Fragmentation and Interrogation as an Approach to Integration

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INTRODUCTION

This paper tracks an attempt to embed the complexity of teaching building systems integration within a design studio context by removing any expectation of building completion on a comprehensive scale, and instead interrogates existing case study buildings and the students' own projects through a series of fragmental design explorations. Our intention is to assist students in developing and applying architectural and technical strategies across multiple scales of a building project. To do so, we have adopted a pedagogical strategy that focuses on building fragments as a device for encouraging flexible thinking when integrating the complex technical systems prevalent in contemporary construction. This manner of schematic development in the SEC studio encourages generative constructive thinking at multiple simultaneous scales rather than design as a closed linear problem solving process. Design is not seen as the creation of objects, but as the guidance of multiple, simultaneously acting forces into an integrated assembly. The corequisite technical course (SECtech) also embraces fragmentation for the purposes of interrogation: three professors provide three different technical (structures, environmental and construction) and conceptual viewpoints for three distinct building pairs. Various forces within those building pairs are compared to illuminate strategic thinking for comprehensive building design. The intense focus on selective systems within these building pairs is intended to support the same development of integrative strategic thinking in the studio.

The fragment as a pedagogical device is meant to reinforce that our work as architects should have extended relevance beyond the primacy of a single object. In other words, that architecture extends across sites, histories, and cultures not as singularities, but as vast interrelated systems that have individual characteristics articulated within the whole. For our students, their work is to bring expression to those fragments while still accommodating the overall system of forces and to consider strategies for technics[1] as part of that integrated field. In addition to comparing the types of knowledge generated by the fragment, we must ask: how does this knowledge compare to the discipline[2] rooted questions pursued in practice? Does fragmentation as a pedagogical instrument further perpetuate the segregation of structures, environmental technology, and construction as distinct knowledge and technologies? Or does acceptance of the fragment encourage the development of more integrative design processes in young architects as they coordinate disparate specialties in contemporary practice? Furthermore, what are the qualities sought through this piecework method and does technical awareness provide sufficient linkage between various fragments at multiple scales?

Our premise is that, by designing discrete moments of their own projects deeply, the student gains greater technical knowledge and more conceptual design flexibility than they might through the broad design of an entire building project. By flexibility, we are referring to the weekly integration of new

technical information from the Technology course into their studio design process. Our expectation is that students have constructed a set of deeper investigations at multiple scales within an integrative building strategy. Examples will demonstrate that as a teaching tool, fragmentary tactics can be useful for preparing students to engage with the multiple technical and compositional forces within architectural project.

BACKGROUND: INTERROGATING INTEGRATION

> "I took it for granted that the WHAT and WHY of architecture could, without saying, be assumed and that in my lessons, the main thing was to teach HOW one can design."[3] (Bernard Hoesli)

While not intended to be mimetic, the lens of fragmentary focus is similar to the habits of contemporary practices with complex building design models tracking multiple streams of information, large task-specific teams, and fast-track construction schedules. Architects are expected to work quickly, to exhibit a holistic understanding of the architectural goals as well as deep knowledge for their own limited scope of responsibility in collaboration with colleagues across multiple scales of the building project. There are still practices that maintain separate design and technology teams just as in academia. This way of conceptualizing separate roles is a false dichotomy avoided by firms that capitalize on the relationship between technology and design. Firms such as Morphosis, KieranTimberlake, Saana, and Renzo Piano Building Workshop seek to establish more systemic practices within the transactional opportunities afforded by conceptual and technical modes of practice. Many contemporary modes of design resolution in architecture are primarily expedient in nature whereas this studio, through the lens of fragmentary focus, endeavors to exploit complex moments as potential sites of integrative design.

The capstone to the undergraduate curriculum is the Structures / Environment / Construction (SEC) Studio taught in the fourth year of the undergraduate architecture program and the second year of the graduate architecture program. During a curricular assessment in 2003, it was decided that there needed to be a greater focus on technical systems within the comprehensive studio model. The proposed solution was the development of corollary courses for SEC Studio entitled SEC Tech 1 and 2[4]. These courses were taught for the first time in academic year 2007-2008.

The previous iteration of SECstudio was in many ways, a typical comprehensive studio project. Students were assigned a program, site, and required levels of technical and formal development to which they were to conform. Overall design strategies were generated from a combination of contextual conditions and theoretical forces of the student's own selection. However, three criticisms had been noted by the faculty: one, that given recent changes in the structure of architecture curriculum (including the development of a Master of Architecture program), additional intellectual rigor was needed to satisfy this more mature group of thinkers. The second criticism was the need to encourage median students to see the integration of technology as more than an expedient task but as a transformable opportunity for their design work. Many students, having worked hard to develop initial strategies were reluctant to revise or truly develop their design work in an opportunistic way upon receipt of new information. We sought a teaching structure that would encourage the development of strategies that were malleable to the multiple formal consequences brought by the manifold streams of technology[5] they were expected to integrate into their work. Thirdly, our own fourth year undergraduate students lacked knowledge of architectural precedents critical for elevating the studio discourse and for the production of technical and formal strategies. In most cases, those projects of which the students were aware had not been deeply interrogated beyond a formal appreciation. Perhaps these criticisms speak more to the difficulty of combining the two different populations of undergraduate and graduate students, but it was the curricular scenario we were presented with and our objective was to address the students' complex needs within that existing structure.

This studio has been revised to consist of a two-quarter studio sequence with a co-requisite technology lecture. Students develop and articulate diverse strategies for design at multiple scales and projections within the studio. The expectation is that the pedagogy supports manifold exploration paths; that multiple scales generate multiple design strategies and that each scale of thought may inform, but does not necessarily coincide

with the others. With this structure, we have attempted to slow down the rush to a singular conception so that multiple systems and forces can influence the project ordering. The open nature of the schematic development in the first quarter of the studio encourages generative integrated constructive thinking rather than detailing as a closed linear problem solving process. For instance, if an architectural strategy is mutable only as an evenly scalable form, it would be a less useful strategy than one that can withstand asymmetrical scaling. Students are encouraged to critique their intentions by seeking not shapes, but vectors[6]. They are encouraged to question whether there are sympathetic alignments between constituent architectural forces.

RESEARCH AS DESIGN: INTEGRATING SYSTEMS, FORCES, AND FORM

> "An architect can not construct a building without a theory of construction, however simple-minded that theory might be. Construction is not mathematics; architectural construction is just as subjective a process as is architectural design."[7] (Edward Ford)

> "But this new understanding will not result from the development and deployment of new techniques alone. The continued dedication to a technical interpretation of performance will lead to nothing more than an uncritical reaffirmation of old-style functionalist thinking—a kind of thinking that is both reductive and inadequate because it recognizes only what we can predict." (David Leatherbarrow)[8]

The goal of SECtech 1 is to provide an introduction to strategic and operative thinking when integrating building technology as a constituent element of the architectural designer's palette. The class teaches that technology, in its many forms: construction assemblies, structural systems and the more broadly held environmental controls, can indicate direction and solve many of the issues and problems that an architect faces in the realization of a building. This technical course parallels studio methods and themes, but is not strictly integrated within the studio pedagogy during the first quarter.

While many have noted the superficial separation of design and technology[9], current department and teaching structures reinforce this distinction. Our ultimate goal may indeed be to completely re-order the existing technical silos in a manner similar to OMA's strategy of re-ordering program at the Seattle Public Library (which is also one of

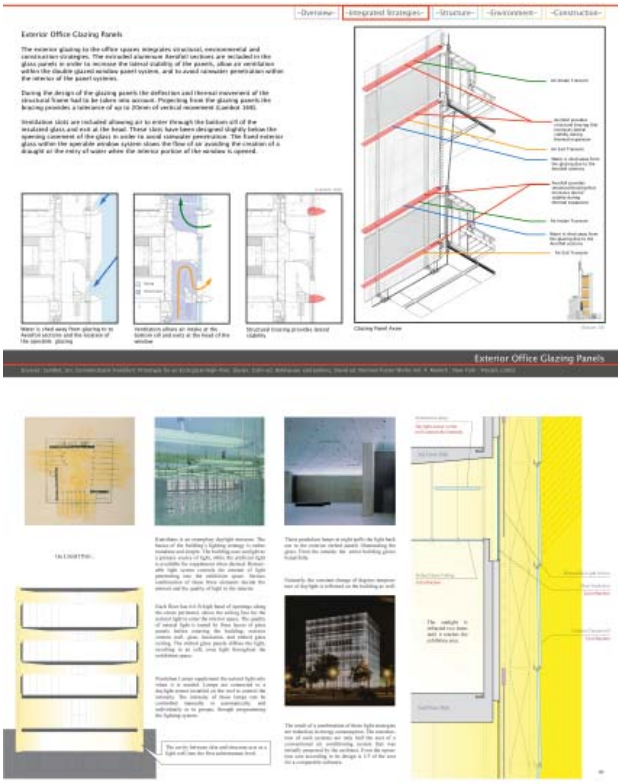

Figure 1. student case-study analysis of Commerzebank Frankfurt.(above) and Kunsthaus Bregenz

the projects discussed by the faculty in SECtech) in order to embrace the opportunistic juxtapositions of technology rather than segregated knowledge areas. For now, the two quarters of SECtech are taught as a collaborative course by three members of the structures, environmental technology, and construction faculty. This has worked well as a first step for modeling a dialogue for technics and form that the students might employ in their own strategic discussions. In each of the case-studies presented a faculty member addresses the impact on the design and issues of technical and theoretical perspectives that can aid students in designing integrated buildings. The tech lectures are intended to provide insight on the integration of systems in design and the design process. An entire week of class is spent on a faculty analysis of each pairing, so that after three classes, students have been immersed in the technical strategies and forces evident in these projects. The conversations are framed around the typological pairings of: museum, library, and spiritual spaces.

Kimbell Art Gallery by Louis Kahn and the Nasher Sculpture Gallery by Renzo Piano

Kahn's concrete series of cycloid vaults are lit by a slit at the top of the vaults that allows light to enter and then bounce off reflectors before washing down the reflective concrete interior surface of the vaults. Thirty years later Piano, in conjunction with Arup, developed a roof skin that effectively filters out any direct light year round while evenly washing the space with daylight. Yet, there are other differences and as a result, the two museums offer fundamentally different phenomenological experiences.

Seattle Public Library by OMA and Ballard Public Library by Bohlin, Cywinski, Jackson

Though one is a main library and one is a branch library in the Ballard neighborhood of Seattle, both of these projects address certain shared aspects of context, climate and program, but with phenomenally different results especially in regards to the design and technology of regionalism. The designers exploited technologies to help define contemporary interpretations of library. Aspects of urban and suburban, scale, public space and contemporary construction versus traditional construction are all considerations in this dialogue.

St. Ignatius Chapel by Steven Holl and Myrramaki Church by Juha Leiviska

Though situated across the world (Seattle, Washington and Vantaa, Finland) there are profound relationships in the relationship to daylight, electric light, mechanical systems and construction in these projects. Site forces have interestingly similar relationships and the overall application of layering for affect provides valuable insights.

The second quarter of SECtech focuses more on practical technical content rather than theories of construction. The lectures are more closely linked to the studio design project; issues of code, construction type, egress, load, thermal regulation, and enclosure are studied in relation to the individual student project. The work asks that students interrogate their building design; understand its constituent parts and performance on multiple levels; and understand the strategies that bind and define their choices.

The final product of SECtech 2 is a technical program document comprised of worksheets and graphics that clearly describe how the systems investigations are informing and impacting the design process. Similar to the analytic structure of the first quarter SECtech case-study, there is an important distinction. Whereas the case-study was produced independently from the studio work with the intention of informing abstract thinking in regards to integrative strategies, the technical program document is a record of their own building design process. It is developed concurrently with the studio design and is meant to enrich the two-way dialogue between the classes. The analysis is two part and includes research and identifying information and content, as well as proposing / promoting relationships that are both evident and latent. Design and innovation comes from understanding the body of information and by making new relationships work for greater consequence. Meant to compliment studio developments, it is a working document. It is intended to facilitate conceptual thinking about the technical issues confronted in the design process and to show an assessment of their success in the final design solution.

Both wisdom and invention show us that the relationship between design and the problem-solving begat by technology is not a linear process, but rather a more cyclical and self-informing set of relationships. It is a multi-faceted and malleable design framework that balances and integrates building technologies with reciprocity. It is this notion of reciprocity, and the formative strategies for design response that include building technologies, that is the focus of this course. This course does not address rote solutions for individual technical problems, but rather exposure to architectural precedents and architectural thinking that balances multiple, sometimes contradictory, agendas within a synthetic design process. In describing Rem Koolhaas's approach to practice, Sanford Kwinter notes: "his insight that it is soft form, not hard, that bears the maximum of active structure."[10] While Koolhaas's interest is primarily programmatic in nature, we can appropriate his strategically inclusive point of view as a useful tactic when dealing with building technics too. Flexible design strategies bear the maximum of contradictory technics.

DESIGN AS RESEARCH: COMPREHENSIVE FRAGMENTS

To bring a foundation to the wealth of issues addressed by the studio, the project is grounded in the complex site of Cranbrook. Besides being an active place during all seasons, Cranbrook has a long history of building projects with strong site relationships. There is a robust material and craft history in addition to periods of intense intellectual independence. Tradition and experimentation exist side by side across multiple scales of the campus providing a clear source of reflection for the conceptual and technical issues within the studio.

The structure for the first quarter of studio is two-part: research-analysis + research-design. The studio begins by researching contemporary architectural precedents. Students use generative drawing techniques (similar to analytiques) of contemporary architectural precedents as entry into current problems of practice. The topics of research have been broken down into limited categories of construction, volume, and site or in the poetic terms of the studio: hand, body, horizon[11]. We seek not only documentation and rote knowledge through this drawing research but inquiry and destabilization of preconceptions.[12]

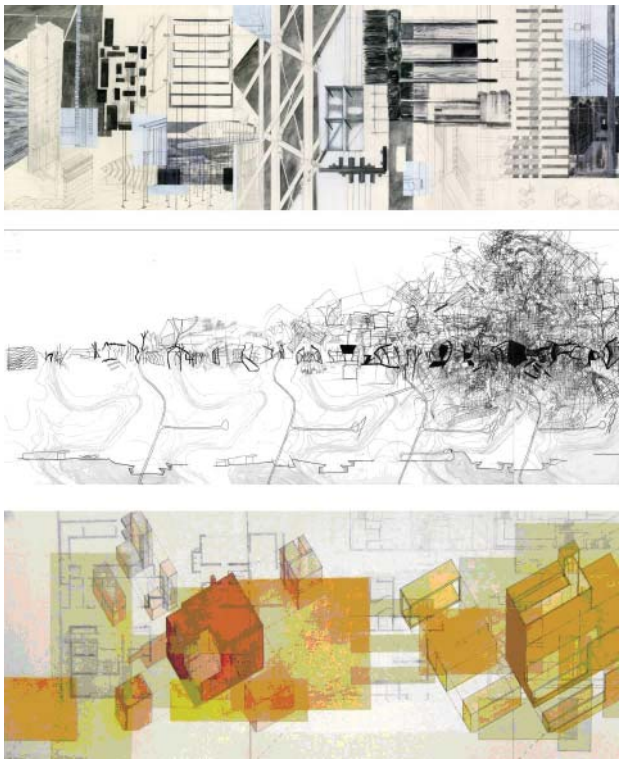

Figure 2. student precedent research and analysis for categories of detail, site, and volume

While much of this analytical work is about strengthening the studio dialogue, our goal in this studio is not to lead the development of manifestos or architectural polemics. Instead, students come to understand the design and composition forces employed across multiple projects and in the service of a variety of architectural problems and scales. Short design charettes that repeat the scale structure of the analytiques, follow this research and eventually the quarter ends with a series of drawn and modeled design fragments[13]. These architectural fragments may be abstracted in terms of scale, but must contain concrete potential for construction, inhabitation, and site. At the end of the quarter, students have collections of differently scaled building fragments useful for development in the next quarter.

The second quarter encourages the development of these design strategies into a more completely described work of architecture. During the second quarter, students develop their early design strategies more independently, but they are still given areas of responsibility including: structure, thermal conditioning, and enclosure. For each of these areas, a large-scale hybrid wall-section/perspective is developed along with bay models, and site models exploring the same areas of focus. These methods are similar in spirit to the drawings from the first quarter in that they are considered to be part of a generative process, but the students are also including specific design components including: joint connections; materiality; passive heating, passive cooling and daylighting; ventilation, insulation, moisture, and vapor components; gravity and lateral structural conditions; and mechanical zoning and routing. It is expected that investigations from SECtech be directly reflected in this studio work.

To clarify, the whole is not completely ignored in favor of the fragment. For instance, concurrent with this work, the students are designing room relationships, researching site conditions, and guiding formal development as technical and practical knowledge is acquired. While there is a general program (a spa and guest rooms) design exercises focus on specific architectural operations in relation to general sensibilities and qualities about parts of

the program rather than conformity to square footages. Instead of thinking of the design problem as being horizontally comprehensive where the entire project is developed equally at a predominant scale; the work is vertically comprehensive where discrete moments or corners are intensely developed at multiple scales. Our expectation is that students have constructed a set of deeper investigations within a potential building strategy.

INTEGRATED FRAGMENTS: TECHNOLOGY AND DESIGN

> "Again, there are two common ways of missing the reality of the architectural work: one is to see the building as nothing but a system of components intended in design and realized by construction, the other is to view it as a system of representations outlined in composition and experienced in perception. Both make the building into an object, the first a result of technical reason and the second a confirmation of aesthetic expectations."[14] (David Leatherbarrow)

The joint between technology and design is held to be problematic within practice and teaching. Fragmentation and integration are contradictory acts and in many pedagogical cases, design and technology are considered distinctly.

Figure 3. building Fragments.

We seek to interrogate in order to integrate. It is an effort both abstract and literal; a conceptual and practical construction of knowledge that reflects the idea of architecture as the coordination of strategic acts leading to comprehensive development. To mediate all of the potential polarities, the production of joints as an orchestration of contradictory systems is emphasized. So while fragments are the means of studying the various complex conditions of architecture, joints are the means of synthesis. All scales: joints between disparate systems, joints between manifold forms, joints between any parts of irresolution become the site of investigation for the studio and are a constant theme in the technical course.

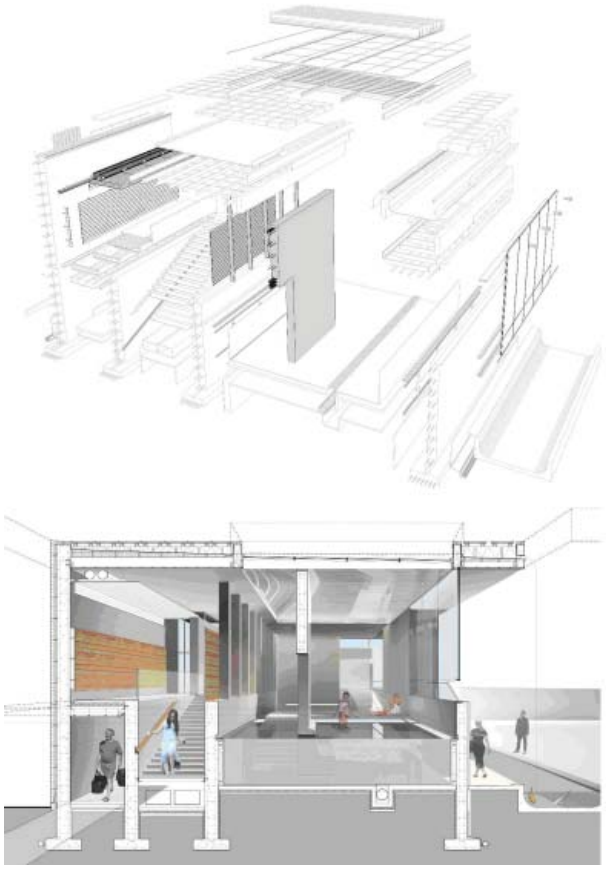

Figure 4. curricular joints between SECtech and SECstudio. Student Details from the Technical Program Document

In many cases, the building fragment developed by the student is the synthetic moment or joint for the studio and technical course, but there are specific structures encouraging joint development as well. In SECstudio and SECtech, the literal joints are embedded in the coursework. In the first quarter, the studio analytiques and the tech case-studies are the sites of conceptual and technical integration. Those

assignments function as intellectual joints between the two courses. In the second quarter after design and technical strategies have been amassed, the student must begin the task of winnowing options down to a direction that accommodates the maximum number of conceptual and technical forces. The integrated curricular joint between the studio and tech course in the second quarter is the technical program document and large-scale wall sections.

CONCLUSION: REFLECTING ON INTEGRATION

> "I consider a system to be the unity of manifold knowledge under one idea."[15] (Immanuel Kant)

The problem of integrating technical thinking and compositional thinking within architecture curricula is a topic under constant reconsideration. The separation of technology and design is a false dichotomy that should be opposed. The management of multiple forces is dependent upon students having knowledge of technical systems and design considerations as an integrated construct. Our world is heterogeneous in the way it works with vast quantities of knowledge not masterable by any one individual, architecture office, corporation, or government body. Acknowledging the importance of unfinished and fragmentary thinking in service of cumulative efforts is a way to work sensitively when attempting to achieve a high level of complex integration. The ever-increasing barrage of information that must be effectively folded into a design process requires that we help students develop a design process that is not only unhindered by technical considerations, but gains credibility with those additional requirements. The nature of architectural practice in the United States is multi-disciplinary, multi-trade, multi-contract, and international. Currently, the professional culture of architecture, construction, and finance support complexity and the fragment is a strategic means of working within these conditions.

In evaluating the successes and failures of SECstudio and SECtech we should face the contradiction between the fragment and integration. This is not a pedagogy seeking a renewed formal deconstruction, but merely a lens by which to focus our efforts. In the positive column, the new pedagogy has proven its practicality in the ease with which it has been accommodated by the existing curricular structure. The fragment has helped faculty manage expectations for student success in designing complex technically oriented buildings. We have also found that students remain more flexible in adapting their design strategies to the conflicting technical requirements they encounter. As a precedent for practice, use of the fragment reinforces nimble and strategic thinking. It also encourages a hunger for multiplicity as a technical and cultural condition.

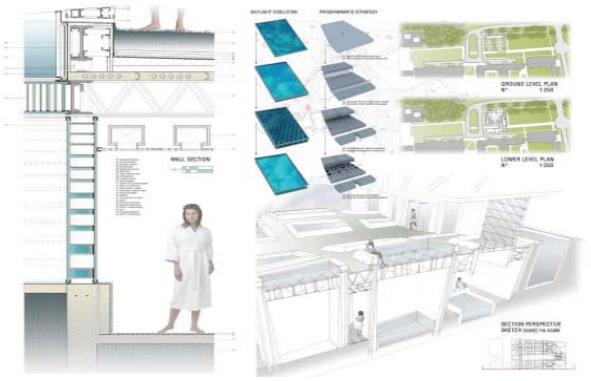

Figure 5. curricular joints between SECtech and SECstudio. Student Building Fragments

The harshest criticism of the fragment as a pedagogical device would be that it is too accommodating. It accepts technical complexity as a given when as academics we should be challenging conditions of United States contemporary practice, construction, and culture in this regard. For instance, is there a correspondence between technical and formal complexity? Is integration a symptom or a tool for complexity? Many of the architecture firms[16] lauded for their strategic integration of form and technics depend on a massive layering of technology. Such systems, thin in individual utility, but complex in coordination, aggregate technology with significant dimensional, economic, and phenomenological detriment to architecture. If our aim in SECtech is to explore unexamined assumptions and to develop a more critical framework for complex technics in architecture, then we must confront clients, contractors, and ourselves to rectify the philosophy of complexity in design.

Fragments provide oblique ways for maintaining both the accidental and the intentional within the framework of studio pedagogy. They may also be a

means for keeping the contradictory and complex modes of inexplicit and explicit forces balanced within architecture. The separation of technology and design is a false dichotomy and the content of both should be taught as interrelated, not distinct. The management of multiple forces is a task interdependent on students linking design and technical knowledge as an integrated construct. Rather than trying to demonstrate technical and formal competence broadly across an entire comprehensive project, we have elected to do less better – a vertical versus horizontal pedagogical structure as in the words of Ed Allen: "Don't try to cover your subject. It's impossible. Instead, uncover a portion of it and teach your students how to learn the rest for themselves."[17]

ENDNOTES

1. Technics refers to building systems, but also more fundamentally to energy and utility potentials within raw matter/resources. Using this word implies not just the technology part, but the qualitative, orientation, and dimensional aspects related to architectural intent. Our definition on technics is an architecture specific version of Lewis Mumford's definition. See Muford, Lewis; *Technics and Civilization*; NY: Harcourt, Brace, and World; 1963. Also see Kwinter, Sanford; "Architecture and the Technologies of Life"; *Far from Equilibrium: Essays on Technology and Design*; Actar; 2008. Also see Moe, Kiel; "Compelling yet Unreliable Theories of Sustainaibility"; *Journal of Architectural Education*; 10/2007.

2. Regarding the discipline and technology, David Leatherbarrow cautions: "Before proceeding, a certain assumption about architectural performance needs to be rejected; namely, that the development of new instruments and methods of predicting the building's structural or environmental behavior will radically redefine the discipline's practice and theory." In other words, the discipline will still call for architecture that meets its social and aesthetic obligations in addition to its technical responsibilities. Refer to Leatherbarrow, David; "Architecture's Unscripted Performance*"; Performative Architecture – Beyond Instrumentality*; NY: Spon Press; 2005. Also, refer to Ed Allen's recent comments underscoring the core contribution of architects in the face of new technologies for design and construction: "My own conclusions are these: First we must solidify our core teaching. By our core teaching, I mean the areas I just mentioned that were important in Saarinen's success as a designer. We have to realize who we are. We are architects. Allen, Ed; "Closing Response*"; Proceedings from Cranbrook 2007: Integrated Practice and the Twentyfirst Century Curriculum*; AIA/ACSA; 2008.

3. Hoesli, Bernard: from Teaching Architecture (Zurich: ETH, 1989), quoted by Caragonne, Alexander*; The Texas Rangers*; Cambridge: MIT Press; 1995.

4. The curriculum proposal was developed during academic year 2006-2007 by the authors and Professors Tom Bible, Terry Boling, and Patricia Kucker at the University of Cincinnati. These courses were taught for the first time in academic year 2007-2008.

5. While we don't refer to formalism within the class structure, maybe we should help reclaim the true meaning of this word. Sanford Kwinter refers to: "What I call true formalism refers to any method that diagrams the proliferation of fundamental resonances and demonstrates how these accumulate into figures of order and shape." He continues: "Formalism demonstrates first and foremost that form is resonance and expression of embedded forces." From Kwinter, Sanford; "Who's Afraid of Formalism*"; Far from Equilibrium: Essays on Technology and Design*; Actar; 2008.

6. Somol, R.E. in his introduction to a monograph on Marc Angelil's first year program at the ETH makes the distinction between geometry and power as a shift in thinking between educational approaches by the Texas Rangers, Cooper Union, and the ETH. The curriculum discussed in our paper is more limited in its ambition (seeking only to help students realize and develop conceptualizations within buildable limits), but the distinction between shape and vector is useful for our situation for guiding students to seek forces external to themselves as they design. See "Operation Architecture"; *Inchoate – An Experiment in Architectural Education*; Marc Angelil; Barcelona: Actar; 2003.

7. Ford, Ed; *The Details of Modern Architecture*; Cambridge: MIT Press; 2003.

8. Leatherbarrow, David; "Architecture's Performance"; *Performative Architecture – Beyond Instrumentality*; ed. Branko Kolarevic and Ali Malkwi; Spon Press; 2005.

9. Many indeed, from Lewis Mumford to Sanford Kwinter to Ed Allen. In particular, Kwinter remarks: "The mechanical and the 'electronic' contrary to popular cultural theory and belief, are by themselves not paradigms and do not represent distinct, successive, agnostic 'ages' or irreducible worlds in collision" from "The Cruelty of Numbers"; *Far from Equilibrium: Essays on Technology and Design*; Actar; 2008.

10. Kwinter, Sanford; "Architecture and the Technologies of Life*; Far from Equilibrium: Essays on Technology and Design*; Actar; 2008.

11. The precedents for the three different exercises include projects by the following architects: (Detail) Tod Williams Billie Tsien, Rafael Moneo, Dan Hoffman, Stevel Holl, Eliel Saaranin, Louis Kahn, Miralles and Pinos, Carlo Scarpa, Alvar Aalto, Patkau, Sverre Fehn, Sigurd Lewerentz, Herzog and DeMeuron, Peter Zumthor, and Mies van der Rohe; (Site) Le Corbusier, Alvar Aalto, Steven Holl, Bernard Tschumi, Williams and Tsien, Gunnar Asplund, Renzo Piano, Dan Kiley, Miralles and Pinos, and Weiss Manfredi; (Space) MVRDV, Frank Lloyd Wright, Le Corbusier, OMA, Rudolf Schindler, David Chipperfield, Adolf Loos, Richard Meier, Louis Kahn, Paul Rudolph, Giuseppe Terragni, and Richard Stirling.

12. In this instance, we defer to Robin Evans: "if one way of altering the definition of architecture is to insist on the architect's direct involvement….[then we must] use the transitive, commutative properties of the drawing to better effect. Evans, Robin; "Translations from Drawing to Building"; *Translations from Drawing to Building and Other Essays*; MIT Press; 1997.

13. Dalibor Vesely discusses both positive and negative aspects of the fragment and fragmentation in "The Rehabilitation of Fragment"; *Architecture in the Age of Divided Representation – The Question of Creativity in the Shadow of Production*; Cambridge: The MIT Press; 2004. For a pessimistic viewpoint of cultural fragmentation, refer to Ignasi de Sola-Morales's essay "Topographies of Contemporary Architecture" in *Topographies of Contemporary Architecture – Differences*, ed. Sarah Whiting; Cambridge: The MIT Press; 1996. We are merely trying to operate within these cultural and professional conditions with a wide range of students. Future versions of the studio may confront fragmentation as a component of the studio research.

14. Leatherbarrow, David; "Architecture's Unscripted Performance*"; Performative Architecture – Beyond Instrumentality*; NY: Spon Press; 2005.

15. Kant, Immanuel*; Critique of Pure Reason; Riga*; 1781; cited and translated in Caroline van Eck*; Organism in Nineteenth-Century Architecture*; Amsterdam; 1994 as quoted by David Leatherbarrow and Mohsen Mostafavi in *Surface Architecture*; Cambridge: The MIT Press; 2002.

16. Firms such as KieranTimberlake, Renzo Piano Building Worshop, Morphosis exemplify the management of complex technics.

17. Allen, Ed; "Closing Response*"; Proceedings from Cranbrook 2007: Integrated Practice and the Twentyfirst Century Curriculum*; AIA/ACSA; 2008.