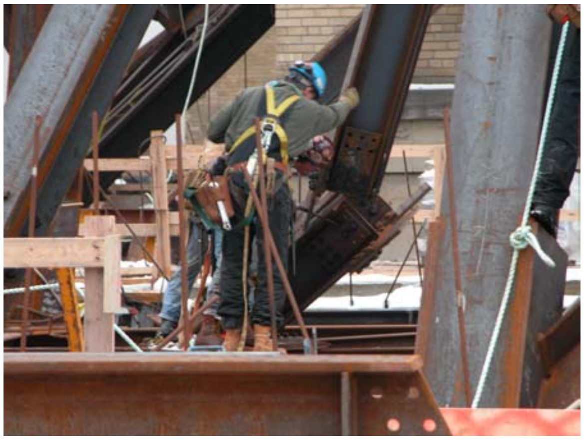

Figure 7: Ironworkers attempt to connect a sloped assemblage of the diagrid

For normal rectilinear steel erection, gravity assists in pulling the pieces into their final position. This project had virtually no vertical members – meaning that all of the column type members were installed at an angle to vertical. This made erection challenging. As a result, gravity was the enemy of much of the erection at the ROM. Lifting points and chain lengths for the complex angled pieces had to be carefully calculated to reflect the gravitational centers of the odd shaped assemblages. The ironworkers sometimes made several attempts at obtaining the correct lifting angle or position so that the piece could be slid into its receiving connection. This sometimes required that the staged pieces be turned over or rotated within the tight staging area, prior to their final hoist. Sudden movements or slippages of members could not be tolerated during a lift, were the gravitational center not found. Contrary to what may be thought, steel joints in a project as complex as this must have extremely tight tolerances as "extra space" that might allow for members to connect more easily would compound into error and lack of fit further down the erection sequence.

Erection technologies with respect to such a large complex project bring to bear simple issues of scale. Observation allows the viewer to appreciate the sheer scale of the individual members and assemblages. The steel is not some distant lacey component, but a rough, rusted material to be viewed quite closely. The ironworkers appear to be lost in the project, like characters in a "Where's Waldo" puzzle.

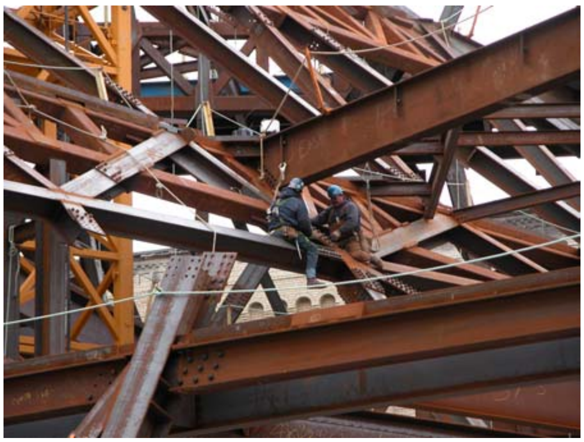

Figure 8: Ironworkers hidden in the steel.

Voyeurism also allows one to get personal with the project. The security guard is known as "Super Dave" to all on site, as well as to the tour bus operators that pass by on a daily basis. The key members of the Ironworkers Local 721 who erected the steel are of the Mohawk tribe. When there is a challenge in the lift, Lick and Tony are on either end of the piece, and always work it into position with little trouble. The steel pieces also have names. The sloped vertical members with the wacky looking "capitals" are known as the "palms", for their resemblance to the same. A key connecting piece that joins some of the main ring trusses is known as "the owl". There is a nice upscale bistro lounge across the street, with lovely white couches and apparently Daniel Libeskind used to come to view the construction, and lay on the couches just gazing for long periods.

And these things also bring human scale to the ordering of chaos.

Teaching Technology Without Knowing: An Ethical Question:

I Compute, Therefore, I Design

It is of paramount importance, in spite of the complexity of the computing systems that are used to assist in design, to maintain humanistic motivated control over the design process. In fact, controlling output makes design with computing systems potentially more difficult than design pursued in a rote or traditional manner. *Just because you can, should you?* This is a question that pervades computer-aided design, at both the academic and professional level. The Libeskind drawings of 1980 can now be built. Twenty years of technology has made speculative visionary design constructable. The pen and ink hand drawings have been overtaken by CAD processes.

Complex buildings such as the addition to the ROM, many of Frank Gehry's public works or the exposed steel projects of Santiago Calatrava, challenge the accepted teaching practices of construction technology prevalent in most schools of architecture. Such projects can stretch the knowledge base of many outside of such innovative practices, who have not had to bring something this challenging to completion. It is critical that professors are up to date with issues concerning the challenges of this type of design, and are able to assist students in making the increasing larger leap from the AISC standard connection details to those that are to be seen in chaotic steel as well as more geometrically controlled AESS projects.

"Do you own steel toed safety boots and a hardhat?"

This is a very important question. It may have been possible to teach or learn construction/structures without experiencing the actual process of building, when modern buildings were simple, rectangular and predictable. Chaotic architecture that must be ordered by rational construction detailing and methods requires a higher level of understanding of the processes, sequencing, tolerances and procedures than can be afforded by a distant view. Can we teach what we do not know? Can we learn what we have not experienced or seen first hand?

Given the radical changes in the ways and means of construction, not to mention critical issues regarding the appearance of its final form, we cannot continue to teach topics like building construction and structural steel design that for the sake of simplicity, tend to ignore the existence of such complex, challenging and often chaotic issues.

The science of regular stereometry, perspective and construction detailing has given way to a technology that must recognize infinity and chaos in design. Yet to build that chaos, we must rationally apply current construction technologies. We are in the midst of writing the "next chapter" of many historic texts that terminated with the Modern Movement.

If we are to prepare to teach which intellectually we do not really know, may not have experienced, nor may have the technical ability to ourselves do, or even fully understand, then

We must pull ourselves out of the ditch
By our boot-straps
Turn inside-out
And see everything with new eyes.

Peter Weiss, Marat-Sade

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Notes:

[1] Lawlor, Robert. Sacred Geometry. Crossroad Publishing. New York: 1982. p. 4

[2] Wittkower, Rudolph. Architectural Principles in the Age of Humanism. W.W. Norton & Company. New York: 1971, p.1

[3] Perez-Gomez. Architecture and the Crisis of Modern Science. MIT Press. Cambridge: 1984. p. 229

[4] Kemp, Martin. The Science of Art.

[5] Jencks, Charles. The Architecture of the Jumping Universe. Academy Group Ltd. London: 1995. p. 44