Parameters of a Digital Design Foundation

Erin Carraher AIA, LEED-AP

Virginia Tech (VT)

Students can begin utilizing the computer as a tool in the first year of their education in the same way they begin drawing, modeling, and diagramming as a basis for developing progressively deeper understandings of the capabilities and limitations of these instruments and their particular roles within the process of design. This hypothesis is being tested in Virginia Tech’s School of Architecture + Design over the course of the 2010-11 academic year by seeding a series of digital workshops into the beginning design curriculum.

The fundamentals of design in a digital age are changing. Axioms like color, scale, proportion and part-to-whole relationships form the basis of Virginia Tech’s legacy of strong first year studio curriculum, but advances in computational design and digital fabrication technologies in contemporary practice have broadened the range of tools available for design inquiry and have fundamentally changed the way we work. The importance of integrating these digital tools and concepts early into the education sequence is related to the way students are encouraged to think in the foundation studios, where the pedagogy is to teach the fundamentals of design indirectly in projects that demonstrate these principles through hands-on experimentation.

Considering design education topologically, we are examining the elements that remain invariant while the shape of the profession changes and identifying new parameters to integrate into the evolving lexicon.
Emerging Pedagogies

In the same way that new models of integrated practice are emerging in the profession, new ways of considering foundation design pedagogies are being explored relative to when and how it is best to introduce digital tools into the curriculum. I believe that in the same way students begin to understand drawing, making, and modeling in the first year design studio, that they can also begin to understand the computer as a generative tool and not just a representational technique. By incorporating digital technology into the curriculum beginning in the first year, students are afforded the time to develop progressively deeper understandings of the capabilities as well as the limitations of these tools.

The School of Architecture + Design’s foundation structure, which combines architecture, landscape architecture, interior design, and industrial design students in a common first-year studio, reinforces the idea that the parameters of design cross disciplinary boundaries. Early investigations into the nature of design lead to further development (both in terms of the specialized nature of students’ particular fields of study as well as in their particular fields of interest) of more complex ideas over the course of their education. Historically, high value has been placed on a pedagogy that encourages development of a ‘durable knowledge,’ the type that once comprehended is with them for the rest of their lives. To this end, the School has a rich history of workshop-based, hands-on learning with materials such as plaster, ceramics, photography and printmaking. Workshops are typically self-contained, intensive, week-long experiments integrated into the design studio that allow students to learn the skills required to work with a material and then to challenge these traditional methodologies. This framework was adopted as the format for introducing digital media to the first-year students with the intent to both provide a basis of knowledge and to encourage students to push the perceived limits of the technologies.

Digital Workshop Structure

Over the course of the academic year, over 200 first-year architecture, industrial design, landscape architecture and interior design students in the Foundation Design Labs as well as approximately 100 upper-year architecture students will participate in the digital workshops. Each workshop is approximately one week long, comprised of one design studio of 22-24 students, and structured around a series of tutorials introducing...
the software program Rhino. In each workshop, a design prompt is given in which the use of technology is integral to the design process. The structure and project for each workshop are generated through discussion with the studio professor, and the workshop format is continually evolving. Each studio is also coupled with a ‘digital mentor’, an upper-year student skilled with the technology who serves as a resource for conceptual and technical questions from the first year students.

Two methods for structuring the workshops within the context of the design lab – integrated and nested – are being tested. ‘Integrated’ workshops build on a previously completed project or are the beginning of one that will continue beyond the week. This approach grounds the new technologies in a material reality and allows students to identify ways to translate between the known and unknown. ‘Nested’ workshops are fully self-contained in terms of the material presented and in terms of the designs produced. These workshops serve as intense introductions to the subject matter and are catalysts for future independent development of the skills learned.

The most successful workshops to date have used a known object or project as a fulcrum to translate from ‘analog’ to ‘digital’ modes of thinking. Operations that had been done by hand during the course of building a model are actually and conceptually translated into the computer, and real material limits help ground the designs within the virtual vacuum.

**Actual to Conceptual Translation**

The sixth workshop in the series – Cut, Fold, Score – began weeks prior to the workshop in discussion with the studio instructor about the format and content of the project. The prompt was developed, and tutorials were tailored to the specific project. In the studio class prior to the first workshop session, students were given an assignment that explored cutting, folding and scoring as means to generate a construction contained within a 4” cubic volume. Three iterations of the forms were made by hand using a 10” x 20” board with particular constraints given for the ordering systems used and limits on removing material.

Students brought their designs to the first day of the workshop where Rhino commands were presented as having analogous actions to known operations from their previous studio work. Basic shapes were organized under headings of points, lines, planes and solids. Actions were structured as additive, generative, reductive, topological, and Boolean. Two possible approaches for beginning to draw in the computer – constructive and structural – were also outlined, not as prescriptive working methods, but as places for the students to start thinking about translating their designs into a digital language.

---

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Workshop</th>
<th>Year</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 2</td>
<td>Fabrication Process</td>
<td>1st year &amp; 3rd year</td>
<td>“Portal” group project fabrication and installation</td>
</tr>
<tr>
<td>Week 5</td>
<td>Beautiful Line</td>
<td>1st year</td>
<td>Plane from a line that is horizontal and vertical</td>
</tr>
<tr>
<td>Week 8</td>
<td>Regulating Lines</td>
<td>1st year</td>
<td>Field pattern studies</td>
</tr>
<tr>
<td>Weeks 9 &amp; 10</td>
<td>Hand + Machine</td>
<td>1st year grad</td>
<td>Re-fabricate glass vessels/ Topological surface</td>
</tr>
<tr>
<td>Week 14</td>
<td>Analytical Modeling</td>
<td>1st year</td>
<td>Demonstrate the kinetic movement of scissors through drawing</td>
</tr>
<tr>
<td>Week 19</td>
<td>Cut, Fold, Score</td>
<td>1st year &amp; 4th year</td>
<td>Fabricate cubes based on ordering systems</td>
</tr>
<tr>
<td>Week 21</td>
<td>Art of Building</td>
<td>2nd year</td>
<td>Model case study buildings</td>
</tr>
<tr>
<td>Week 23</td>
<td>Questions of Scale</td>
<td>1st year</td>
<td>Model space at multiple scales</td>
</tr>
<tr>
<td>Week 26</td>
<td>Animated Space</td>
<td>1st year</td>
<td>Animate sequences of movement in space</td>
</tr>
<tr>
<td>Week 28</td>
<td>Framed Space</td>
<td>1st year</td>
<td>Form defined by regulating systems</td>
</tr>
</tbody>
</table>

*Figure 2.* Workshop Matrix. Ten workshops are scheduled for the 2010-11 academic year. Eight first-year Foundation Design Labs as well as several upper year studios will take part in a week-long workshop to introduce digital technologies tied to a physical design project. Sequence order is tracked relative to the 32-week academic year.
The ‘constructive’ approach analyzed methods students had already used and proposed an equivalent digital action to each physical one. In some cases, there was a direct translation to a Rhino command, but where a break in the logic occurred, with ‘scoring’ for example, students were asked to develop a series of operations to achieve similar ends. The ‘structural’ approach analyzed the resulting forms from the first exercise to identify existing frameworks, connections or relations in the work. Students were encouraged to make a digital representation of these ordering systems as a way to begin structuring successive iterations.

For the second day of the workshop, students made at least three iterations of each of their three original forms (nine digital models). During the second session, we reviewed issues with conceptualizing and actualizing their designs and discussed methods for preparing their ‘three-dimensional’ computer models for ‘two-dimensional’ fabrication using the laser cutter. One series of second-generation iterations was further developed and then fabricated. On the last day of the workshop, there was a review of the students’ projects, a discussion of digital working methods, and an analysis of the tool’s abilities.

**Initial Findings**

In the early stages, the workshop approach seems to be working with an above-average success rate. Both during and after the workshops, students ask informed questions that demonstrate a searching approach to understanding digital form and conceptualizing virtual space. They develop methods to track ‘up’ and ‘down’ sides of materials as they move things around in space; they are able to conceptualize physical joints between objects and understand material thicknesses; and they utilize the program’s iterative capabilities to test the limits of design ideas.

Tying the workshops to a physical result forces a slowness and resistance to the seeming ease and fluidity of the software. Students understand that just because they can draw something in the computer, unless they are able figure out how to make it, the design will never be realized. This does not mean that the computer cannot and should not be used as a tool for conceptual exploration, but rather that the students must first be able to ground their explorations in the context of known limits.
Less successful results have occurred in workshops that were situated too close to the end of the semester. At this time, the students are in production mode trying to finish their studio work and are distracted and rushed when learning the new tools. They have more of a ‘get the job done’ approach, and allow less time for experimentation.

I am also finding that some students have a difficult time figuring out the capabilities of tool sets beyond those specifically presented in the workshops. I think this is tied to the brevity of the workshops and am developing a resource that will present a broad range of tools in the context of their analogous ‘analogue’ actions. I also believe that as the students recombine in their second-year studios, that the diverse range of skills covered over the workshops will allow students to use each other as a resource. However, this hypothesis will have to be tested over time. The true impact of these workshops will be tracked as the students enter the second year studios, which is the first year in-major, where we will continue to engage upper-year faculty to determine whether more advanced, discipline-specific workshops should be conducted at that time.

**Continued Explorations**

**Figure 4.** Cut, Fold, Score Workshop Review. Each workshop resulted in a physical project – a hand-made or digitally fabricated model, 2D graphic, or some combination thereof.

Less successful results have occurred in workshops that were situated too close to the end of the semester. At this time, the students are in production mode trying to finish their studio work and are distracted and rushed when learning the new tools. They have more of a ‘get the job done’ approach, and allow less time for experimentation.

I am also finding that some students have a difficult time figuring out the capabilities of tool sets beyond those specifically presented in the workshops. I think this is tied to the brevity of the workshops and am developing a resource that will present a broad range of tools in the context of their analogous ‘analogue’ actions. I also believe that as the students recombine in their second-year studios, that the diverse range of skills covered over the workshops will allow students to use each other as a resource. However, this hypothesis will have to be tested over time. The true impact of these workshops will be tracked as the students enter the second year studios, which is the first year in-major, where we will continue to engage upper-year faculty to determine whether more advanced, discipline-specific workshops should be conducted at that time.

**Figure 5.** Analytical Drawings. During the course of site analysis, students studied the impact of their design on people’s movement through the space where the Portal project was installed. Students use analytical drawing and other tools carried into the Digital Workshops from their previous studio work as methods for conceptualizing, realizing, and analyzing their designs.

In my own Foundation Design Lab, students are using the tools learned during the digital workshop holistically over the course of the year. They participated in the first digital workshop, which took place two weeks into the fall semester. Prior to the workshop, students began working on the first day of class with individual explorations in
form-making. They then joined into pairs to combine those forms into fields, and further reconfigured into teams of 5-6 where they were asked to use their previous approaches to define a 2’ cubic volume. Next, the students individually or in groups made proposals for an installation in the school’s lobby that defined a 6’ x 6’ x 6’ space. A jury of faculty selected a winning design, named Portal by the students, which the entire studio went on to further develop and construct.

After Rhino was presented in the workshop, students used digital modeling as a tool throughout the design and construction of the Portal project – first as an iterative design tool in the development of their group projects, then as a representational tool during the installation proposals, and finally as an evaluative tool during the refinement and construction phase of the installation. Their digital skill set continued to grow through the course of the subsequent studio project, which combined ideas of biomimicry and analytical drawing to develop a form that interacted with light. Their projects were drawn in the computer and fabricated using the laser cutter, CNC mill, CNC router, 3d printer or plasma cutter.

**Figure 6.** Portal Studio Project. After participating in the first Digital Workshop of the fall 2010 semester, my students then utilized the software as a tool to help design and fabricate an installation in the school’s lobby. The built work was the last in a series of iterations looking at form in ever-increasing scales and how it can be used to define space. The project began on the first day of classes and within one month progressed from drawing and modeling by hand to computer-based representations and shop drawings for the installation.

**Figure 7.** Biomimetics Studio Project. This student studied fish scales and developed a topography and two-way structural system that allowed for the same flexible movement of a fish’s scales within a CNC-milled wood field.
This integration of emerging ideas and technologies alongside traditional concepts within foundation studio projects is part of larger pedagogical question on my part concerning design education. Contemporary practice is never about one discrete thing, but the possibility of many adjacent things. As such, I believe it is important to integrate concepts from the ever-evolving design professions into the studio at the earliest stages rather than first introducing them as discrete fields of study later in the curriculum.

This context helps students target the relevant in a world of ever-expanding possibilities. Iteration and early integration are keys to developing an understanding of the variables and constants related to an idea and how that idea is situated in the larger framework. I am finding that by bringing these concepts into the studio early on in a grounded way, students begin to recognize the affinity or disjuncture between the ‘new’ and the ‘old.’ They realize the potential of multiple working methods and are able to start making critical decisions about what tool is right for the job. Of course, this is not true in every case. There are still students who use a chainsaw when they should be using a scalpel, but even these mis-steps provide for valuable discussion amongst the group.

Process + Product

Neil Leach states: “We are witnessing a new generation of designers operating within the digital domain, who are not simply using these technologies as a sophisticated tool for testing out designs conceived in a more traditional paradigm, or as a technique for assisting in construction calculations, but rather as a medium through which to pursue design itself.” It is essential that as educators we recognize that this paradigm shift has occurred in the profession. The question at Virginia Tech then becomes: how do you incorporate digital technologies into the design curriculum and not lose the value placed on hands-on learning?

Within the ever-evolving digital world, the idea of developing a ‘durable knowledge’ is difficult to fathom. However, I have found that students are spending more time in the wood and metal shops as a result of their work with digital fabrication. It is through the process of realizing their designs in actual materials that they discover these new ways of making have ties to traditional design principles and construction techniques. This develops an understanding of the affect of digital
tools on both the ‘product’ of design – the thing itself – as well as the ‘process’ of design – the making of the thing.

Early feedback from the workshops is showing that after an initial struggle to gain a facility with the tool, students are able to think spatially about digital design, work iteratively both inside and outside the computer, and make projects that demonstrate an ability to fabricate using related digital technologies. I believe tying a physical project to the media introduction facilitates this transition. Every architecture and design school has digital modeling, representation and fabrication courses in their program, but most of the discourse on the subject seems to surround the results of groups of advanced students with a particular interest and facility with the technologies. I think that there needs to be a broader pedagogical discussion about where and how it is best to begin introducing digital tools in a holistic way into the design curriculum.

Limits

It is important to clearly convey the possibilities as well as the limits of the software to students so that they do not default to standard methods of working. Today’s students will learn countless programs over the course of their educational and professional lives and each one will have different capabilities and constraints. The School of Architecture + Design selected Rhino as the package that each first-year student is now required to purchase because it is a good platform to be able to actually and conceptually translate to other software products, because it is used in practice by all the disciplines taught within the school, and because it supports a broad range of plug-ins that allow for specialized application in different areas of design.

Amongst the foundation faculty, the question of digital fabrication in the first year is still a topic of much debate. Many think that these tools should be reserved until after the students have a firm understanding of more traditional working methods. They believe, with valid concern, that because a technician controls the actual programming and operation of the machines, that the students are not developing the ‘deep knowledge’ that more traditionally built projects afford.

I believe that digital fabrication has an affinity with digital modeling and as such the two are appropriately

Figure 9. Cut, Fold, Score Workshop Projects. The project for this workshop began prior to the first digital tutorial through a series of hand-made models and continued to develop through the week of the workshop via computer modeling, study models made both by hand and machine, and resulted in a final project that was required to be made using the school’s laser cutter.
ACADIA Regional 2011: Parametricism: (SPC)

introduced in tandem. Though different than traditional
collection, digital fabrication is not a hands-off process.
Students who use the CNC router, for example, are
required to understand how the machine works
operationally, to make informed decisions about material
selection and tooling, to coordinate with the technicians
regarding methods for fixing materials during fabrication,
to design a way of tracking and joining separate
components and layers, and to do all of the material
preparation and post-production work themselves. I feel
that having gone through this process is a valuable
educational experience and one that mirrors the way that
designers interface with these technologies in practice.

Educational Invariants

In school, students learn how to think like designers. This
time shapes the trajectory of where they will situate
themselves within the landscape of design practice. To
respond to the current developments in the profession,
we must continue to build on the paradigms of the past,
continually question and negotiate our position relative
to the present, and challenge ourselves to incorporate

Pedagogically, there is much room for debate on where
and how digital tools are incorporated into the curriculum
and even what tools are introduced. The lure of the quick,
the seductiveness of the computer-generated image, and
the illusion of the infinitely possible are all traps to be
avoided when introducing digital tools to first-year design
students. Technologies must always be grounded in a
constructive reality where the qualities and limitations of
the materials and methods of making inform the
understanding of the design itself. Limiting variables and
emphasizing the value of iteration are also essential to
providing a solid foundation for digital technologies after
such a short period of time working with the new media.

References

1. Burchard, Charles. “A Curriculum Geared to the
2. Poole, Scott. “Pumping Up: Digital Steroids and the
Design Studio.” In Material Matters, edited by Katie
3. Leach, Neil, ed. Designing For A Digital World. (Great
Britain: Wiley Academy, 2002), 6-14.