Break It Till You Make It

A design studio for problem-finding

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In a context where architectural education is undergoing great transformations due to the impact of digital technology, the authors present a design studio model that rather than teaching how to operate the tool en vogue focuses on the formulation of questions. Traditional pedagogic practices have privileged answers in knowledge production, but an alternative is proposed. A methodology was devised in which problem-finding is moved forward by an iterative process of experimental making. This was tested in Winter 2017 with results showing a diversity in questions raised, but also the premature discontinuation of several paths of inquiry. Only one completed all 6 planned iterations and benefited from the final, in which the building of a 1:1 prototype informed its research focus. The conclusions highlight the contribution of this model in preparing future practitioners with an attitude of inquiry and drive to experiment that will resist obsoleteness from rapid technological developments.

Keywords: Architectural Education, Design Studio, Problem-Based Learning, Material Systems, Digital Fabrication, Wood Construction

AN ATTITUDE OF INQUIRY

New modes of teaching architectural design studios are emerging with the continued integration of digital technologies in the discipline (Oxman 2008, p.99). Indeed, as Rivka and Robert Oxman point out “fabrication labs in education, which were rare even just a few years ago, are today commonplace” (2010, p.23). It is however paramount that architecture students acquire a set of skills that can be applicable beyond the current technical paradigm lest rapid developments render their knowledge irrelevant. This implies that rather than indoctrinating students with the use of a specific tool or technique, our main responsibility as tutors should be in the cultivation of an attitude of constant inquiry and driven to experiment. Such an approach is more adapted to the “essentially progressive” (Leatherbarrow 2012, p.6) nature of architecture and better suited to address what Donald Schön denotes as the “messy problematic situations” (1983, p.47) prevalent in its exercise.

In this context, it is then the contention of this paper that such a research-oriented attitude towards architecture can be inspired by guiding students through the process of formulating research relevant questions. The claim is that even if scientific research is not itself conducted in the scope of a design studio, there is significant educational value in learning to arrive to such questions. This hypothesis is founded on
the idea that raising “questions, alternative perspectives and new possibilities have the same dignity as underpinned verifications” (2010, p.225) as is solidly defended by Catharina Dyrssen. In order to test then what value there is in such an approach and if students can in fact arrive to research questions that are relevant, original and informed the authors have devised and implemented a method which is presented below, along with its results and assessment.

**THE CLASSICAL AND THE RESEARCH-BASED DESIGN STUDIOS**

In a context where the existing models of architectural education are undergoing great transformations in a “process of adjustment to new cultural and technological conditions of the digital age” (Oxman 2008, p.108), it matters to review how the design studio has been traditionally taught, how its pedagogical framework has adapted to research-oriented study and how both of these contrast with the methodology presented in this paper.

The main characteristic of the classical design studio resides in a structure that follows a linear progression from problem to solution. Indeed, in its most conventional form it comprehends a sequence of stages that commences with “the analysis of a given site, definition of functional programs, followed by conceptual design, the generation of architectural space, to visual representation” (Oxman 2008, p.111). In such a process, students start with a problem, move through analysis and theory, apply theory back to empirical studies, and finally arrive at concluding solutions (Dyrssen 2010). This model mimics the workflow of the profession as it is traditionally practiced and tends to rely on well accepted knowledge (Oxman 2008, p.110). In such a process, students start with a problem, move through analysis and theory, apply theory back to empirical studies, and finally arrive at concluding solutions (Dyrssen 2010). This model mimics the workflow of the profession as it is traditionally practiced and tends to rely on well accepted knowledge (Oxman 2008, p.110).

Another model of design studio that is better suited to the pursuit of exploratory work follows a nonlinear process looping between conception, simulation and materialization. An example of such is the design studio for final year architecture students described by Earl Mark in which the “process of going between physical prototype and digital model was repeated a number of times” (2007, p.223). In this case, the brief called on students to design a small waterfront complex on a site in Maine, USA and led them through the investigation of tensile membrane structures. Thus, despite a process that breaks away from the traditional one-way relationship between conception and materialization and reflects a clear research-based agenda, a question is still provided and students are still expected to return a solution.

**FROM PROBLEM-SOLVING TO PROBLEM-FINDING**

As shown above, both the classical and the research-based models of design studio focus predominantly on problem-solving and such can have its limitations. Indeed, solution-oriented projects tend to make assumptions on the premises of the problem that narrow and condition the spectrum of possible responses. As Dyrssen points out “despite seductive in the sense that they deliver seemingly final conclusions, [solutions] may contain lots of normative traps - prescriptions on how things should be, sometimes on quite loose grounds” (2010, p.225). Thus, the authors join Oxman in positing that the process of “[architectural] education need not necessarily be solution-oriented” (2008, p.111) and argue that instead a problem-finding strategy can provide an equally qualified ground for the development of research-based skills.

It follows then that the design studio model presented in this paper does not start with the presentation of an architectural problem, but rather makes the problem the very object of discovery. Such a method can be considered to belong to the family of educational practices commonly labelled as “problem-based learning” which place “the emphasis on the formulation of a question rather than on the answer” (Graaff 2003, p.658) and in the vast majority of cases, afford students with “the opportunity to determine their own problem” (Graaff 2003, p.658). In comparison to the traditional models, it is proven that these methods increase the level of motivation in the students, their intellectual satisfaction, their engage-
ment and capacity to cooperate (Graaff 2003, p.659) as well as the ability to think and act originally and creatively (Ersoy 2014, p.3498). Such a methodology seems then of utmost importance to help prepare students for a world where machines already outperform humans in solving many of the tasks and in which setting the goals and envisioning the problems remains exclusively the human prerogative.

ITERATIVE MAKING

To lead students to ask questions, the authors designed a methodology for studio teaching that is based on an iterative process of experimental making. Indeed, making is an ideal instrument to get the process of problem-finding moving forward as it returns feedback that is not anticipated, which in turn informs new perspectives and provokes questions. As Dyrssen describes it, such experiments can “shake up ingrained patterns of thought and provide [...] discoveries of hidden possibilities” (Dyrssen 2010 p.229). Additionally, making facilitates the exercise of analysis and discussion by providing an object around which different points of view can be grounded. As Bob Sheil noted in his keynote address at the “Practice in Research <> Research in Practice” symposium on 27 July 2017 “a physical thing starts a conversation in a different way” [1]. Finally, making also fuels progress by forcing decisions and the clarification of choices amongst sets of multiple alternatives. It is then through a process of iterative making that students begin to understand more about the problems they face and learn to arrive to increasingly informed (and more relevant) research questions.

Each iteration in this process of problem-finding consists then of making, analysing and questioning tasks. It starts first by presenting the students with a disruptive challenge that foments lateral thinking and creative responses and concludes with an analysis that consolidates a new perspective on the question. This process can best be described by Dyrssen as “oscillating between disruptive and converging mechanisms. The disruptive mechanisms dismantle, break up, provoke conditions, vary the material, shift positions and priorities [while] the converging mechanisms [...] gradually focus the situation” (2010, p.232). Ultimately, this situation or question is the project that is sought after by the students during the design studio all the while avoiding “the pitfalls of prematurely seeking final answers.” (Dyrssen 2010, p.229).

ITERATIONS 1 TO 6

Following on the strategy outlined above, the authors planned a set of guidelines for the process of problem-finding in the design studio. These guidelines consist of the objectives, disruptions and questions to be analysed in each iteration as well as the duration and organizational mode for the student work. It is important to note however, that the scheme mapped below responded to the conditions in which the testing of this model was undertaken. That is to say that it should serve mostly as a demonstration of the process, but one which can naturally be modified and adapted to other contexts. In the specific case of this implementation, the constraints included a programmatic brief provided by a consortium of associated partners as well as the building materials and tools made available by them.

Iteration 1: Physical Model

Duration: 1 week. Organization: students work individually while in residence at Gunther Domenig’s Steinhaus in Carinthia, Austria. The building provides an inspirational context to start the investigations. Objective: to make a physical model that establishes a point of departure towards the definition of a research relevant architectural question. Disruptions: exploring possibilities of handling and combining different materials through the employment of analogue techniques. The use of analogue means aims at getting quickly to results and loosening up some of the control over the process so as to afford happy accidents. This educational method rooted in the physical testing and simulation of material behaviours follows in the tradition of the pedagogy of Moholy-Nagy at the Bauhaus where students found
new ways of handling materials [...] through actual experience of its properties, its possibilities in plastic handling, in tectonic creation, in work with tools and machines...” (1938, p.5). Analysis: what are the unexpected results that the model can reveal or hidden dimensions highlighted in its creation?

**Iteration 2: Material System**
Duration: 2 weeks. Organization: students work individually. Objective: to make a system that codifies a research question on a material and procedural logic. This should be titled so as to clarify the question at stake. As Dyrssen remarks, fictions have the power of modelling tools in “changing the obvious to create or evoke new meanings” (2010, p,232). Disruptions: changing the medium of the system into wood and adopting a more controlled technique for production, namely digital fabrication. Analysis: how can this system be applied to an architectural scale?

**Iteration 3: Architectural Application**
Duration: 1 week. Organization: students work in groups of 2 or 3. Objective: to make an initial design that contextualizes the research question in the architectural domain. Disruptions: merging the work from the different students that make up the new team and deploying the system at an architectural scale to respond to a brief set by the partners. This determines that the structure should act as an information stand to be installed in different locations in Murau, Austria and contribute to rebrand the region as a touristic destination. The designs should create a unique visitor experience and offer a space of about 15 sqm. that is dry and sheltered from weather and which accommodates seating as well as the display of information. Analysis: how can the architectural design perform structurally?

**Iteration 4: Structural Analysis**
Duration: 1 week. Organization: students work in groups of 2 or 3. Objective: to make a structural simulation that informs the research question on architectural feasibility. Disruptions: responding to the physical forces of the natural world. Analysis: how can the architectural design deliver on the objectives of the brief?

**Iteration 5: Design Proposal**
Duration: 3 weeks. Organization: students work in groups of 2 or 3. Objective: to make a final proposal that can validate the research question with the client and end-user. Disruptions: using industrial machinery to produce a prototype at scale 1:2 as well as accommodating client and user-feedback. Analysis: how can the architectural design be built?

**Iteration 6: Prototype**
Duration: 4 weeks. Organization: students work in groups of 5 or 6. Objective: to make a prototype at scale 1:1 that informs the research question with the experience of construction. Disruptions: building on-site with all the challenges that it entails including detail design, material and tool supply and digital and manual fabrication. Analysis: how can the architectural design become pre-fabricated and mass-customized?

Despite having designed a methodology consisting of the 6 iterations described above, this model of studio teaching can be expanded beyond this number of iterations if conditions allow it and as long as the process respects the principle of cyclic making, analysing and questioning. In fact, the hypothesis is that the more iterations a question has to go through, the more precise and informed it will be and the greater its revealing potential. Nonetheless, the process can also be interrupted at any earlier stage without jeopardy to the pedagogic model given that from the very beginning, every iteration is directed towards continuing a path of inquiry and formulating a research question.

**PATHS OF INQUIRY**
The design studio model presented in the previous chapters was tested by the authors in Winter 2017 at the Institute of Architecture and Media, TU Graz with Master’s level architecture students. From this, a variety of results were obtained in terms of attain-
ment of objectives, effect of disruptions and progress through iterations. In fact, some of the paths of inquiry initiated were not pursued beyond a certain iteration and only one completed them all. In order to show this range of work, the following illustrative sample has been selected.

“Freeze it”
Iteration 1: Physical Model. An assemblage of hinged cardboard frames that allows for rotation (see figure 1) evolved into casting plaster in a formwork subject to the same movement. Research Questions: what formal conditions can be produced by applying movement to the drying of plaster?

“Mend it”
Iteration 1: Physical Model. A collection of steam-bent wood sticks that have fractured under pressure evolved into predetermining breaking points in wood elements and casting resin to fix their cracks (see figure 1). Research Questions: what type of joints can be achieved by mending partially fractured wood elements?

“Burn it”
Iteration 1: Physical Model. A composition of interlocked cardboard boards onto which wood sticks are glued evolved into burning cavities in Styrofoam blocks (see figure 1) and interfacing them with casted plaster. Research Questions: what kind of joints can result from chemically sculpting the contact surface of 2 materials?

Iteration 2: Material System. Exploring a change in material and technique by replacing foam with wood, plaster with Plexiglas and the chemical process of corrosion with CNC milling. Research Questions: how can the system serve as a watertight membrane? Is it discretized in panels? Is the system propitiative to a logic of aggregation? What are the limits in size and scale of the units?

Figure 1
Six paths of inquiry; from top left to bottom right (“Freeze it”, “Mend it”, “Knock it”, “Burn it”, “Embrace it”, “Split it”).
“Knock it”

**Iteration 1: Physical Model.** A terraced topography cast in plaster with a formwork of Styrofoam cubes packed with varying density. Research Questions: what surface qualities can be achieved by casting material and knocking it partially away?

**Iteration 2: Material System.** Exploring a change in material and technique by replacing casting in plaster with saw cuts in wood (see figure 1) and knocking with a hammer. Research Questions: how can the system serve to sculpt three dimensional geometries for columns or beams?

“Embrace it”

**Iteration 1: Physical Model.** A block of plaster inlaid with pockets in the cast where irregular wood branches are inset. Research Questions: how can an irregularly shaped component interface with a standardized block?

**Iteration 2: Material System.** Exploring a change in material and technique by replacing plaster with processed wood and using photogrammetry to scan 3D geometry and CNC milling to carve the interface (see figure 1). Research Questions: how can unprocessed branches serve to connect and brace beams of processed wood? How can the system be stacked vertically to produce a wall? How can the system be deployed to produce a slab?

**Iteration 3: Architectural Application.** A wall of stacked elements following the irregular shape of the unprocessed wood. Research Questions: what different functions can be served by the processed and unprocessed wood? How can the balance of processed and unprocessed components serve the structural stability?

“Split it”

**Iteration 1: Physical Model.** A structure of wood sticks spanned by tracing paper embedded in a plaster-made base evolved into splitting blocks of plaster with the insertion of sheets of tracing paper. Research Questions: what qualities can be produced by exposing the interior surfaces of a split material?

**Iteration 2: Material System.** Exploring a change in material and technique by replacing plaster with wood and introducing a range of semi-controlled splitting techniques (see figure 1). Research Questions: can the system function as a column or as a truss? How can the split elements connect to others? Can the halves of the split beam connect back together?

**Iteration 3: Architectural Application.** A facade consisting of twisted lamellas spanning between two horizontal slabs (see figure 2). Research Questions: can thin lamellas act as load bearing components? Is

“Twist it”

**Iteration 1: Physical Model.** Two monolithic blocks of plaster connected by a bridge over a narrow gap evolved into casting with an elastic fabric formwork (see figure 2). Research Questions: how can the bridge between the two components be deformed through rotation?

**Iteration 2: Material System.** Exploring a change in material and technique by replacing the plaster with wood beams and slitting them to allow their rotation (see figure 2). Research Questions: how can this system of twisting elements be transferred to an architectural scale? What is the ratio of wasted material in making the beam able to twist? What is the impact of the proportion between width and length in the capacity of the beam to twist?

**Iteration 3: Architectural Application.** A facade consisting of twisted lamellas spanning between two horizontal slabs (see figure 2). Research Questions: can thin lamellas act as load bearing components? Is
there a need for an auxiliary structure?

**Iteration 4: Structural Analysis.** Simulating the deformation of lamellas under compression forces applied to their ends (see figure 2). Research Questions: what architectural conditions and aesthetic effect can be achieved by the gradual variation of the rotation and position of the lamellas?

**Iteration 5: Design Proposal.** Building a 1:2 mock-up consisting of two slabs with pre-cut grooves that allowed for testing the twist and configuration of lamellas spanning between them (see figure 2). Research Questions: what components are prefabricated? Which are subject to manual and digital production processes? How can it be produced?

**Iteration 6: Prototype.** A pavilion delimited by walls of lamellas spanning between slabs of milled cross laminated timber (see figure 2). Research Questions: how can the twist of thin wood elements improve their structural performance? How can wood lamellas and their aggregation strategies be used for the multi-objective optimization of spatial organization, program, material use, structural performance and aesthetic effect?

**THE PROTOTYPE**

The building of a prototype in 1:1 constituted the final iteration of the process of cyclic making in the design studio. This was undertaken to advance the formulation of an architectural question pertaining to one of the paths of inquiry and to this end the whole class joined efforts. Indeed, the test of constructing in full scale raised many challenges and required the students to work on a number of new tasks. These included the detail design of the project, the optimization of its structural solution using Karamba, the preparation of an interface between Rhino and the machine program Cambium that was to generate the
digital fabrication procedures, the operation of the 6-axis Hundegeger robot, the manual use of analogue tools and finally the construction of the prototype itself on the grounds of TU Graz (see figure 3).

This was made possible by the asymmetric position and orientation of the slots carved out from the slabs in between which the lamellas were fitted. Besides the aesthetic effect, it was this twist of the lamellas that created the necessary stiffness and load bearing capacity for the structure (see figure 4). Ultimately, the prototype demonstrated a static behaviour and architectural intelligence which raised new research questions that would commend for a continued investigation if there were to be consequent iterations in this path of inquiry.

**DIVERSE, BUT DISCONTINUED PATHS**

The results that emerged from the testing of this model of studio teaching show the diversity of questions and range of approaches initiated by students as well as the number of which got discontinued at an early stage of the process of problem-finding. Indeed, this reflects the level of difficulty that students faced to accommodate disruptions within the constraints of the logic and history of their path of inquiry. Firstly, there were paths that stopped immediately after iteration 1 for failure to transfer the medium of the model to wood and the process of fabrication from analogue to digital. Such was the case of “Freeze it” or “Mend it” for instance. Secondly, there were paths that stopped after iteration 2 for failure to jump from the abstract domain of the material system to the realm of architectural conditions of scale and program. Such was the case of “Burn it” or “Knock it” for instance. Thirdly, there were paths that stopped after iteration 3 for failure to respond to the physical forces of the natural world. Such was the case of “Embrace it” for instance. Fourthly, there were paths that stopped after iteration 5 for failure to control the process of fabrication. Such was the case of “Split it” for instance. Finally, there was one path that managed to cope with all the disruptions and complete all iterations, each of which building upon the previous. Ultimately though, given the hardships, students were often tempted to skip an iteration, start from a clean slate on a new question or simply leave their path of investigation and join another.
CONCLUSIONS

Some of the results obtained from the test of this methodology were not anticipated in its design and may recommend the adoption of changes in future implementations of this design studio model. On one hand, it was unexpected that students would struggle so much to deal with the disruptions introduced in their investigations. Naturally, many of the experiments ended up failing and it was not always clear where the work was leading, but it seems now essential to develop strategies that tutors could adopt to support students when they grow discouraged. These can include for instance praising explicitly what appear to be defeats and highlighting the importance of challenges to the refinement of their questions. On the other hand, the fact that the majority of students left their path of inquiry meant that as a side-effect they tried different investigations and were able to explore multiple interests and tasks within the framework a single studio course. As it so happened, a number of students who seemed less engaged in some of the initial iterations, came to life and excelled when the prototype had to be constructed on site. Thus, by failing to stick to the same path, tutors were able to observe students take on different roles and gain a more comprehensive understanding of their multifaceted profile.

Additionally, there were a number of premises maintained in the design of the methodology for this studio that the evaluation of the results confirms. Firstly, that the more iterations the research questions go through in this process of problem-finding, the more precision and rigour they exhibit. Indeed, the question that revealed the greatest clarity and research focus is precisely the one that was derived after completion of all 6 iterations, the only one to have done so. Secondly, that the act of making is a motivational factor for the students and one that fosters their engagement. This was especially clear when it came to build the prototype. Further evidence is also in the fact that about two thirds of the participant students have formed a collective to continue working on “Twist it” beyond iteration 6. Finally, that students improved their capacity to navigate in a context of uncertainty intrinsic to explorative practices. Indeed, the feedback received speaks of gained confidence and comfort in experimenting, especially so after all the students actively took part in the final iteration of that one path and realized in first person the progress that can be achieved by following consistently and
incrementally such a bottom-up process.

Given the above, the authors postulate that the methodology presented can contribute to the mission of architectural education in preparing future practitioners to “go into the unknown [and] forge a new attitude for thought” (Corbusier 1930). In fact, in a context where our discipline becomes increasingly permeated by digital technology, it is fitting to recall Pablo Picasso’s notorious remark that “[computers] are useless. They can only give you answers” (cited in Fifield 1964). Ultimately, the capacity to inquiry beyond the current paradigms and envision alternative worlds relies on a human mindset that needs to be cultivated - hopefully that is proven to be so in the case of this design studio model.

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