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THE INHERENT POTENTIAL OF THE INDUSTRIAL DESIGN PRAXIS: TEACHING NON-DESIGNERS THE CREATIVE PRACTICE

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My responsibility to teach industrial design students and non-industrial design students started more than 25 years ago. A combined studio of senior mechanical engineers and senior industrial designers was the inception of a lifelong educational challenge. How can we find ways of teaching, mentoring, and guiding students to apply the design process to be creative in their own discipline? This tension between curriculum and coursework spawned a 10-year longitudinal experiment of teaching the same design process in two different courses: Junior level industrial design studio and an elective course for junior-level or higher, non-design students. The course material, emphasis on traditional people-centered methods, and final outputs pursued the same goals - find innovative solutions to the given problem. The final output for achieving these goals differs because of the differences in the student's previous education and experiences. But the common processes achieved appropriate innovations by utilizing a visual matrix as a design tool and method of practice.

Keywords: design education, design management, design process, design praxis

1. INTRODUCTION

Design is currently perceived as a competitive advantage in business, academia, non-profits, and other organizations. [Brown, 2019] The power of design and the design process has been widely shared in many forms. Workshops in design thinking, service design jams, courses for non-majors, and other offerings are more commonplace in industry and education. The unique results of applying the design process have changed how other disciplines teach their curriculums and how businesses approach their missions. [Roger, 2009]

Teaching the process and craft of industrial design is a complex endeavor. In a four-year span, undergraduate industrial design students need to be capable problem solvers for developing the physical appearance, function, and manufacturability of a product. This is accomplished by years of practice in freehand sketching, physical modeling, and several 2D and 3D digital software. This also demands an understanding of the dynamic relationship of the physical product to human cognition, human factors, and ergonomics. In addition to these studio skills and conceptual knowledge, students need to know how materials and processes, business factors, and other system-related subject matter

related to their product success. With a combination of faculty and a proven curriculum, students can become highly capable studio-trained industrial designers. They can make sense of highly complex open-ended problems. [Cennamo, et al, 2011] And they are also capable of imagining new paradigms that create new ways of living or working. This secret sauce of innovation has been most coveted by other disciplines. [Kolko, 2015] How can we transfer this type of seeing, doing, and thinking to others? Does it require many years of experience and practice? What are the necessary skills and knowledge that allow a non-designer to start noticing, acting, and working like a studio-trained designer? To address some of these questions, the hypothesis: Is there a visual model that could enable designers and non-designers to work together at an operational level? Was the impetus to bridge the differences.

The difficulty of teaching non-designers is a unique challenge. And this complexity is increased when attempting to teach students from different disciplines to work as a team in problem-based learning environments [Augsten and Gekeler, 2017] [Jonassin and Hung, 2008]. Literature has shown that the value of design is highly effective when multidisciplinary teams work well together. [Bowen, Durrant, Nissen, Bowers, and Wright, 2016] However, the lessons learned from teaching a highly skill-based studio discipline such as industrial design have provided a framework that can be applied universally. This framework, a generative design praxis matrix, is an effective design management tool that provides designers and non-designers a way to leverage the design process. With more than 25 years of experience teaching and managing various academic and professional teams, my motivation was to establish a course that would teach the power of the design process to upper-level non-design majors.

2. DIFFERENT FORMS OF THE DESIGN PROCESS

A prior research study was conducted over two years that sparked this current research trajectory. 133 senior-level or graduate-level biomedical design engineering students were asked to visualize and describe their design process. Distinct patterns showed that students understood the design process as linear, circular, or loop forms. While co-teaching teams of engineering and design students, it was clear some form of design process model was needed to help interdisciplinary teams work and understand each other better.

The design process has been discussed and researched in the fields of design, design management, and human-computer interaction communities. [McKenna, Mazur, Agutter, Meyer, 2014] The traditional design process primarily represented by the double-diamond, generic four to five serial stages or cyclic versions has inherent limitations. Though highly useful for introducing a methodical process, the over-simplified structure does not provide an operational guide nor reflect the actual workflow required when design teams work on complex, open-ended projects.

Currently, the value of the design process has been utilized beyond the traditional design discipline. Business entities and non-profit enterprises have adopted design thinking and design processes to

understand themselves and their constituents, stay competitive, and produce innovative products and services. Essentially adopting a way of examining themselves and the world to understand and re-invent themselves. They are using the design process to imagine the near and far future as their current business paradigms change.

This adoption and reconfiguration of the design process to fit their needs are not well represented by current design process diagrams or visual concept models. There is a dynamic workflow of nuances atypical of the prior generic design processes that lead to innovative solutions and paradigm shifts in the final outcomes. Nor is it strictly applying the scientific methodology. The design praxis matrix presented results from managing both industrial design projects and open-ended interaction UX design projects. The challenge is to find a method or tool that allows interdisciplinary teams to work together, especially in nebulous environments at the front end of the design process. This can include creating tangible physical and digital artifacts which propose new business solutions and product innovations. These innovations in both products and paradigms are a direct result of the human-centered research, analysis, and reframing of the problem. This elusive secret sauce that outsiders continue to search for usually lies in the details, not the high-altitude, systems-level framework of a generic design process. [Kolko, 2015]

3. DISCUSSION: DESIGN PRAXIS MATRIX

This paper makes two primary contributions to the design field. First, it is a new representation of the design practice in relation to observed activities and output conducted by studio-trained designers. Second, it is a visual tool that acts as an educational method to guide team actions during a project and as a reflective tool for post-project evaluation. The examples provided here act as an account to show the dynamic nature of the design practice can be taught to non-designers. And with support and resources, the output can be viable and valuable to a client's strategic needs. [Chung, 2018]

To better represent the intricate activities, a matrix built on two continuums was developed in direct observation of multiple project teams. The industry projects were open-ended proposal challenges from the US Big Three automotive companies, first-tier automotive suppliers, and IT consulting companies (Ford Motor Company, Bridgestone, Cognizant Technologies, LG Electronics). Each company, regardless of their primary business practice, challenged the design teams to divest focus on what they traditionally produced, such as cars or tangible products. Instead the design brief pulled outward to define automotive manufacturers' remit to be in the business of 'the future of mobility.' Similarly, the clients challenged the design teams to focus on understanding the human in the context of work, play, or other living scenarios. These companies seek the design process and methods in response to the ever-shifting world that can make traditional businesses extinct. For example, companies such as Uber, Airbnb, and other companies leveraged the synergy of social factors, products, and technology to change many preexisting paradigms. The necessity to stay relevant and understand the landscape demands

understanding a combination of societal, technological, and business factors. Thus, the design process was seen as an effective method and way of approaching innovation.

The traditional design discipline concerns itself with making in different mediums. This is still true in today's educational system. And this craft-based part of the design discipline cannot be understated as a significant part of the success of interdisciplinary teams undertaking open-ended project briefs need to produce something visual and tangible - in the physical world, digital world, or both. However, it is the integration of these craft-based skills and the ability to synthesize high-level topics such as human behavior, consumer trends, and business practices to produce compelling stories of innovation. This is different from the scientific process. The design process has many overt and subtle actions and outputs which can make a difference at a product interaction scale or business paradigm. It is the combination of these activities and output that is poorly recognized that the design praxis matrix attempts to capture.

Visualization of the operationalized design process is shown as a 2x2 matrix, Design Praxis Matrix. Figures 1 and 2. The quadrants are labeled as: Defining, Framing, Doing, and Making. The Defining quadrant is the lowest left position as the most grounded with the tangible activities and outputs. The upper right Framing quadrant is conceptually opposite from the Defining quadrant as the activities and output are less observable and intangible. Stradling these two quadrants are the mixed methods of Doing and Framing. Each of these quadrants has varied activities and outputs in relation to the axes' continuums. This visualization of the design process is a direct result of the ability to observe tangible phenomena occurring versus intangible events. For example, implicit individual and team cognitive activities are considered intangible aspects of the matrix. In comparison, the directly observable and explicit activities can be deemed tangible aspects of the matrix. The Design Praxis Matrix differs from other previous models as it uses terms and quadrants as actionable tasks or goals to enable progress. These terms were derived from the observation of experienced or successful teams.

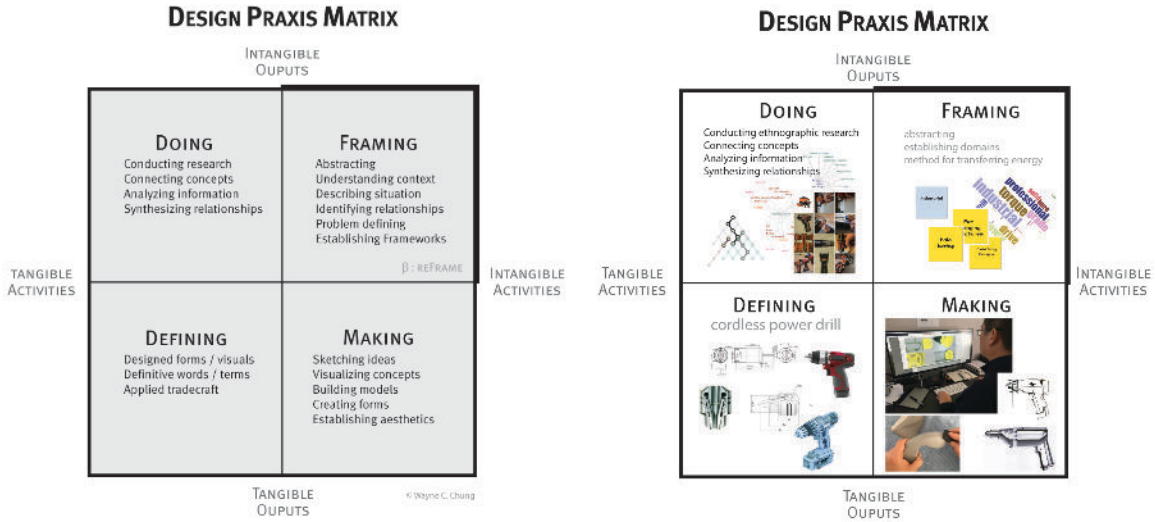


Figure 1 and 2. Design Praxis Matrix and Design Praxis Matrix Industrial Design Example

4. DESIGN METHODS OF STUDIO PRACTICE

The following project example conducted with Cognizant Technologies illustrates the highly complex aspects of designerly activities and output. Seven interdisciplinary teams with three students per team were organized in a 15-week elective project course. At least one studio-trained designer was a team member. The course was a longitudinal mixed-method research, project-based studio. Emphasis on understanding the broad context and phenomenological aspects become the basis for developing participatory and generative tools. Design teams work through the problem by subsequent investigation of how participants could imagine future work, play, and living [Madsbjerg and Rasmussen, 2014]. The student teams are shown several design processes, including the Design Praxis Matrix at the start of the semester and the introduction of the project brief.

The following images highlight the combination of various research methods and mappings that directly affect the subsequent concept directions and ultimately determine the AR technology design solution. The front end of the design process is notable as the examples illustrate the non-sequential aspect of design practice. The praxis of understanding people, visualizing concept mappings, research analysis, and synthesis to build new methods and tools for deeper discovery and a repertoire of making, thinking, and reflecting is represented in the following series of images and descriptions of a three-person interdisciplinary team. The following figures portray the beginning and end of the project activities and outputs. Figures 3 and 4. Only towards the end of the design process do the activities and output populate the Defining quadrant. Figure 5. Design Praxis Matrix Defining Quadrant by Studio-Trained Design Teams

This visual matrix is developed to allow users to assign their own activities and outputs as they see fit. This generative stance is purposeful so that the matrix acts as a structure while the team decides on their own designations and internal syntax. Though this visual tool hopes to better represent actual categories of activities and output during open-ended projects, the value for both client and team is multi-faceted due to its direct and applied nature. The intent is to have more plain and explicit discussions on the nature of the design practice while being aware of distinct differences at an operational level.

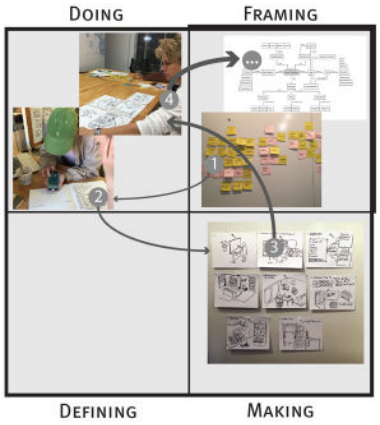
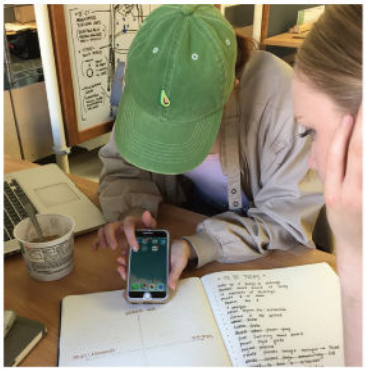
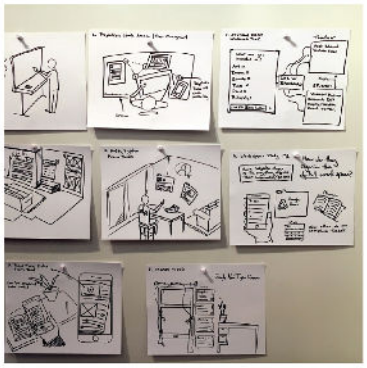


Figure 3. Design Praxis Matrix Cognizant Technologies Patterns of Activities and Output

Activity 1 Framing: Post-it note affinitiy diagram mapping.

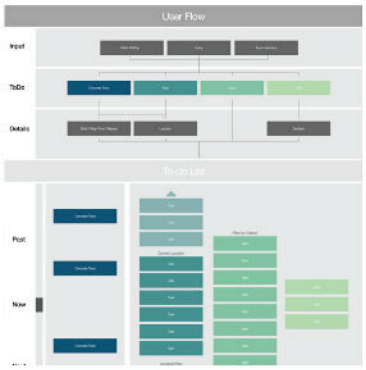


Activity 2 Doing: Conducting interviews with a pre-determined protocol.

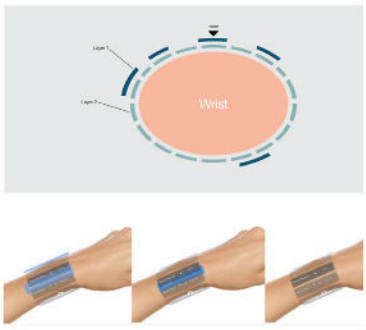


Output 3 Making: Line drawings created as provovcations to a followup interview.

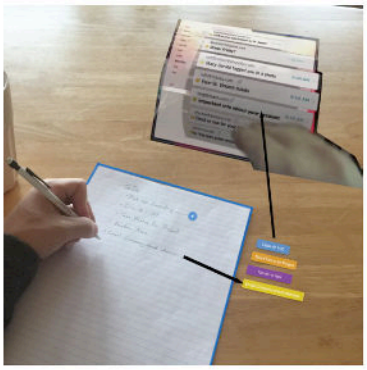
Figure 4. Design Praxis Matrix Framing, Making, Doing Quadrant Activities and Output



Activity 15 Defining: Formalizing user flow in relation to to-do list in conceptual form, not designed form.



Output 16 Defining: AR design as layered interface.



Output 17 Defining: Compositing various layers/channels to create proposed design and how the system would work for intended users.

Figure 5. Design Praxis Matrix Defining Quadrant by Studio-trained Design Teams

5. DESIGN METHODS OF PRACTICE AS A NON-DESIGNER

With this template of understanding how studio-trained designers operate, is it possible for non-designers to apply it with similar success? The 15-week semester course called Tools for UX Design 51359 (undergraduate) and 51759 (graduate) was developed to accept a range of different disciplines to work on open-ended design projects. The students included a spectrum of different engineering majors, information systems, computer science, and various humanities majors. The course typically had 18-24 students. They were teamed together with three to four members. This course has been conducted since 2011 with more than 225 students of various disciplines and levels. Also coinciding with these courses was the democratization of design thinking and the disembodied design process from the design craft. [Brown, 2019] The School of Design was delivering continuing education to industries and institutions such as the United States Air Force Academy, BNY Mellon Bank, Highmark Healthcare, the Food Bank, and several internal colleges that included the business school and school for public policy. It is no coincidence that design, design thinking, and the design process was recognized as a highly sought-after way of working.

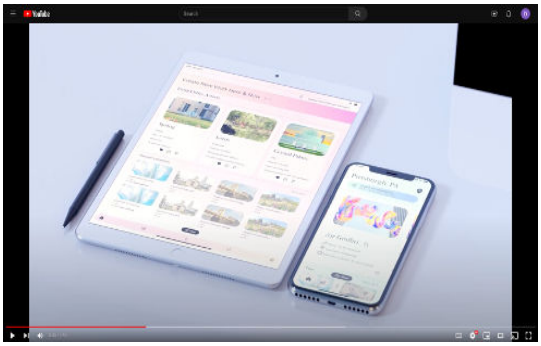
By observing more than 50 project teams, there was no significant pattern of design activities for such open-ended and different subject matter projects. Additionally, each team comprised different team members, skill sets, and experiences. Thus, the power of the team can only be leveraged with a flexible and generative process that takes advantage of the given resources. Rather than a progressive linear progress, a repertoire of various activities and outputs needs to occur so that teams can work through a process of discovery. These movements of activities and output allowed the teams to identify the opportunities in the given problem space.

When working with the non-designer teams, it was observed that teams that never conducted complex, open-ended projects quickly became stymied by what and how progress could be achieved. Most students were hoping for more explicit next-step directions. Learning how to proceed in open-ended projects is an essential component of the educational struggle and process. However, observing successful teams and individuals showed that some form of productive activity or output was necessary to initiate the next step of the inquiry. These concepts were identified as Activities and Outputs and is the common denominators and operational essence of the Design Praxis Matrix.

Most of the client project statements were intentionally created to be open-ended. So, the difficulty for many teams unfamiliar with longitudinal behavioral research and analysis was looking for guidance and prescriptive methods. The design praxis matrix demonstrates that a generative methodology takes advantage of the unique aspect of the team members, subject matter, and participants. This enabled the teams to be successful at framing new opportunities and focusing their resources. Good design comes from the investigation and understanding people first. Many of the appropriate and innovative solutions can hang their success on this acceptance.

To further qualify whether innovative design processes can be taught to non-designers, we can look at the evidence of output. Does innovation look the same for non-designers compared to studio-trained designers? The most significant difference occurred in the Defining quadrant. As expected, non-design students cannot develop or craft products, communications, or environments to a highly polished resolution as studio-trained designers. The non-design teams excelled at systems-level thinking, diagramming of various concept maps, and service mappings. The access and availability to most tools and apps were not necessarily a factor. The same software, such as Adobe CS Suite, Solidworks, and other design programs was readily accessible. The campus has multiple 2D and 3D labs or the ability to send to a service bureau. It is the inherent lack of experience and prior use of these tools that inhibited or prohibited non-design students from building refined forms of expression.

In contrast, most non-design students use written reports and slide deck presentations. So, a form of communication and final deliverable needed to be achievable and effective in that both student teams and the client could understand the proposed solution. The final deliverables for each of these projects were a video sketch and presentation slide deck. A video sketch was defined as a combination of stills, short videos, video footage, text, audio voice-over, and/or foley compilation. Student teams used best practices from the animation and film industries to build out a video sketch that told the story of their process and solution. The traditional use of creating a script, developing physical or digital assets, taking A and B roll footage, utilizing stock images and video, and including their own first-person research allowed teams to tell their unique story to the audience and client. The level of expertise in Adobe Premiere and After Effects ran the spectrum from novice to advanced, depending on the team members. Therefore, a video sketch could still be accomplished even with basic software such as PowerPoint or Keynote. These and other presentation software allowed a relatively finished communication medium to deliver a storyline effectively.



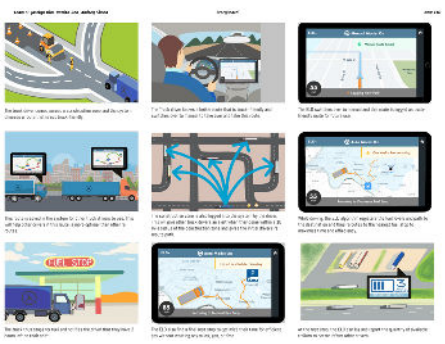


Figure 6. Non-designer team Art Rio Project: Connecting people to their immediate environment through making and sharing AR art. Chen, Y., Li, H., Santiago, V. https://youtu.be/HYmkNz6Uw-s

Figure 7: Non-designer team ELD Pro Project: Kim, J., Rao, N., Simon, A. https://youtu.be/mY4OpvlSH6w Comparative Video Sketch of Studio-Trained Design Team. Mitchell, G. Kang, J., Yang, H. https://youtu.be/cgzEayXtIJE

One of the main differences between non-design teams and studio-trained design teams is within the Defining quadrant. For studio-trained designers, a prototype in digital or physical form is expected and readily produced. For other majors, applications that can tell the story is essential. However, the credibility of the newly proposed innovative idea can hinge on both the systems-level paradigm view and the props that make up the fictional future state. This is where the traditional studio-trained designers can provide a more realistic version of the proposed future state with highly refined 2D and 3D models that serve as pre-production assets. These video assets become part of the scene and tie into the believability and viability of the newly proposed innovative design solutions.

After conducting more than 50 team projects specifically for the 51359/759 Tools for UX Design course, the evolved universal hypothesis: Can a visual design process model help non-designers work like studio-trained designers? Resulted in a positive affirmation. The Design Praxis Matrix has been used and provided to students for the past five years. The research protocol included introducing the various design process methods, including the Design Praxis Matrix at the semester start of each course. Course evaluations and verbal feedback of approximately 118 students who completed the Tools for UX Design and Advanced Product Design courses provided qualitative responses. Explicit references to the Design Praxis Matrix occurred mainly in the first part of the project in relation to the human-centered research methods. Results of adopting or use of the matrix were observed when direct reference in the form of visually representing the matrix or using the continuum terms: activity or output, tangible or intangible. In the primary quadrant terms, Framing was the predominant term used; the other quadrant terms were rarely referenced in direct relation to the matrix. This lack of matrix term recall may have limited its conceptual efficacy but not necessarily the applied utility. An additional study to discern if the terminology is linked to the method application would be necessary to determine the significance.

However, having several design process models, including the Design Praxis Matrix was seen as a team benefit. If the project client is the third-party evaluator, and as the primary judge of success/validation, the corporate clients have returned for repeat projects on several occasions, publicized the results through international publication venues, invited teams to present at the corporate locations, and hired students for intern and full-time positions. These residual results may not point to the direct impact of the matrix. But is positive anecdotal evidence and indications that the management and execution of the educational experience lend itself to effective results.

The multitude of project results shows that non-designers can apply their prior experience (computer programming, technical writing, research methods, diagramming, storyboarding) to convert that work into a visual communication medium (video sketch in combination with slide presentations) to propose an innovative story. The matrix's quadrants act as both target goals and landing pads which are linked to the expected activities or output options. Whereas the continuum terms, Activity and Output were more easily referenced and applied. These operational elements, coupled with the human-centered mindset, provided the structure for the designerly ways of discovery and innovation.

6. CONCLUSION

The design process is regarded as a universal method for solving problems. More so, it can be a powerful tool to reframe a problem for innovative solutions. This allows others to see opportunities when it was not self-evident. This paper portrays that the highly applied and detailed nature of practicing design is useful to designers, non-designers, and creative practice. This work aligns with the past and emerging discussions on design theory, design processes, and methods for designing. And this matrix is in response to advancing the understanding, visualization, and discourse of how and what designers do at an operational level. [Cross, 2007] The double-diamond visual process still is highly effective. The concept of divergent and convergent processes is at a systems-level or meta-cognitive thinking. Achieving this pattern requires several actions and results to occur. The Design Praxis Matrix pairing with the double-diamond process complements one another. Students' creativity was aided by having two or more different models of design thinking.

This work is becoming more important as other disciplines adopt and augment the design process. These are especially relevant to the speculative design, futuring, and forecasting as they embrace and create their own practices. Further, this re-perspective on how designers work in concert with skill-based or cognitive activities and output for traditional product, interaction, and UX design is important in understanding our own practice. Without more mapping of the definitions, designations, and descriptions of the highly complex nature and state of the design process, the field cannot advance in discussion, debate, and development. The hope is that a more diverse set of perspectives, values, and applications of the design process may evolve and be realized by others.

Richard Buchanan's paper, Wicked Problems in Design Thinking is the sentiment that '...design continues to expand in its meanings and connections, revealing unexpected dimensions in practice as well as understanding.' [Buchanan, 2002] holds true. The practice of design is expanding and so does its representations, definitions, visualizations, and discourse. The hope of this paper is to continue these dialogues to guide future designers and non-designers. And subsequently, this paper expands on how design education and the profession may fundamentally perceive itself as new visual and conceptual models provide a more direct reflection of actual design practice.

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