An Evolving Strategy for Integrating Digital Methods into Foundation Design: Diagramming, Modeling, and Parametric Design.

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The subject of this paper is a brief overview of the present state of how digital tools and methods are introduced in the foundation design program at the School of Architecture at the University of North Carolina at Charlotte. Our Core curriculum map, against which these efforts are measured, includes the sequence of the first three years (six semesters) of our undergraduate degree program. For the purposes of this report, we will concentrate on the sequence of the first four semesters, as the co-ordination of the final pair of semesters in our Core Curriculum has yet to be fully aligned with the plan that we have laid out for ourselves.

Guiding our efforts at devising exercises that align the acquisition of digital skills with the broader design objectives of each studio in the sequence is the notion that it is the *conceptual framework* that each of the digital tools provide that is of primary concern, rather than the mere mechanics of any such tool. In other words, students are conditioned to consider *when* and *why* to employ digital tools, not merely *how* to operate them. Studio exercises are ordered in such a way that direct comparisons between manual and digital techniques are possible, encouraging students to recognize attributes, those common to both, and those unique in either respect.

The Core curriculum map may be summarized as follows:

First Year:

- Pattern recognition & its implications for design
- Integration of baseline set of skills
- In its 3rd year of full coordination across all sections

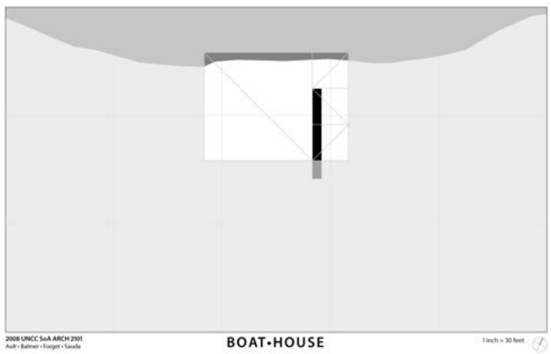
Second Year:

- Occupation
- Tectonics
- In its 1st year of coordination across all sections

Third Year:

- Program
- Structure and building systems
- Reinforcement of those skills established in 1st and 2nd year.

Among the baseline skills delivered in the First year sequence, we include fundamental digital graphic tools, essentially those enabled by the basic Adobe suite of applications. First year students are familiarized with the principles of raster and vector based graphics, the basics of formatting and composition, as well as an overview of typographic conventions. Accompanying the first two studios in this sequence are a pair of required seminars that enable us to co-ordinate, and expand upon, the skills taught and employed in the design studio. These graphic skills culminate in the creation of a year-end portfolio of each student’s design work, composed in In-Design, exported to Acrobat, and printed through an online publishing service (lulu.com).



Figs. 1 – examples of the first (manual) diagram exercise, with figure/ground operations carried out within a site bordering a river (left) and generating lines which structure the composition (left)

At the outset of the Fall semester of second year, students reprise many of the compositional and digital skills acquired in their first year through a pair of initial exercises in a larger project for the design of a rowing facility. The first exercise has the students develop diagrams outlining a series of iterations for the initial clearing of a forested site alongside a river (fig. 1). These diagrams are constructed manually using yellow trace layered over a given map template. In the follow-up exercise, students conduct a similar series of diagrams, this time with a more detailed set of constituent program components (fig. 2). Apart from this nominal progression, this exercise is different in that it is enacted digitally, through the manipulation of an Illustrator file that is modeled upon the same referents used in the initial, manual diagrams. In addition, to introducing a vector-based application (Illustrator) to their graphical toolkit, this exercise permits students to distinguish the various strengths of manual and digital means of diagramming. Students learn to acknowledge the more direct and 'intuitive' techniques employed in manual construction, while recognizing the power of the computer to permit rapid ordering of layers, along with the rapid development of varying permutations.

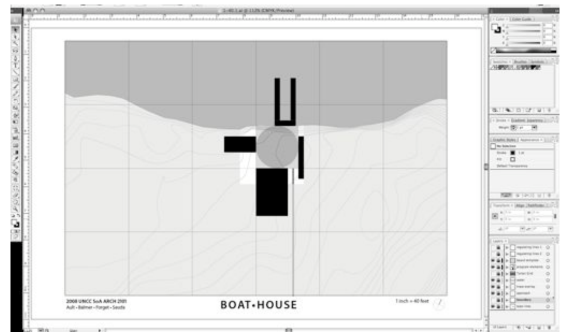


Fig. 2 – examples of the second (digital) diagram exercise, with figure/ground operations arranging programmatic components (workspace, boat shed, club house, docks), and using Illustrator.

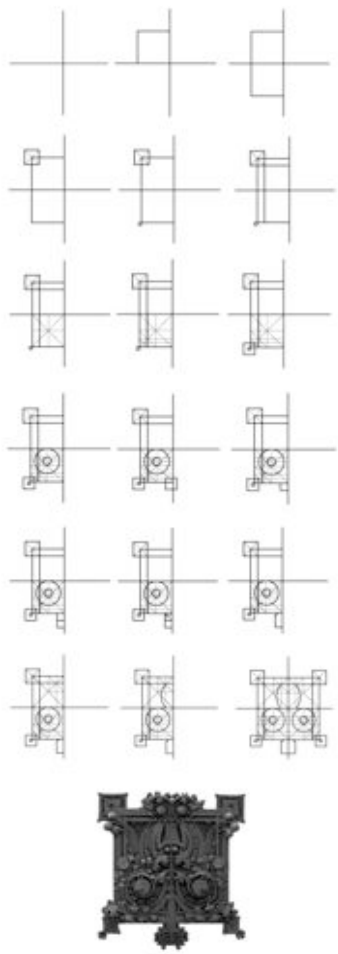
In the next phase of the boathouse project, students are asked to develop a simple, architectonic framework from a given set of dimensional lumber, using physical modeling (fig. 3). As a follow up to this exercise, and as an introduction to digital modeling, students are asked to replicate the physical model utilizing the component tools in Google SketchUp. The component elements in SketchUp capitalize on the software ability to capitalize on the parent-child relationship present in many, more advanced, software packages. Components are a set of geometry that has a predetermined set of properties, length, width, height, etcetera, that are embedded in the original object, the parent. These properties are then replicated into the three-dimensional model whenever the object is copied, capitalizing on the kit-of-parts approach engrained in this project. These components can then be adjusted at the parent level with the children all responding with the same properties, a very powerful tool when dealing with a very repetitive structural system as in this project. These digital components are then manipulated in order to develop a common architectonic language to be used in the design of the constituent parts of the rowing facility (covered workspace, boat shed, club house). Again, through the use of paired exercises, one demonstrating physical methods (basswood models) and the other utilizing digital modeling (SketchUp), students are not only being asked to develop proficiency in two apparently divergent skill sets, they come to acknowledge the varying strengths of two means of modeling (physical and spatial tangibility vs. efficient iterative variability).

Fig. 3 Examples of the first (manual) modeling exercise, with tectonic explorations of dimensional lumber for workspace component of the program.

In this sense, SketchUp is introduced as a modeling program, but limited to its role as one that generates a type of three-dimensional diagram, rather than a tool to develop renderings of a completed project: in addition to addressing a tool's strengths, there is also ample discussion concerning that tool's limitations. For SketchUp, its initial ease of use in generating models is balanced by its limitations in representation and line quality. This latter problem – that of the digital generation of line weights equivalent to the sophistication of the manual drawing techniques that students develop in our first year studios. Final orthographic drawings for the boat-house project are completed through a carefully managed hierarchy of line weights in both manual drawing and digital models, thus completing the cycle of paired manual and digital exercises developed throughout the semester.

The second project of the semester has been a response to the schools traditional second-year visit to Chicago. A first investigation into an urban environment the students pursued a project about the photographer Richard Nickel. Nickel, prominent in the 1960's and early 1970's, thoroughly documented the work of Louis Sullivan and other members of the Prairie School that was being destroyed during this time. As an analytic exercise and an introduction to two-dimensional computer drafting each student chose a Louis Sullivan ornamental detail that they would study further. This exercise has the students analyze the constituent geometric structure of their selected detail utilizing a logic easily represented utilizing Vectorworks (Fig. 4). This utilization of Vectorworks in this case is meant to have the students utilize the drawing tool to reconstruct the geometric logic of the detail in as few steps as possible. This method of working reinforces the intelligent understanding and utilization of the tool as a method of working and a means of study, not strictly as a form of representation. While an important aspect of the assignment, this project attempts to escape the doldrums of focusing on line-weight and software utilization and focus more concisely on concept and method.

The following exercise for the Richard Nickel Archive revolved around the integration of two-dimensional and three-dimensional digital environments as a method for creating a new three-dimension grid system, an expansion of the tartan grid that they have become familiar with in previous exercises. This integration allowed the students to work iteratively in space, a concept purely accessible through an understanding of three-dimensional space and a reinforcement of the idea that software, when applied correctly, has the unique capability to alter your method of working and elicit a systematic and methodological approach to architecture.



Figs. 4 – examples of the Sullivan Ornament analysis depicting the geometric structure of detail

Our most recent efforts to introduce and integrate digital capabilities into the Core curriculum occur in the second half of Second year, and focus upon the introduction of iterative parametric methods of design. As with the exercises described above, we have sought to introduce new concepts and practices by couching them in terms already familiar to the students: in this case, we have based this exercise in parametric scripting on a project originally assigned in the spring of First year. Titled "Architectonic Space", the First year exercise introduces students to the principles of three-dimensional composition, wherein students are asked to combine a series of volumes by employing 5 different compositional categories: *sandwiched, stacked, bridged, bundled*, and *superimposed*. This problem is itself a continuation of an extended series of exercises conducted in two dimensions. Fundamentally, the students are asked to examine their own intuitive definitions of each type of organization, and to engage their abilities to design and construct volumetric compositions to scale in chipboard.

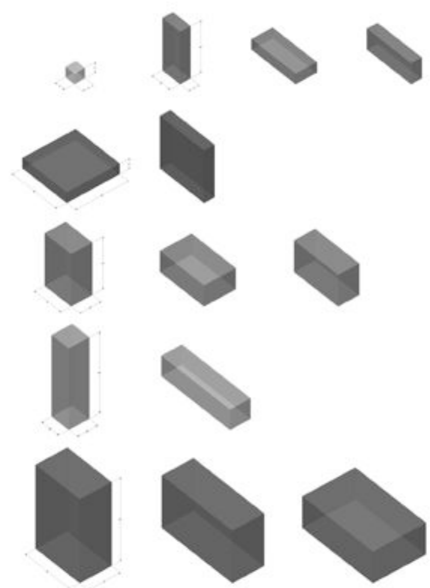


Figure 5 – the 1st Year exercise *Architectonic Space*: required initial volumes (left) and provided examples of each organizational strategy (right).

Equal to the significance of exploring architectonic composition, this exercise is orchestrated to introduce students to the practice of iterative generation, that is, to instill an awareness of the vital importance of generating multiple variants as part of the necessary processes for architectural design. To quote our project description:

> Throughout your investigations you will develop alternatives, or lateral investigations, that ask you to develop parallel, and sometimes competing solutions to the same problem. These lateral investigations will test your flexibility as a designer in order to explore all possible solutions to the

> given task. Therefore, you will have to avoid the temptation of forging ahead quickly to find the single, best solution. Such a process leaves little to be explored (or imagined) and often leads to missed opportunities.

As part of this introduction to the iterative process, we assign students the opening chapter of Edward de Bono's *Lateral Thinking*, which outlines the limitations of traditional linear approach to problem solving, and describes the advantages of processes of creative thinking that privilege lateral, or iterative procedures. In line with this approach, we structure the exercises in the assignment so that at every stage of their development, students are required to generate multiple iterations of each compositional category, and then engage (both individually and in groups) in the task of evaluating their alternatives, then selecting versions for further iterative refinement.

Figure 6 - First Year students evaluating the products of their (analog) iterative processes.

While one of the pedagogic objectives here (reinforced by subsequent assignments throughout the Core curriculum) is to instill the notion that iterative explorations are central to the 'slow and patient search' of architectural design, this exercise also lends itself to the introduction to the powerful capacities of parametric modeling. Although digital tools are generally harnessed to produce linear efficiencies, and thus may seem by their nature antithetical to lateral investigation, parametric thinking has within it the capacity to embody both the traditional advantages of analog iterative processes, and the infinitely greater power of digital generation.

The parametric exercise that we have under development utilizes a set of physical manipulations to enable a series of discrete permutations based upon the users input. The eight sequential iterations are intended to assist the students in producing a fulsome set of diagrams; primarily meant (at this stage) to help the students investigate a variety of instantiated diagrams through the process of animation, all derived from two predetermined compositions of their own design.

This parametric investigation was applied to the architectural program of a Natatorium. The projects primary components were a twenty-five meter pool, a modestly sized fitness center and an indoor/outdoor café space; at approximately 12,000 square feet it is by far the largest and most complex program that the students have tackled to this point. The size, complexity and specificity that this program requires creates a set of adjacencies to the pool area. Additionally, the students develop a narrative component that provides a critical context to the form of the project. Prior to the full involvement of the building program the student first developed a series of analog modeling exercises that were intended to help them focus in on a conceptual idea which ultimately act as the analog precursor to the automated series of digital diagrams. The diagrams focused on the interrelationship between spaces though explicitly *not* on a potential massing strategy.

The procedure for executing this exercise were purposefully lean, and have been written to appeal to even the truly novice user. Utilizing Rhinoceros, we composed a the script which, analyzes the relationship between two sets of diagrams. The script utilized the two sets as a baseline condition and prompts the user for a series of rotational angles and axis inputs in order to populate a series of eight diagrams "in-between." The diagrams are produced almost instantaneously, enabling the students to think iteratively not just within the script, but also by subsequently altering the predefined compositions, in an effort to create further sets of diagrams.

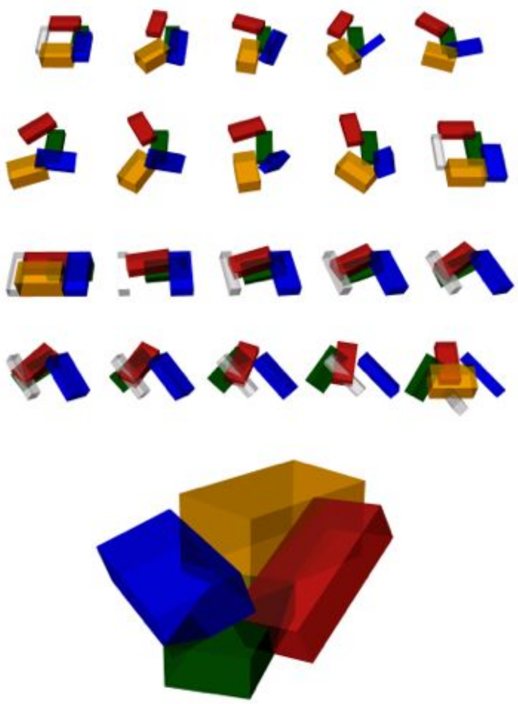


Fig. 7 – examples of the parametrically generated component blocks showing the interrelationship of programmatic spaces

We have used the results from this exercise to frame discussions about how to use comparative iterative analysis, while considering unexpected outcomes. This process of diagram generation allows the students to design the building in a cursory and qualitative manner simultaneously, a condition generally difficult for second year students to grasp. Deeply embedded in the schematic design phase of the design process the visual remnants of these diagrams have all but faded away.

Our hope is that this introduction to parametric scripting will lead the students to consider alternative methods of form generation using the tools that they have learned. By learning to use these tools in ways that challenge the ends to which they are normally used, we aim to not only stress the conceptual underpinnings of digital methods, but to begin to test the limits of the role that digital tools may play in design. If we rely on digital methods to only improve efficiency of production we are cornering ourselves into an ever-diminishing capacity for creative production.