Synchronizing Decisions: Design-Through-Production Methodology

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Abstract

This paper demonstrates the process-oriented decision-making developed through multiple years of case studies developed in partnership with the Institute for Digital Fabrication at Ball State University in concert with industry partnerships. Crucial steps in the process of developing solutions will be used to illustrate potentials for informing new strategies for future projects. A catalogue of the diverse issues inherent in a design-through-production project will be included to serve as a road map, and enlighten the human decision-making factor in these technological processes.

Keywords: Digital fabrication; Design-through-production; Performance architecture; Industry collaboration; Digital exchange.

Design-Through-Production

The digital design-through-production methodology requires a rigorous and diverse team-oriented approach to problem solving for architectural and related design solutions. Fundamental to accomplishing productive work is the rigorous management and documentation of possibilities from design inception to final production, and multiple iterations (and failures) along a pathway to determining final form. As such, the coordination of inputs, operatives, analyses, and variables must be closely managed and documented, and the record of decision-making rendered as a visible and valuable component to any project. Any deviation along the decision-making process may lead to very diverse outcomes. Every project reveals multiple levels of potentialities that add value not only to the given project, but also to a knowledge set that may be harvested and spun out to the benefit of future work.

Fail faster

Failure must be expected and embraced as fundamental to determining new courses of actions. Within failure lie the seeds of success, and it is useful to arrive at, and embrace, failures as soon as possible in order to best inform design decisions. Multiple iterations (and failures) are critical to evolve work along the pathway to determining final form. Additionally, this pathway contains the relevant process information that may spin into multiple projects. Form is informed by performance, and multiple iterations reveal weaknesses and improve decision-making (Klinger, 2012). The digital design craft team find kinship with inventors, like Benjamin Franklin, Thomas Edison, and Andrew Dyson. Clearly, the most fascinating stories of these inventors are the long lists of tried and failed experimentations, many of which inspired future thinkers and tinkerers to further develop their ideas. A catalogued open documentation of process decision-making will facilitate the evolution of a rigorous body of work to a collective global group. To be certain, a necessary belief in an open source sharing of ideas and failures is needed to accomplish a useful catalogue. However, this does not negate the realities of patents, which tend to shut down information sharing. So, it is important to make the distinction of what gets shared as basic steps along a certain pathway to an end result, although the result may still be intellectual property. Similarly, James Dyson suggests, “you can’t patent something that another skilled engineer in the field could have calculated or done with [their] basic knowledge.” In the end, it is the knowledge generation as a viable collective enterprise that is the true currency serving design-through-production methodology around the world. And further, it is within the process documentation, including failures, in which the true knowledge capital resides.

The design-through-production methodology requires a rigorous and diverse team-oriented approach to problem solving, where all of the players add value to a design process, and “fail” good ideas in order to improve them. The rigorous management and documentation of design-through-production possibilities, therefore is essential to the enterprise, and this requires new habits. Sharing the process-based knowledge will facilitate the enterprise. Radiating the successes will inspire a new consumer market. For a solid example, one need only to turn to the critical role the journal “The Craftsman” played in disseminating and enabling Arts and Crafts ideas in the last century.

Jeff McGrew of Because We Can, in a keynote speech at Autodesk University in 2011 made the not so audacious claim that “[they] don’t even make drawings most of the time, unless we have to for permit.” It is just model, export, and make.” This is true with many contemporary design-through-production projects; however, the importance of representation should not be disregarded, but rather, seen as shifting. Projects still need to evolve, and solid

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visual thinking is critical to help make effective decisions. The shift occurs in the process nature of design-through-production strategies. In order to effectively understand the complex and interrelated variables influencing design decision-making, these relations must be rendered in terms that will help facilitate decisions and record the knowledge developed during an experiment. Documentation of process decision-making, which examines the benefits and problems of every decision, must be inherent as integral to the knowledge capital of each project. Any slight deviation within the matrix may lead to completely new results. As such, the process IS the project, and multiple outcomes may be expected. It is within the documentation that the true knowledge capital resides.

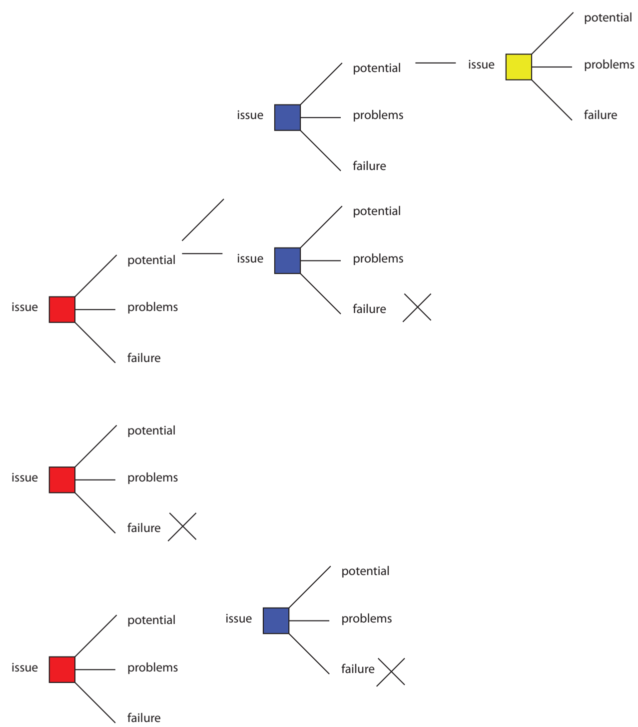

Figure 1: Typical decision tree for process-based inquiry

Facilitating Design-Through-Production

Each region and facility has its own local situation. Fundamental relationships need to be established, and how these relationships are formulated will have a direct impact on the work that may result. A catalogue of available facilities is a very useful endeavor. For example, a catalogue of Latin American Fab Labs has proven quite useful to illustrate the complexities of getting the right mix of industry, equipment, and software. (Herrera, Juarez, 2012). In considering digital design-through-production catalogue building, the main ingredients should rely heavily on the following: Material production and sourcing (inputs), Industry types and fabrication partnerships (operatives), Design and analysis software (informing form), Human resources (decision-making).

Digital Exchange

Once facilities and collaboration relationships have been established, the critical step is to organize a main communications and documentation protocol. The process/project is dependent upon critical experimentation, analysis, failure as opportunity, and rapid informed decision-making. Rigorous documentation of this process "interrogation" is much needed. Thus, the digital workspace/file-sharing/communication/dissemination environment is critical to the success of the work. An interconnected matrix of decision-making will guide the development, *and be* a major outcome of each case. Particular input parameters must be cross-examined as key value adds to each project and set the agenda for the workflow. Much of this information may not even make it into the final project in any visible way; however, it is useful to note the influence of these key input parameters for methodology.

Design-Through-Production Ingredients

An effective approach to any process/project depends upon thoughtful experimentation, analysis, failure as opportunity, and rapid decision-making. Rigorous documentation of this process-based "interrogation" will be expected. Materials are interrogated, Industry capacity is interrogated, Design and performance is interrogated, and Human labor is interrogated. The key ingredients for design-through-production (with a suggested "connect globally make locally" ethic) are as follows:

- Material production and sourcing (local)
- Industry and fabrication partnerships (local)
- Software for design and analysis (global)
- Human capital and collaboration (global/local)

Information collected, and more importantly, analyzed, through experimentation will feed into continual design evolution. Below are some categorizations of pertinent issues to address in a globally connected, locally made design-through-production project.

Collaboration (local/global)

Team roles/ credits. Every person adds value to the process. Even the slightest input can affect the outcome in significant ways. Recognition of contributions to a project respects the value of a collaborative exchange.

Communication protocol. The information stream needs to be efficient and clearly articulated, in order to ensure effective transfer of information in a complex design and production process.

Digital workspace/file sharing. Standards for data exchange will provide a backbone for associated teamwork.

Consultation. Every collaborator has unique experience and expertise. Finding the right consultant may be much more efficient than trying to anticipate and solve all of the problems in a given project.

Materials (local)

Supplier survey. It is useful to have a list of available materials for projects. This survey will serve as a catalogue for any project, and all future projects.

Production process knowledge. How a material is produced may inform how it can best be used for a given situation.

Material analysis. How a material performs will greatly impact the possibilities in design solutions. Sometimes this information is available through industry organizations, but other times additional testing needs to be a part of the design experimentation in order to best understand how a material will perform or fail.

Engaging manufacturers before a finished material product. Perhaps the best solution is an unfinished material that can receive its finishing through operatives in the design-through-production process. If material suppliers are willing to collaborate, materials may be obtained, not as final products, but rather as raw materials.

Fabricators (local)

Current operative/process focus. Determine the existing expertise of the fabricator and understand their process, as they may be willing to alter techniques based on a strong understanding of how they use the machines.

Capacity and availability equipment. Determine the limits of what can be produced and consider this as fundamental information for revising design strategies.

Software standards/file protocol. Understand the software that is most typically used by the fabricator and make certain that the intentions will translate between software packages.

Software (global)

Survey of available software packages. Do not privilege one software package over another software package. Some packages may be useful for even a simple solution to a design or fabrication question. Stay current on the raft of possibilities by continually developing skills. Use each project as an opportunity to develop new skills.

Performance analysis. Exporting model information into a performance analysis software such as structure, acoustics, and daylighting tools. Performance analysis may provide early feedback on design directions. Do not wait until the model is complete to study the impact of performance-based issues.

Generative potential. Understand the power of relations in design thinking. By establishing a few critical associations with a parametric model, the design may evolve in gradient ways as a fine-tuning of the strength of certain associations. Input selection is a critical first step in determining generative potentials.

CAM based production. Many different CAM analysis and production tools exist. Some may be better than others for nesting, optimizing, and understanding the impact of the tooling. CAM based software selection should consider these facts and decisions should be made in relation to the *survey of available software packages* and the *software standards/file protocol* of the fabricators.

Design (local/global)

Start somewhere… anywhere. The value of the design-through-production process is added by interrogation of the factors limiting design, performance, and production. As such, design thinking evolves by getting started and failing ideas as you go in order to improve the strategy.

Design/Function. "Why" do our design decisions take a particular form? Certainly the software has a big influence on what may be possible, however the real decisions are made in the context of solving human needs in relation to physical and environmental conditions. Possible solutions for design today are unique to our contemporary problems and techniques, and have never before been seen in the discipline. We must have a good answer to the "why" we make what we do.

Form is informed by performance. The entire design-through-production process is dependent upon the exchange between input parameters and output realities. This symbiotic process informs form through analysis of process-based research and development.

Production realities informing design intention. Machine limitations, tolerances, capacity, time, and cost provide tangible consequences for design decision-making.

Testing iterations based on material performance and machine tool capacity. Multiple solutions should be considered alongside one another in developing decisions about a design direction. Tooling, patterning, detailing, joints, finishing, all may be realized in multiple ways. A rigorous process will examine multiple directions simultaneously and make critical decisions based upon the analysis of the outcomes. Many tests will fail.

Feedback loop. Value is added during the collaborative process. Final formulation of design is dependent upon the feedback from material, industry, software and human capital.

Production (local)

Scaling 1:1 issues. Moving from model scale to full scale presents a myriad of issues not only in the fabrication of materials, but in the organization and assembly of component parts. Prototyping at full scale becomes necessary to input production factors into the equation of design formulation.

Tolerances. Scaling up presents new complications about the actual tolerances of final production. Machines have influences, if even on the miniscule scale that can add up over the aggregation of a total system. Materials perform in unexpected ways due to milling, shearing, bending, and other operatives on them. These tolerance issues are not revealed in the original design model but only through the production process.

Bracketing. It is useful to make multiple variations of an operative in order to test the final fit. The term "bracketing" is borrowed from the term used in print photography. Multiple versions of the same image were produced, changing slightly the f-stop or aperture in order to determine the best resolution. Similarly, joints may slip if they are off just the slightest fraction of a measurement, finishes will be completely different if production strategies differ. Therefore, it is useful to test variations in order to determine the best outcome.

Operatives as details. Many results from the production process may end up serving as good solutions to joinery, or finishing. Thus, interrogating production outcomes may better inform final design strategies.

Dissemination (local/global)

Process documentation (matrix-based processes, iterations, time-lapse). Since the value of the design solution is added during the total design-through-production process, innovative documentation strategies are necessary in order to best communicate the knowledge developed during the project. This communication can be useful in future projects as directly applied knowledge into new design formulations. As such, a catalogue of design process and production should be incorporated into the rigor of each design inquiry, and knowledge should be seen as cumulative across all projects.

Scholarly discourse on any number of related inputs. A body of design-through-production knowledge exists, particularly on a case-by-case basis. Each project adds knowledge to techniques in material, industry, software and human capital. Inform design work with what has come before each project.

Publication, social media, buzz, event-based celebration of work. Make good solutions, and radiate the knowledge and understanding with a loud voice. The global collective work solving contemporary problems through design-through-production strategies is defining the shape of the discourse with each new applied research project. Each contribution to this collective is significant.

Note on Charting Principles

We see by the rapid expansion of organizations such as TechShop, the rise of the maker movement, the continuous buzz about 3d printing and production, and the increased attention of vocational technology training schools, that there has been a recent elevated attention of the mass public towards design-through-production strategies. In this mass marketization of a complex process, resulting in mass-customized solutions, it is critical to develop guiding principles to rise above the everyday solution, and the novelty of just the technology. Just because we can make anything, "why" should we? Thus, through applied research on every project, and the cataloguing and documentation of the process based decision-making of each design-through-production project, we can help craft for the global collective an open exchange of ideas and make better informed decisions for developing an architecture that is relevant for our era.

Note on Techno-Human Decision-Making

As the agents of design in a technologically driven design decision-making process, we must strive to include a broad understanding about the "why" we do what we do. Steve Jobs of Apple Computers underscored this necessity for the human application of technology in his Apple Keynote on March 2, 2011: "It is technology married with liberal arts, married with the humanities, that yields us the result that makes our hearts sing" (Jobs, 2011). In the end, humans still privilege certain input parameters, decide where to stop the algorithm from generating variations, and make critical choices throughout the design-through-production process. Clearly, we have moved beyond the techno dominant rhetoric so prevalent in the last decade. Now, we need to establish powerful principles governing the "why" we make what we do, so as to emerge with an architecture that is truly of this era—unique in it's worldview at this moment. We need an architecture that is relevant to pressing questions of our increasingly interconnected society, serving our human needs with technology, with a strong connection to our physical environment. If indeed we are on the edge of a cultural/technological shift as significant as eras such as the Renaissance, let us design and produce with a global/local minded ethic and a human perspective.

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