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Exclusively Mutual

As individuals, institutions, and agencies stumble over each other creating new benchmarks for performance, speaking past one another along the way, the concept of performance becomes increasingly illusive – as does its implication in architectural practice. *MECHANISTICALLY*, it is a manner or quality of functioning. It's *EMBODIED* meaning is firmly attached to the notion of accomplishment. *CONTRACTUAL* performance is tied to the fulfillment of an obligation or responsibility. The creative modality assigned to it's *PRODUCTIVE* definition places emphasis on process based metrics. *INFORMALLY* the word describes a tiresome procedure. Scope of "work done" provides the *LEGAL* context for use of the word. *COLLOQUIALLY* performance is equated with competence. A *REPRESENTATIONAL* dimension exists as well in ceremony. And, performance exists as a *MODALITY* in embedded conduct and behavior.[1]

While the distinctions regarding the origins and meaning of performance may appear to be tedious, the interpretive disparity clearly illustrates why perceptions of those embedded in the delivery of a building project vary so widely when discussing level of success achieved. The National Institute of Building Sciences (NIBS) recently acknowledged that the challenge in identifying and measuring "performance" exists due to widely divergent perceptions in two dimensions: one, *conceptual* and the other *practical*.[2] *Conceptually* there are different meanings assigned to the word based on environmental, consumptive, economic, social, and health based metrics. *Practical* challenges currently include difficulty in reconciling actual vs. modeled performance, data availability, data quality, data consistency, comparative benchmarks, and effective analytical isolation. Many of the *practical* challenges are reflections of *conceptual* challenges, and this is primarily due to a desire for descriptive singularity. When multi-dimensional, simulation based design, production, and monitoring are predicated on parameterization, why are *conceptual* conditions considered mutually exclusive of *practical* conditions? The conditions are exclusively mutual.

RELATIVE PERFORMANCE

Reviewing a hypothetical relationship scenario that exists in the delivery of any construction project governed by an *AIA A201 General Conditions Contract*, the notion of performance as a one-dimensional characteristic becomes unviable. The architect has a first order rela-

tionship with the owner. That relationship is *elective*. The architect also has a relationship with society, and that relationship is *requisite*. Despite the disparity in performative priorities that exist between these private and public interests, the architect is charged with the unenviable task of fostering the resultant *embedded* relationship that exists between an owner and society. Extending the taxonomy of relationship that exists in a hypothetical scenario, the architect maintains a contingent first order relationship with project consultants. There is a second order *embedded* relationship with contractors. The architect's consultants also maintain a *mediated* second order relationship with contractors. If a contract form involving construction management is employed, the architect and consultants are extended in a second order *contingent* relationship with that entity. It is not uncommon in those situations for sub-consultants to be engaged by any of the entities identified in this chain. The architect maintains a third order relationship with those entities that also resides in a *contingent* realm. Sub Contractors and Fiscal Agents involved in project delivery remain at a distance occupying fourth and fifth order *mediated* relationships. But what is of greater significance is how this taxonomy maps onto those of the others embedded in the delivery process. The Fiscal Agents embedded in this taxonomy often have a first order relationship with Construction Managers in commonly executed contract forms, a clear inversion of the relationship that exists between the architect and these entities – with very different priorities and perceptions of what constitutes performance.[3]

With the complexity and multiplicity of perspectives represented in the supply chain it would be difficult to argue that any one of positively biased environmental, consumptive, economic, social, or health based performance metrics do not benefit humanity. They are all relative conditions. And, as with any project, they exist in a hierarchical value chain that correlates directly with priorities of the clients they serve – both public and private. It is precision in communication that becomes the critical component in establishing the appropriate performative hierarchy for a specific project to avoid exclusion that is symptomatic of a non-integrated project delivery method. Those sensibilities must be engendered in the academy.

Unfortunately, the concept of performance as a complex, multi-variant influence in project delivery remains oblique in the academy. Marginally valued professional practice courses strategically placed in as benign and ineffective a location within curricula as can be identified often provide the only forum for this discourse. Frequently, these courses are positioned in the terminal semester of a curriculum and, in most cases, is taught utilizing as uninspiring a method as can be conceived to deliver content. This is an unfortunate circumstance – precisely because the content delivered in these professional practice courses is instrumental to the maintenance and preservation of conceptual design intent in professional practice. Delivered outside the context of a design scenario, already abstract concepts of social, legal, economic, and contractual performance become entirely opaque, or even impenetrable for most students. As a result, the content remains entirely irrelevant in the academic setting and many students emerge into the profession without capacity to evaluate priorities as they relate to performance. This has nothing to do with an ability to design or represent intention – it has everything to do with a graduate's ability to navigate contingent influences that can deteriorate design intent.[4] The remedy to this deficiency already exists within architectural pedagogy, it is a matter of correcting a balance and defining a relevant and vital content delivery method.

DIVERGENCE AND PROSPECT

Architectural Pedagogy traditionally employs two divergent, segregated methodologies; 1) *Consolidated Methodologies* and 2) *Displaced Methodologies. Consolidated Methodologies* employ processes characterized by involve-

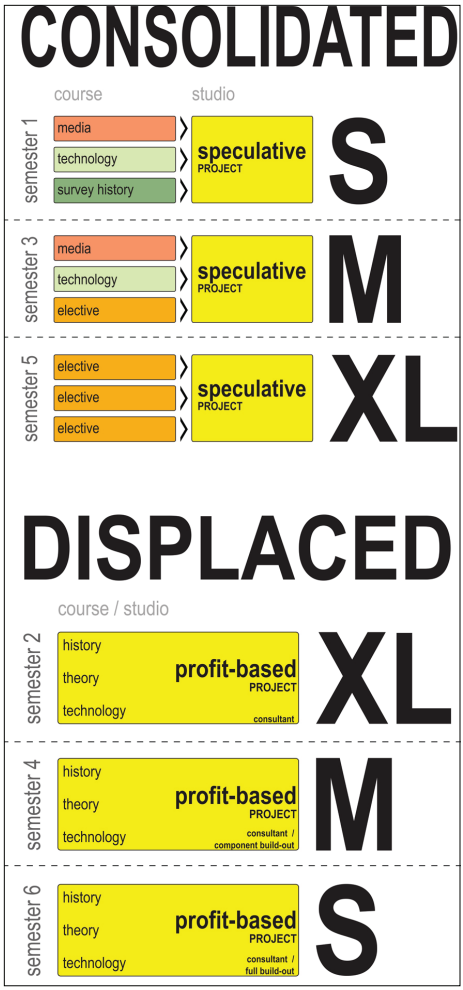

FIGURE 1: Diagram outlining a schematized three year professional degree pedagogy predicated on the alteration of Consolidated and Displaced methodologies. In semesters focused on Displaced Methodology, support course work is developed in support of a profit based, or bottom line driven performative project that reduces in scale by year and increases in degree of completion - culminating in the delivery of a small scale structure for a need based client. Consolidated work is developed in a speculative environment over the three year term, increasing in programmatic scale and complexity – culminating in the individuals most significant speculative exploration.

ment, substantiality, tangibility, presence, immediacy, and direct action; these are methodologies where the student has a singular relationship with a project exclusive of external collaborative influence. *Displaced Methodologies* employ a process characterized by obliqueness, abstraction, mediation and action at a distance; these are methodologies where there is significant collaborative involvement, economic constraint, and/or legal influence.

Within the *Practice Academy* model of architectural education and internship a clear dichotomy has persisted between the academic and professional realms. The source of this dichotomy can be linked to these two methodological realms. Architecture curricula have been predicated on *Consolidated Methodologies* while the reality of Architectural Internship and Practice has remained firmly aligned with *Displaced* action. If the model is to evolve, and engender fundamental sensibilities critical to successful non-hierarchical integrated practice, the dichotomy can no longer exist. Architectural design education must move toward expanding the set of experiences in the academic setting beyond the pursuit of the individual without eliminating those experiences. The exclusion that exists in *Consolidaed Methodology* has tremendous significance in developing sensibilities and critical thinking skills. There is substantial research by Garry Bertieg, Jean Pol Martin, and Ernest Boyer that provides evidence of necessity for conditional exclusion in the academic context. Conditional exclusion, as a component of broader methodologies, can maximize the individual's capacity to focus on a specific content area.[5] The danger is that without a counterpart, the individual develops notions of what constitutes performance which may be at odds with the realities of how performance is influenced and valued in a collaborative environment – a *Conditionally Inclusive* environment.

The prospect is a curriculum that calibrates relationships between alternating cycles of *Conditionally Exclusive* educational experience and *Conditionally Inclusive* educational experience. The latter being able to closely replicate the pragmatic realities of performance in architectural practice with the earlier reinforcing focused development of individual thinking and skill development. Considered across the

breadth of a given curriculum, there is potential for the development of a much stronger set of sensibilities in the emerging design professional. It is an additive proposal.

INFRASTRUCTURAL PEDAGOGICAL CHANGE

If we accept that interdisciplinary education is of positive benefit to the academy[6] – blurring the distinctions between academic units on a campus and embracing the reality of collaboration in practice, why not bring the full set of conditions and performative values that influence the realization of a project into the mix – social, legal, economic and contractual? Each of these dimensions requires the expertise of allied fields, that extend those traditionally valued in the arts, landscape, and engineering. It can be argued that even with the best interdisciplinary models, students are rarely being exposed to project delivery mechanisms that require them to act at a distance in a *Displaced* context. If we consider a hypothetical curriculum that recognizes the significance of general knowledge bases, specified knowledge bases, the necessity for developed critical thinking skills of the individual, the ability to collaborate, dexterity with scale of program, and ability to define/evaluate performance in the context of those variables, what would it look like?

It would be a *Variable Curriculum*; one that requires students to engage in a broad spectrum of activities in a wide array of contexts at multiple scales. Some experiences would be academically oriented, others would remain biased toward the gravity of social and professional responsibility. In either case the studio would be the central environment for experimentation; reinforcing the relevance of pragmatic concerns in the context of a design scenario. The Objectives? The sensibilities and skills to be engendered?

A *Practice Academy Model* presented by Marvin Malecha outlines a series of *Educational Objectives, Professional Behaviors, Core Knowledge Areas*, and *Target Outcomes* that should be considered as instrumental in the development of such a curriculum. The skills, sensibilities and proficiencies that constitute the four components identified by Malecha are: *1)Developing Communication Skills, 2)Guiding Problem Solving Skills, 3)Project Agility Through Creative Connections, 4)Appreciation for Practice Legacy, 5)Valuing Collaboration, 6)Nurturing Project Empathy, 7)Ethical Conduct of Practice, 8)Managing Time, Resources, and Results, 9) Design Proficiency,10) Technical Proficiency, 11)Management Proficiency, 12) Marketing Proficiency, 13)Enriched Emerging Professional Experience, 14) Specialized Credentialing, 15) Advanced Academic Credentialing,* and *16) Life Long Learning Strategies*.[7]

For the sake of argument, the constellation of proficiencies outlined by Malecha have been presented out of sequence - and without reference to component headings that place them within a taxonomy. This is done in an effort to suspend assignation of priority; an act that traditionally opens the door to discussions about which is, or are, most important. Once that discussion starts, the tendency is to eliminate, and exclude; an entirely unacceptable proposal when all of the skills, sensibilities, and proficiencies are critical and interrelated. Some of them can only be addressed through *Consolidated Methodologies*; others can only be addressed through *Displaced Methodologies*.

Figure 1 proposes a schematized curriculum model that explores the potential of alternating cycles of *Consolidated* and *Displaced* delivery mechanisms and design methodologies. In the model, the Fall Semester focuses on *Consolidated Methods/Sensibilities* and the Spring Semester focuses on *Displaced Methods/Sensibilities*. The *Consolidated* activities are biased toward speculative research and are not inherently metric based; students work individually on projects that allow them to explore curricular components as discrete but interrelated disciplines with limited constraint. The design studio acts as pure, explorational, idea based

environment. The *Displaced* activities are collaborative and interdisciplinary across university academic units. They are explicitly metric based with economic viability and implementation logistics (4D and 5D consideration) being the primary criteria for evaluation. These studios are *Profit Based* - meaning that there are hard budgets and bottom line expectations. In the *Displaced Context*, curricular elements which are traditionally engaged outside of the studio become integrated. Technology, Professional Practice, History, Theory and any other project related content are explored organically in the service of the project and client.

In this proposal each unit of study is linked to a scale of project that alternates rather than building incrementally. The scales are inverted in alignment with seasonally related semester strands and the associated methodologies. This strategy is focused on developing agility and dexterity while engendering process born sensibilities in problem definition and iterative refinement. Most importantly, the model is predicated on developing a student's ability to execute the delivery of multiple real projects – on budget, and with objective profit and performance benchmarks.

This is of critical significance and is proposed in direct response to deficiencies that have existed in the architectural design profession for decades – as Greg Pasquerelli of SHoP recently recognized in an interview - *"While architects contribute a tremendous amount of intellectual capital to the building process, they are afforded little power or reward because the profession is fundamentally terrified of economics. If you do not understand how finance works, you do not understand how a project gets built - Without architects understanding finance, they are relegated to the sidelines of the most important design decisions and have no say in how the building is ultimately completed."*[6] This curricular model is specifically framed in a manner that requires the student to navigate traditional territories of fear so that they develop a knowledge and confidence that ensures the relevance of the designer in contextualized decision making. This proposal would require *Infrastructural Pedagogical Change*. A form of change that is not easy to implement for a host of reasons, including Institutional inertia.

ASSIMILATIVE PEDAGOGICAL RE-ORIENTATION (IN THEORY)

A more viable mechanism for change in shifting the balance might be *Assimilative Pedagogical Re-Orientation*. Working with small scale, real projects in 9 Credit Unit courses (elective or required), students can be exposed to interdisciplinary processes that reveal the complexity of performance definition in collaborative situations without modifying the global structure of an architectural curriculum. The financial infrastructure to make this a viable proposal already exists. Soft costs and commissioned prototyping for the projects can be funded with *Lab Fees* that are assigned each semester at all architectural institutions. But as with the fiscal reality that surrounds any project, access to those fees must be *Incentivized* through performance; the students and faculty embedded in the process of developing the project must be *At Risk*.

ASSIMILATIVE PEDAGOGICAL RE-ORIENTATION (IN PRACTICE)

The Alternative Delivery Methods (ADM) elective course at Carnegie mellon University was developed specifically to test the effectiveness of *Assimilative Pedagogical Re-Orientation*. Sixteen upper level undergraduate architecture students enrolled in the 9 Credit Unit elective understanding that they would be responsible for the parametric analysis, design, construction documentation, and commissioned scalar prototyping of a pedestrian bridge for the Pittsburgh Children's School (PCS). The 38'-0" span connects a historically significant institutional building designed by Henry Hornbostel with an urban dell that will be utilized for play and outdoor educational activities for pre-K students attending PCS. The ridge navigates a grade sep-

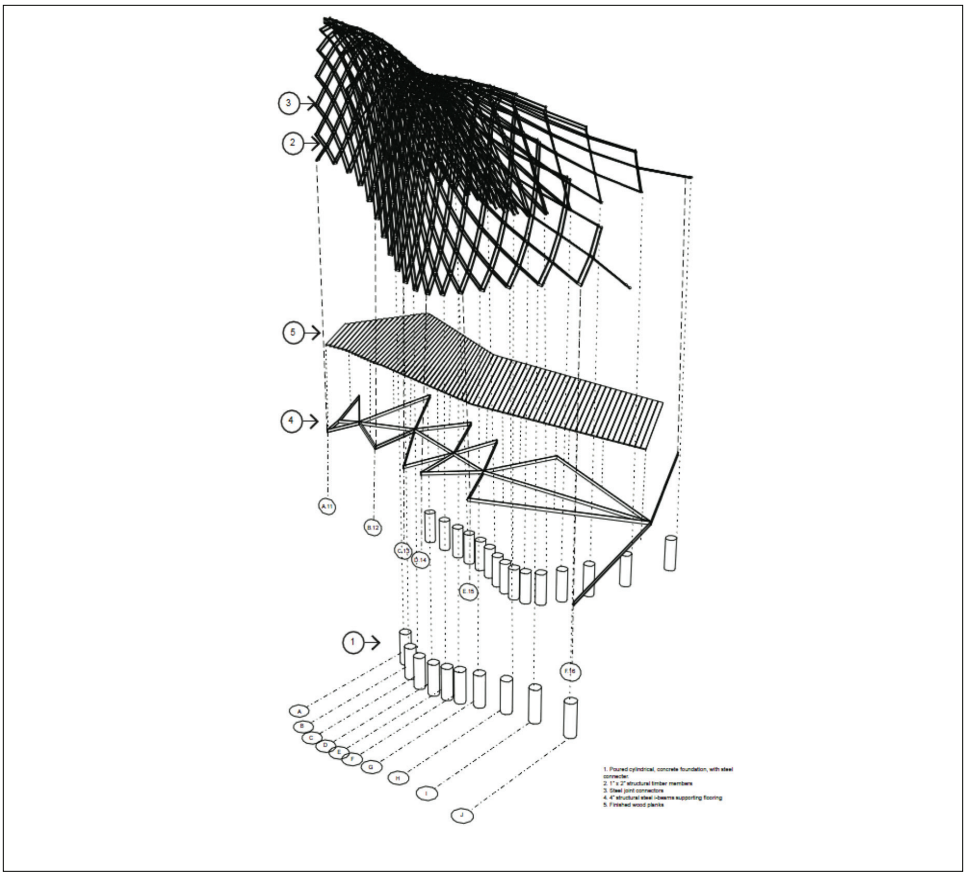

FIGURE 2: First iteration of the 10K Bridge developed for the Pittsburgh Children's school by the Urban Design Build Studio (UDBS). The grid structure proposed was modified significantly over the course of three iterations. This exploded perspective diagram was executed utilizing Grasshopper and Kangaroo programs in conjunction with Rhino to create hosting entities for the final Revit working file. The diagram illustrates how the design is configured around seven components – each developed by pairs of students and coordinated by an eighth group of students responsible for workflow management and coordination.

aration of 14'-0" at the building which gradually diminishes toward the dell. The bridge is being built not as a celebration of these physical conditions, but out of programmatic necessity. This distinction is important, because it at once establishes a condition demanding integrated project delivery and at the same time establishes the At Risk condition necessary for the *Assimilative Pedagogical Re-Orientation* model.

The bridges is being funded as part of a building restoration that will make the current exterior learning and play spaces inaccessible during construction. The contractor responsible for the restoration of the Hornbostel building has already developed a design for the bridge connecting PCS and the dell as part of their contract. The students in the ADM course were presented with the opportunity to design something of better quality within the same hard cost investment parameters, $10,000.00. If the students were able to deliver a solution that could be constructed within the same time frame identified in the general contractor's critical path schedule, meet the hard cost investment threshold, satisfy the construction management entity, and pass the scrutiny of the Design Review Committee (DRC), their pro-

Figure 3: Top, excerpt of shop drawings created by the Urban Design Build Studio (UDBS) for commissioned fabrication of the scalar prototype; Bottom Left, 1/6 Scale prototype of PCS bridge being assembled and prepared for load testing; Bottom Right, Exploded Perspective assembly drawing executed utilizing Revit.

posal would be built utilizing the contractor's crew working to prevailing wage scales.

This project structure, and the associated development parameters, immediately place the notion of performance squarely outside of what is normally considered in the academic environment - without diminishing the capacity of the academic environment to engender sensibilities related to the significance of design on the environment. It Incentivizes students to perform at a level expected by society, or at a minimum, representative sectors of society and places them *At Risk* without placing the client *At Risk*. The students invest time with the expectation

that they will meet the performance standards set. If they fail, the proposal and their efforts remain a socially irrelevant experiment and the bridge that was proposed by the general contractor meets the needs of the PCS is executed. If they succeed, the PCS benefits from a more thoughtful consideration of the program and its manifestation in physical form. Either way, the students benefit from understanding hierarchical decision-making and the corollary evaluative assignation of performance standards.

One of the administrative challenges in developing this pedagogical model is project soft costs. Those investments had already been made by the client and construction management entity in the ADM case study. It would be irresponsible, and untenable, for a school of architecture and university to ask a client considering an alternative design to bear redundant soft costs. For this model to be viable, the school of architecture must be able to provide the soft costs associated with the alternative proposal. This does not require a significant investment; in most cases the resources necessary for design are available within the university structure, offering an opportunity for interdepartmental collaboration promoted at all universities. In cases where resources are not available within the structure of the university, Lab Fees assigned by every school of architecture can be utilized to defray soft costs.

In the case of the ADM course and the associated PCS bridge, $1,000.00 of Lab Fee were allocated to the development of work. Structural engineers from the school of engineering collaborated on the structural analysis and design of the bridge. Graduate students in the Masters of Architecture, Engineering, and Construction Management (AECM) program collaborated on project scheduling and cost estimation/projection in advance of contractor reviews for credit. The architecture students completed all design and production work associated with the project for credit. The $1,000.00 was utilized specifically to commission fabrication of a scaled prototype that students had to assemble, effectively testing assumptions about construction/fabrication methodology and the effectiveness of construction documents and shop drawings produced.

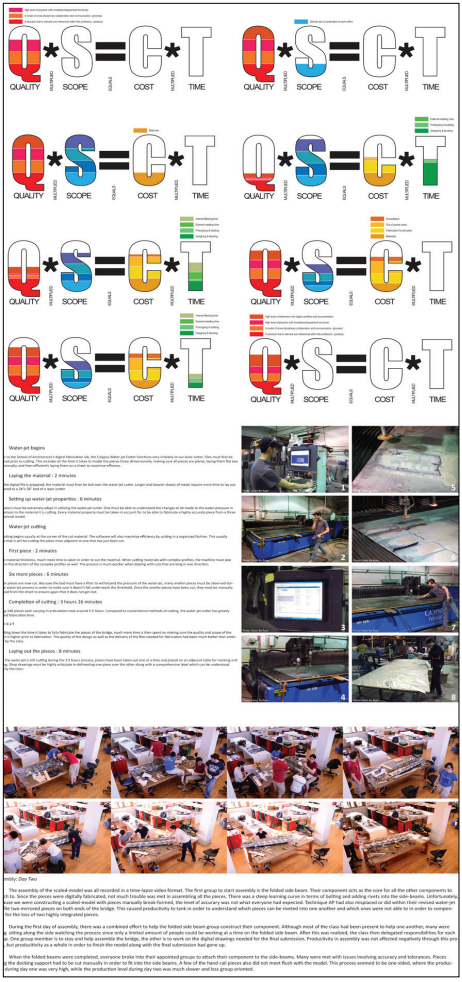

FIGURE 4: Summary excerpt of critical evaluation produced by two UDBS students assigning values to the fabrication/production work and assembly sequence management work.

PERFORMANCE EVALUATION WITHIN A DISPLACED CONTEXT

The ADM course is predicated on developing understanding of performance in a *Displaced Context*. The work in ADM is completed under the umbrella of the Urban Design Build Studio (UDBS) program. The Urban Design Build Studio (UDBS) is a university affiliated outreach

arm that works with challenged communities in Allegheny County on the development of catalytic demonstration projects. Students who commit to the UDBS program must agree to complete the projects that emerge out of a semester long Urban Analysis and Partnering/ Capacity Building Process initiated in the Urban laboratory studio. Historically the sequence has required a commitment to two upper level 18 Credit Unit studios and two 9 Credit Unit paired electives and a paid internship to complete. It is a substantial commitment with limited capacity for enrollment. It is also an insulated environment out of necessity – failure is not viable.

University affiliated Design Build programs rely heavily on external funding, revolving lines of credit, and the faith of clients they work with. The long-term sustainability of a Design/Build Program mirrors that of a viable private practice – it is based on success and reputation. Because of this dilemma, students are often navigated through the delivery process with a heavy hand, never really being provided an opportunity to fail catastrophically. While this ensures the viability of the institution's Design/ Build activity in the future, it suspends reality for the individual students, diminishes the potency of the educational format, and places a heavy burden on post-professional development – ultimately perpetuating the constant argument over the relevance of the academy. Beyond the fact that work in most design-build programs can be criticized for being singularly planted within the Consolidated Realm, more significant is the false sense of confidence in the student's abilities that can be fostered – both from the instructor's perspective and the student's perspective. It is for these reasons that a complimentary structure has value.

RESULTS

The students worked collaboratively on the development of the bridge proposal with eight pairs taking on distinct responsibilities for design (illustrated in Figure 2 and outlined in caption), but coordinating through one master Building Information Model. The tool utilized for construction documents was Revit, with the geometric components being generated in Rhino to provide hosting elements in the .rvt files. This process allowed students to work with great dexterity manipulating both global and local geometries with the assistance of Grasshopper and Kangaroo. The resultant Rhino files not only formed the foundation of the work in Revit, but also provided the primary exchange mechanism for finite element analysis by engineers utilizing Solid Works. CAM files that were ultimately utilized for the water jet cutting and CNC brake forming processes needed in the commissioned fabrication of 66 unique plate steel elements came directly from Revit through the use of DXF and SAT file formatting.

There is little unique about this digital workflow. It is described to convey the tools utilized in collaboration and provide a pretext to the critical evaluation of work that students developed. Ultimately, the ability to meet performance criteria that they and others embedded on the design side of the equation and mesh that with the demands placed by the program, client, and contractor was tied directly to the effectiveness with which these tools enabled collaboration and communication.

In the ADM course the soft cost budget, utilized for the commissioning of the prototype acts as the fundamental mechanism for establishing the importance of, and regard for, effective communication. The course evaluation is predicated n a level of success with that commissioned prototype. Because the project is small in scale, it exaggerates the significance of veracity in the collaborative design process; there is little opportunity to misrepresent intent. Through three iterative stages of prototyping, the students created mock-ups of the components that were ultimately commissioned for fabrication. This component of work is relatively familiar for students and reflects the way knowledge is traditionally built in the academic environment. It is immediate, or a *Consolidated* form of work; students have the ability to place

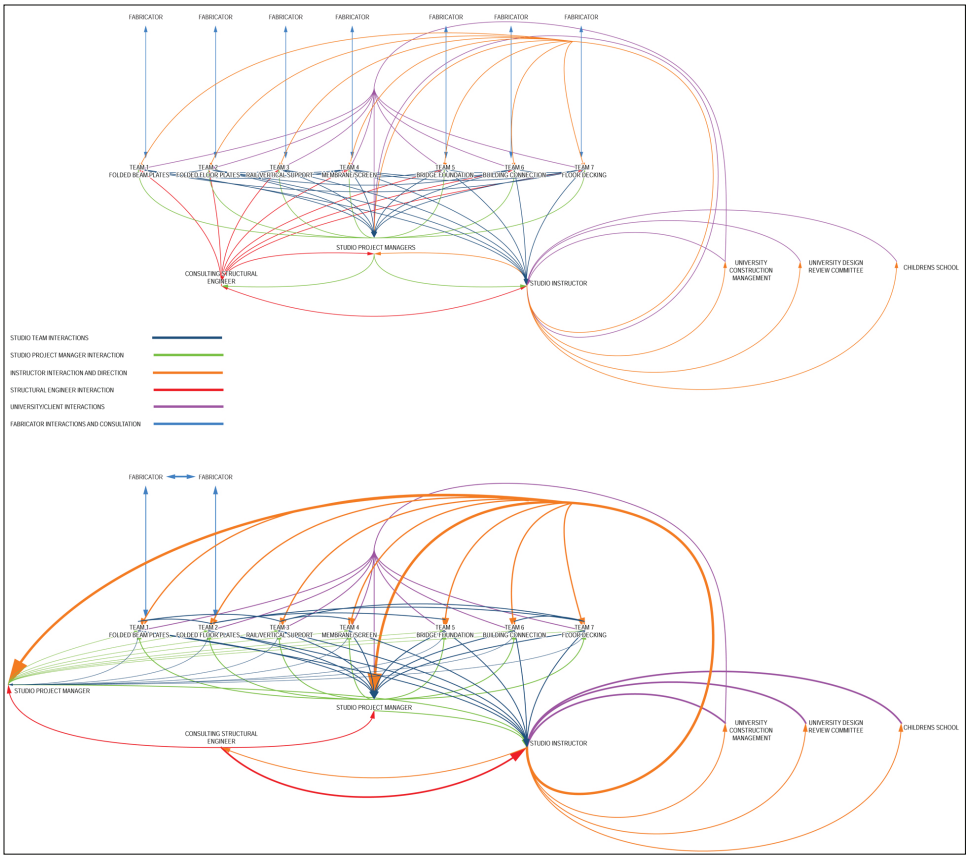

Figure 5: Illustrative workflow charts developed by UDBS students Alex Greenhut and Shawn Cencer. Top Chart reflects is an idealized version of workflow and project delivery developed at the outset of the project. Bottom Chart defines reality of workflow as demanded by the performative standards of entities embedded in the delivery of the project.

their hands on the object being manipulated and utilize those mock-ups to influence communication and negotiations with fabricators. While those sensibilities and conditions are still difficult to navigate in a collaborative context, they pale in comparison to the reality of *Displaced* conditions ultimately encountered in project delivery.

The *Displaced* condition of project delivery is addressed through the commissioned fabrication of the prototype, the terminal iterative component of the ADM course, and the mechanism for establishing the veracity of the proposal and its ability to meet the multi-variant performance standards. Being present for the fabrication of the components, but not being allowed to speak as fabricators work through challenges in communication lapses that become inherent in both digital and hard copy documents, students understand through first-hand observation the significance of the architect's ability to communicate graphically, verbally, and in a manner that reveals the full intention of work. Errors in this dimension of the work also illuminate the significance of budget most immediately and tangibly when it needs to be re-produced or modified post production to meet performance criteria. The concept of "value" is most apparent in this mode of productive activity.

REFLECTION/REVISION

The PCS bridge proposal was brought in on budget and the prototype brought into conformance with performance criteria expressly desired by the Design Review Committee and client. That points to the success of the individuals embedded in the collaborative process and their tenacity in working through the resolution of multiple objectives, often incommensurate. But ultimately, that is not the measure of the courses success as a model for *Assimilative Pedagogical Re-Orientation*. That assessment comes from student's abilities to reflect on the process and critically analyze successes and failures that were resultant in the final product, design, and process.

Evidence of this was provided in the development of graphic matrices that described first, second, third, and fourth order relationships that were anticipated vs. those that were achieved. Those matrices were then analyzed to project what modifications in structure might have yielded a better project. This information was tied directly to sequential evaluation of the project's salient equivalencies or disparities utilizing an equation relating Quality, Scope, Time and Cost. [9] Ultimately, it is in this body of work and associated analytical narratives that the value of the course in guiding students toward a broader understanding of performance can be assessed – either positively or negatively. What is clear in the evaluation work is that from Modal to Mechanistic interpretation, the students understood the notion of performance as Exclusively Mutual – *not Mutually Exclusive*.

ENDNOTES

1. Definitions of *Performance* identified by the professional constituent groups represented in the body of text: Refer to American Institute of Architects, National Institute of Building Science, American Society of Heating, Refrigerating, and Air Conditioning Engineers, American Society of Civil Engineers, World Business Council for Sustainable Development, National Association of Development Organizations, the American Finance Association, American Society for Testing and Materials.
2. *Defining High Performance Buildings*, Brandon Lorenz writer/editor – quoting Earle Kennet, Vice President of National Institute of Building Science. Reference to 2009 report/recommendations to Congress.
3. This scenario of ordered relationship and type of relationship is predicated on a traditional Linear Path Method of project delivery, or Design-Bid-Build. It assumes the execution of an AIA B141 contract in the context of AIA "*Conventional Family*" Agreements . The Construction Manager components introduced into the taxonomy assume Construction Manager as Advisor (CMa) and not Construction Manager as Constructor (CMc).
4. Professionals Weigh Graduate Skills, Weaknesses, Design Intelligence Nov 15, 2008, Greenway Communications, John Cary, Phil Bernstein, and Katherine Bojsa Discuss results of skill assessment survey and provide insight on architectural student preparation for engagement in professional architectural practice.
5. Garry Bertieg and the *Building Momentum Developmental Model*; Jean Pol Martin and the *Learning-Teaching Paradigm; Ernest Boyer and Reinventing Undergraduate Education*.
6. *Integrated Practice and the Twenty- First Century Curriculum:* Proceedings from Cranbrook 2007: Friedman, Daniel S. editor; The American Institute of Architects and Association of Collegiate Schools of Architecture, Washington DC 2008; This was a recurrent theme in the speculative curricula proposed and presented on pages 37 through 45, with one proposal being referred to as Integrated Curricula; see also Closing Response by Edward Allen.
7. *The Learning Organization and the Evolution of Practice Academy Concepts;* Malecha, Marvin J.; NC State University Press, 2005; Chapter VI, Learning Models.
8. Quote included in State of the Academy Column, *ARCHITECT* Magazine September 2010, Article Facing up to the Numbers: For Too Long Architecture Schools Shied Away from Teaching Business Basics. That's Changing Fast. Quote taken in reference that Greg Pasquerelli gave on business and architecture where each of the entities took on an anamorphic identity.
9. Discussion and evaluation was predicated on writing and discourse included in Kieran and Timberlake, *Refabricating Architecture*, 2003, McGraw Hill related to Quality x Scope = Time x Cost.