Prototyping the not-yet-existing for research and innovation: a possible process model for design research.

Juan de la Rosa, Universidad Nacional de Colombia, Bogotá, Colombia University of Illinois at Urbana-Champaign, USA; Institute of Design, IIT, Chicago, USA.
jadelarosam@unal.edu.co

Abstract

Design argument and ability to recognize complex systems (Rittel & Webber, 1973) and find a way to modify them, has led other disciplines to try to understand design process and apply it to other areas of knowledge. Creative solutions and ability to innovate (Verganti, 2009) have made design a valuable resource on the contemporary economy. Nevertheless, there is still a polemic about the meaning and model of the process of academic research in the field of design (Muratovski, 2015), the ways in which design research should be conducted and the specific knowledge that is produced with the design research process.

This paper tries to recognize the prototype as a basic element of the process of design, since is connected to a specific type of knowledge and based on that; it also proposes a model of the use of prototypes as a research tool based on four different theoretical concepts which importance in the field of design have been strongly stablished by different academic communities around the world.

Keywords: *Design, Design Research, Prototype, Not-yet-existent, Framework, Design process.*

Introduction

This article is intended as a further development of the framework presented by de la Rosa (2016, 2017), and seeks for a more detailed definition of the model presented as a tool for research and the introduction of new theoretical concepts.

The model of use of prototypes as design research objects was supported on three main theoretical concepts (de la Rosa, 2016, 2017) that are commonly connected to the process of design. The first one is the assumption that there is a specific type of knowledge that is generated on the contact with the world and that cannot be stablished or predicted based on theoretical bases, but defined by our experience of the world (Polanyi, 1958; Polanyi, 1967).

The reaction produced by our contact with the world creates a new tension between the predetermined functional requirements of the artificial world and the specific needs of the users, both the pre-existing ones and the ones that are going to appear in the future as new affordances arise from that contact. That displacement (Simondon, 1958; Latour, 1990; Akrich, 1992) between intent and affordances that produces a constant force of transformation is the second theoretical concept proposed.

Finally, the assumption that design is, by definition, a discipline that seeks for complexity as its desired perspective of the world, and constantly tries to establish the problems as part of a complex system that require a broad perspective (Rittel & Webber, 1973). Based on those concepts, the model presented tries to support and explain how prototypes can be used as probes to test the complexity of the future states of the systems where they are deployed.

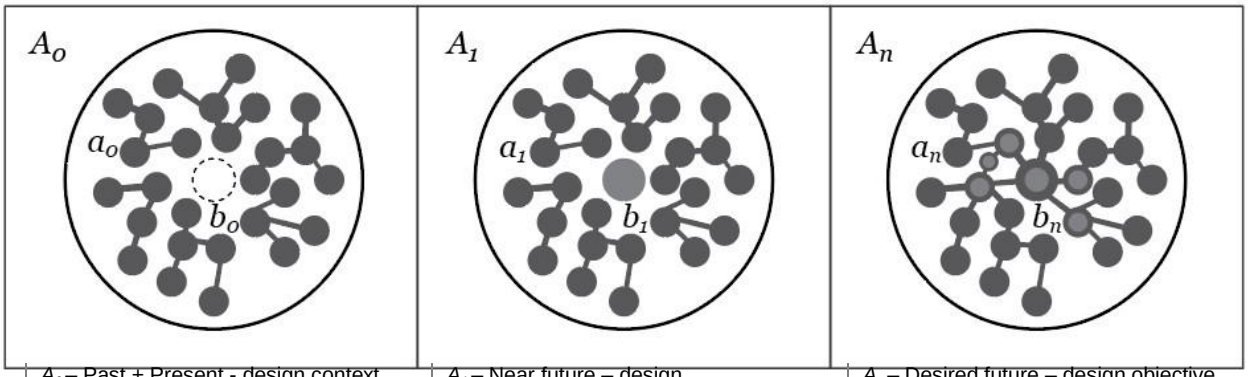
This paper seeks for a better explanation of a possible use of this model for research purposes and introduces an initial explanation of the role of time and uncertainty into the model. These concepts are important to define the reason why the use of prototypes becomes a valuable resource when observing complex systems and the variation that they have when new elements are introduced. These ideas are intended as new bases to propose a different model for design research, but since the main idea of the process is the production of design knowledge, or knowledge related to the ways a complex human system can be transformed based on the insertion of designed objects (possible future states of the system and their implications), we believe that the model has also possible uses for design practice.

Conceptual bases for the model and their role in it

When trying to understand the possible nature of the knowledge produced by design as a discipline and the role that based on that can be defined for the design researchers, it is necessary to determine the nature of the design process and product. Based on Simon's (1969) description of design we could recognize two major arguments on the process:

1. Design is about the construction of the artificial, or that, what we have built into the world. Meaning that every design process seeks the construction of a human artifact, either physical, digital or conceptual but a defined human construction.
2. Design is about planning for a desirable change. That means that the argument of design is that we can modify the future on a specific direction by an interaction with the present.

From this definition, we could argue about the existence of a series of intrinsic elements on the model related to time and structure of the system (figure 1),



A_0 – Past + Present - design context	A_1 – Near future – design implementation	A_n – Desired future – design objective
a_0 – Pre-existing state of the complex system	a_1 – Active state of the complex system	a_n – Transformed future state of the system to the preferred
b_0 – Not-yet-existing design solution	b_1 – Implemented action of design or designed object	b_n – Design object interacting through new affordances

Figure 1. Initial representation of time and system elements based on the definition of Herbert Simon.

Based on Simon's definition we could recognize the idea of a time structure (A) that is divided into three moments, the existence of a system to be transformed (a) and a design object or solution to be implemented (b): Initially, we have a time where design process is happening, that is the present observation of the past state of the system (A_0). In that, design recognizes a pre- existing problematic condition of the system (a_0) and the idea of the possible, but not-yet- existing, solution (b_0). We also have an implementation time (A_1) where design solutions (b_1) are deployed into the real system. Most design models will present the implementation or production of the object as the final state of the design process. Finally, we have the real target of the design process: the desired future (A_n), the one where the system (a_n) has been transformed by the action of design, and the one that is usually not included on the design process models.

Once these elements are defined as part of the design process, there are a series of questions that arise from this model: If the process of design is supposed to take us from a_0 to a_n, why do current design models focus their research process on the previous state of the system, rather than desired one? How do we test b_1 as a viable catalyst of a_n? How do we produce an image of a complex future system that has been already altered by the not-yet-existing (Bødker, 1998) design implementation?

Based on the representation of the model presented based on Simon's description of the nature of design, we can also recognize three major elements that can be defined based on major theoretical concepts (de la Rosa, 2016). The first major acknowledgement is that, from the perspective of design and of GST, nature is by definition systemic (Maturana & Varela, 1987; Maturana, 2007), therefore, even the more reductionist view of problem solving must be based on the interaction with the multiple factors of the system. In fact, general design process seeks to recognize the complexity of the system (Flood & Carson, 2013) and the problems underneath (Rittel & Webber, 1973).

The complexity of the system for design has an additional element: the fact that we deal with both the current state of the system, the plausible future and the preferred one. The uncertainty of that future state becomes then, one of the main discourses of designers, as a way to explain how the design process is not something that can be automatized or forced; but in

contradiction to that, design practice promotes the idea of a professional certainty over the success of the things that we design to fit on those future-state systems and transform them on a preferred way.

Complex systems are based on the existence of elements that interact (Zeigler, Prähofer, & Kim, 2000), that, from the human perspective, define the existence of actors (both human and non- human) as primary elements of the systems. But actors for design are not stable, they are dynamic and in constant change, adapting to the changes that the environment requires from them and to their needs and desires. Even though we can only see the current state of the system and the past index of it, we know that the system is constantly moving and that what we see is always about to change.

One of those forces that is constantly leading transformation and evolution (Simondon, 1958) of the system is the tension between the needs and desires, the uses and affordances, of the actors inside the system. That tension between the current state and the future desire or affordance has been described on ANT as a 'displacement' (Akrich & Latour, 1992; Latour, 2010), a force that is persistently urging us to act.

That tension represents an ever-existing distance between the actors or elements of a system that are connected by their interactions. That is the distance that design always seek to populate, a gap between users and their needs, or their ideas of the future. That tension also defines the not- yet-existing space, the notion of something missing, a constant idea of a better fit with the world that surround us.

Finally, we recognize that the previously mentioned tension, plus the interaction itself of actors inside the system, will produce a transformation of the different elements of the system. That part of the transformation that is based on the interaction of the elements of the system has a significant portion that cannot be formalized or put on a propositional form because is based on tangible experience of the world (Polanyi, 1967).

In his intent to try to define this type of knowledge, Merleau-Ponty, influenced by the work of Heidegger (Gallager, 2010), proposed a concept of '*embodied knowledge*', as the type of knowledge that requires our body, our hands, to experience the different factors implied on our experience of the world. For Merleau-Ponty & Smith (1996) we are band to understand the world as part of it; our physical existence on the world cannot be eliminated from the way we perceive and understand the world.

As designers, we build meaningful objects for others and try to understand the future state of the object and the system around it. We recognize that we learn about the world as we transform it, as we build on it (Heidegger, 1971). Therefore, it makes sense that at least one type of deign research process should involve investigating through actual experiences of individuals of the world surrounding them.

Discussion: General issues of the current models for design process and adaptations for design research

On his intention to reveal the design process with the purpose of eventually being able to automate it, Alexander (1964) proposed the 'Analysis and Synthesis' model. This model portrait the design process as three stages (an initial intent based on parameters and requirements, a structured view of the system and the possible solutions run by a program and a final realization where the program has been implemented) and two basic processes (analysis and synthesis).

Later, Banathy (1991) redefined this representation of the process by recognizing that the central stage where 'the program' is produced requires a process of synthesis, then, the model became an iterative process of divergence and convergence actions that produces first an image of the future preferred state of the system and then a model of the not-yet-existing solution. That iterative double-diamond (figure 2) model is still used as a foundation for many design process methods (Kumar, 2012).

Both models present significant advances on the definition of the Design Process, especially when it comes to the notion of analysis or divergence, the models present a completely different approach to the traditional engineering process, where the uncertainty only exists at the beginning because even though initial requirements and needs are defined from the beginning, there are uncertain factors that can alter the implementation of the optimal solution.

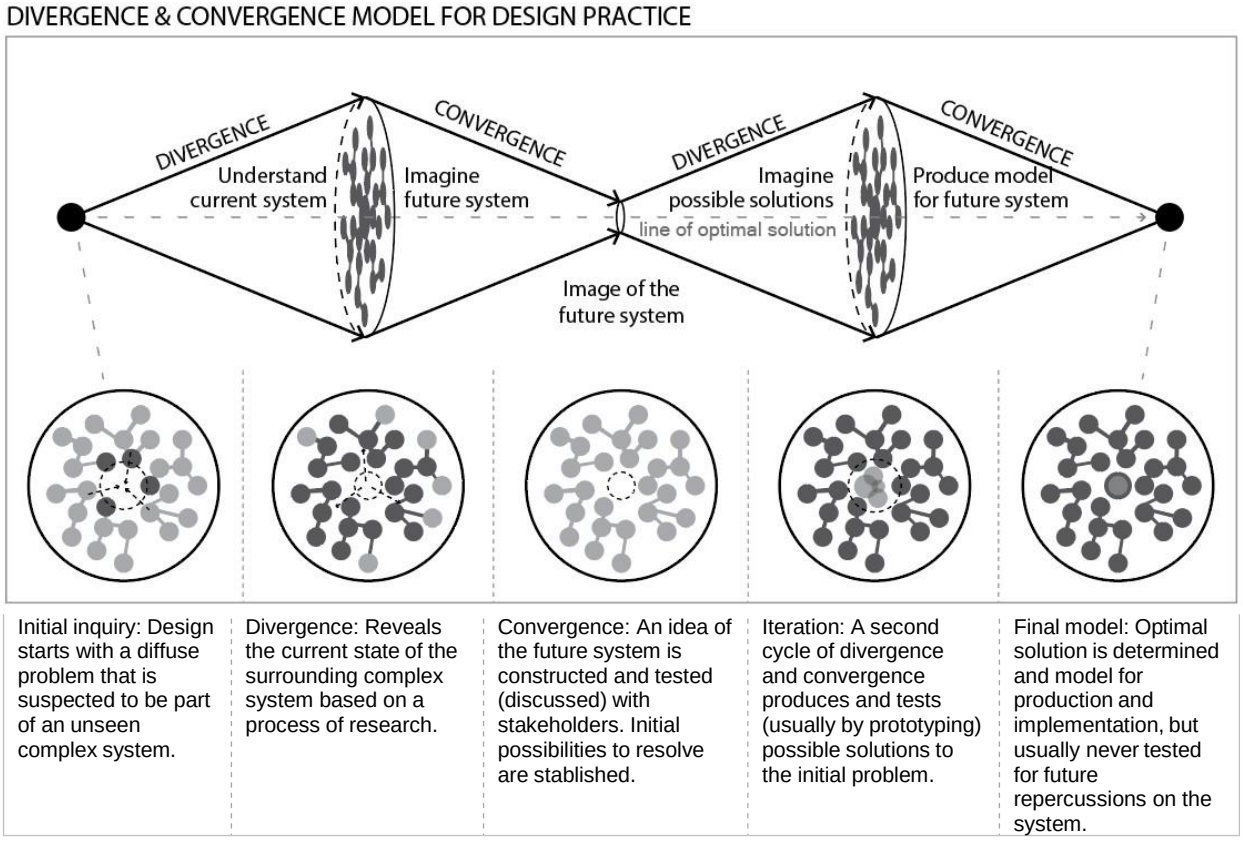


Figure 2. A representation of the intention of the use of iterative divergence and convergence on the design practice process based on Banathy's description.

This concept has been largely described as the 'cone of uncertainty' (Bauman, 1958; McConell, 2006) and applied in many different areas of knowledge. Opposed to engineering and management where the cone is recognized as a model to measure the possible variations of the program based on the existence of external agents that can modified the implementation of an already defined solution (McConell, 2006), design based models (Alexander, Banathy) recognize the concept as a way for the design process to portrait the undoubtable variations of a not-yet- existing future; the notion of uncertainty in design models is defined as a double-sided diamond, where the initial requirements are not necessary enough for the designer to understand the problem itself, and there is a constant need to build uncertainty by investigating the complex system where the problem is situated.

While the concept of uncertainty is more commonly used on his convergent way, an actionable principle that portraits an initial high level of unforeseeable factors that alter our ability to achieve a desired goal, other disciplines like meteorology manage this concept as an approach to the future, a way to portrait our natural inability to forecast every single factor of a complex system as it untangles. Models of the future presented from the perspective of design (Voros, 2003) also portrait the cone as a view of the different outcomes for the future. Voros defines five types of alternative futures on his model: potential, probable, plausible, possible and preferable; these categories are constantly growing as we extend our view of future, the farther we go, the more the system expands.

When considering our ability as designers to consider the repercussions of the implementation of designed solutions, this model allows us to see that the farthest we try to see on time, the more unpredictable those repercussions become. Regardless the fact that this model does not use the term 'uncertainty' to describe the enlargement of possibilities as we move though time, we can recognize how the same model of the future can exemplify the correlation between the increment on the level of uncertainty and the distance of time into the future.

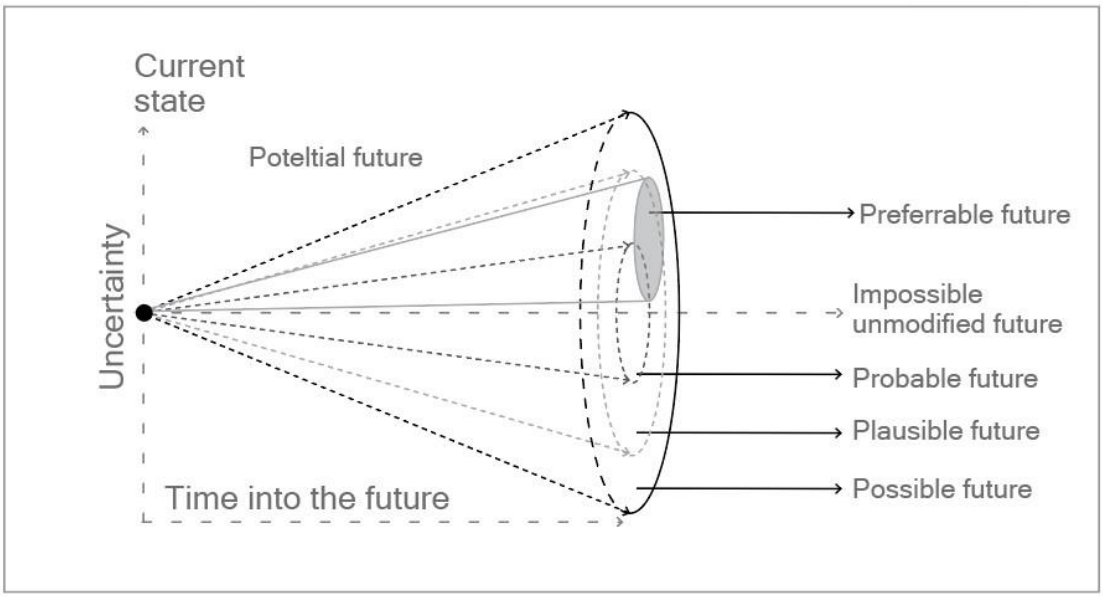
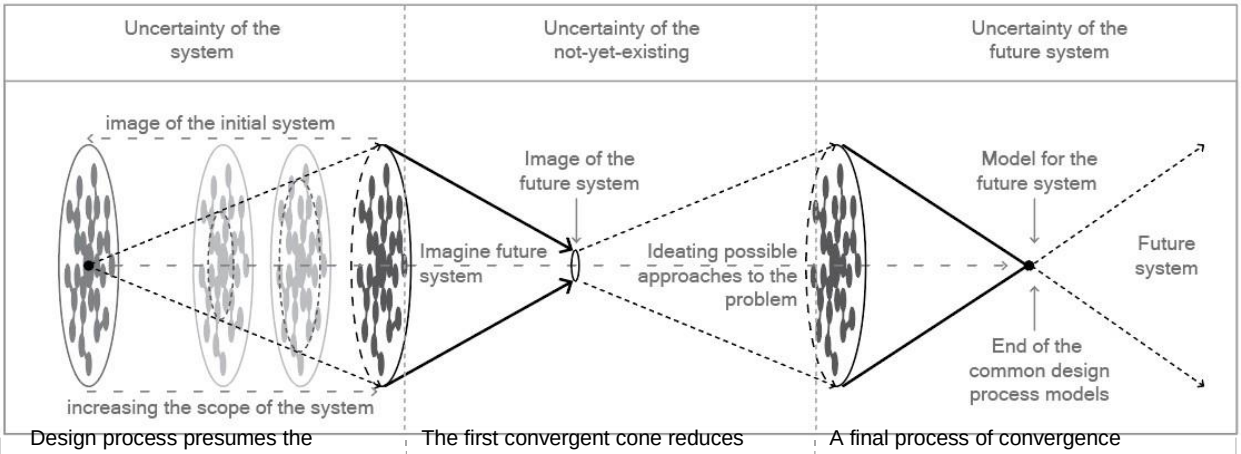


Figure 3. Modification of the model presented by Joseph Voros (2003) to exemplify potential futures.

Looking back to the time instances based on the work of Herbert Simon, that were presented before, we could also establish then, three different stages of uncertainty: an uncertainty of the current system where the initial inquiry could be situated, a stage of uncertainty of the future not- yet-existing designed solution, and a final one, an uncertainty of the future system and the repercussions of the implementation of the design process (figure 4).

This final stage of uncertainty is the less acknowledged and tested by designers, and when recognized through the model of the different futures presented before (Voros, 2003), we could argue that since the implications at the system scale level are usually noticeable on a long-term time-frame, the uncertainty of those becomes higher than usual, therefore, the forecast of the future system becomes less accurate and more complex to determine.

When it comes to the notion of design research in academic communities that believe that there is a certain type of knowledge that can be produced through the process of design (Frayling, 1994; Godin & Zahedi, 2014), the uncertainty to determine system-scale desirable modifications seems to be one of the reasons why the use of common design process models could present several problems when applied as a method to produce reusable knowledge surrounding the subject investigated (de la Rosa 2016, 2017).



Design process presumes the existence of a complex system where the initial problem is situated and embraces the uncertainty of that system and therefore the uncertainty of a not-defined problem. An inverse cone is proposed to build uncertainty, usually by revealing the complexity of the system with a process of ethnographic research into it. The scope of the project determines the complexity that the process is willing to embrace and how detailed or complete is the image of the initial (and therefore past) system that is produced at the end of the analysis process.

The first convergent cone reduces uncertainty by building consensus of what could be the goal of the design process: an image of the transformed future system. A second process of divergence is deployed to search for possible options of designed solutions that can fit into or produce the expected future system.

In this phase, the uncertainty is built on the idea of a possible solution, the designer here presumes the existence of a not-yet-existing tangible solution that can be implemented in the system.

A final process of convergence produces a final model to be implemented. This is the final step of most design models, but the uncertainty of the future system is rarely taken on account or tested.

The not-yet-existing becomes existing and is implemented on the new current system and new affordances are engender by the process of interaction with users.

The tensions produced by the displacement between the new solution implemented and the real needs and affordances creates the space for a new iteration.

Figure 4. Applying the notion presented based on Simon's definition of design, we can propose three stages of uncertainty

Summing up, that even though Banathy's model recognizes the existence of a future state of the system, does not provide any views on how to understand or test the functionality of the designed solution to get us there. In addition, common models stop at the implementation process, assuming a positivistic and linear interaction of the designed solution with the system, and do not account for the actual affordances and the unintended transformations of the system. Finally, and probably more important, these models do not seek to produce a reusable knowledge of the future system and its elements and interactions, but a local usable knowledge that is supposed to be embedded on the final solution proposed.

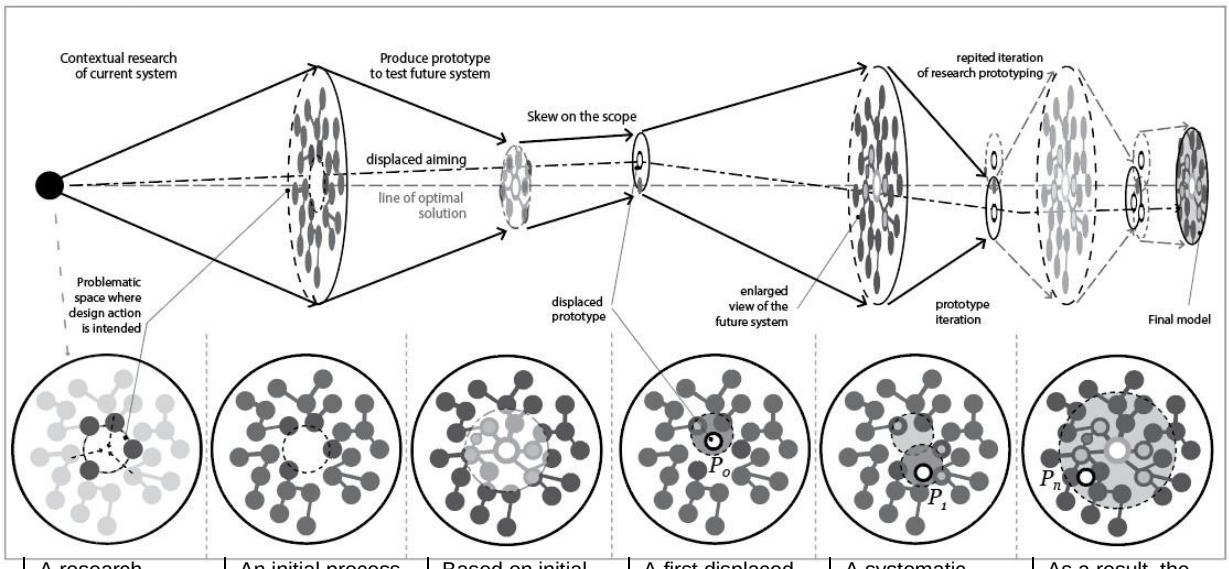
Here is where the concept of displaced prototyping and embodied knowledge becomes an important addition to the design model; since we are trying to investigate on future interactions and responses of the system as we implement design solutions, we should test the system for future responses and review how the peripheral structure of the specific problem can be recognized and questioned to establish plausible and possible variations into the future.
Recognizing that the designed solution is always part of a system and that the distance that every new actor in our socio-technical network has with the rest of us, with the desires of the client, the intentions of the designer, and with the needs of the user give us the chance to produce models of reusable knowledge regarding the principles that define future interactions and transformations of the current system into the desired one. We require new models and methods that allow us to evaluate future interactions and specific knowledge surrounding the objects that we create and design researchers should be able to build those models based on the investigation of real interactions of the system with objects that argue with their users (Galey & Ruecker, 2010).

Conclusion: a model for design research

As design researchers, we should be able to recognize and investigate the actual human experience of the world and the parameters that could determine the design process to achieve certain specific transformation for a desired future system. For that purpose, this paper proposes an experimental approach based on the use of prototypes. The main difference with common prototyping processes, is that the one presented here does not intend to validate pre-existing ideas or concept that the designer wishes to implement, but to investigate the structure of the future system as it is being modified by the tangible action of this objects. This action of intentionally producing prototypes as argumentative objects to explore the system might be describe as prototypes as exploratory probes into the future system (Brandt, 2004) or as an object of conversation as defined by Galey and Ruecker (2010), that unveils the possible connections to be created on a real physical relationship with the users and with other objects.

The model then proposes the use of displaced prototypes as research tools. With this model, we stop trying to aim to the ideal solution, and consciously aim to the periphery of the problem on an attempt, not to solve the problem, but to recognize the emerge of new knowledge on the physical interactions of users with it. On a model like this, each instance seeks to increase our understanding of the possible future shifts that this object could generate and in the same process a new understanding of the problem itself (Figure 4).

ITERATIVE MODEL FOR DESIGN RESEARCH BASED ON PROTOTYPING



A research problem is defined around a gray area where there might not be enough knowledge.	An initial process of contextual research seeks to produce enough understanding of emergent trends and possible external factors.	Based on initial research, design produces a hypothesis of the possible desired future system to be tested.	A first displaced prototype is produced and deployed on the system to probe possible reactions of the system.	A systematic deployment of displaced prototypes on the periphery of the problem are produced.	As a result, the researcher produces a model of forecast of the structure of the preferred future system.

Figure 4. When prototypes are aimed to the periphery of the problem we gain a better understanding of the future system.

We can see that instead of converging into the 'optimal' solution, the model seeks for knowledge of the possible ways in which the system can be modified, and the complexity of the system that contains it. (Figure 5).

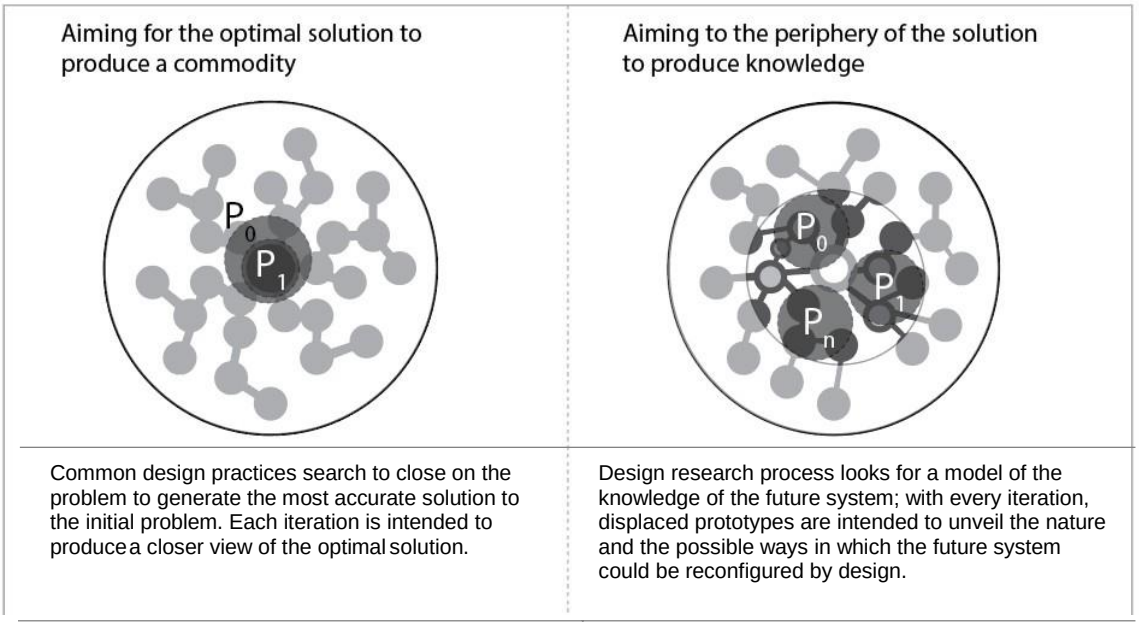


Figure 5: The role of prototyping on practice based design and in research based design

This model presents a possibility for design research or for design on complex system, and for the different practical applications of those areas, to redefine the way they investigate on diffuse, complex future scenarios, by changing the notion of the prototype from a tool for validation, to an exploratory device that can be consciously deploy by the researcher to produce informed images of the future system.

This type of prototype is not common on regular design practices, and neither it is on design research. Its experimental nature and the fact that, it does not necessarily produce an actionable model or insight for the design process, makes it rarely used; especially since in most cases, prototyping process occurs just once on each stage of the process. Nevertheless, some isolated cases can be recognized when observing distant future innovation on complex, diffuse systems, like the ones presented by de la Rosa, Khöler & Ruecker (2017) as case studies. In those, prototypes were not implemented as validation tools, instead, they were deployed as an intuitive tool to produce a better understanding of a possible long term future on a specific business environment.

One of the possible reasons why this type of prototypes is not more often seen on best commercial and professional practices could be that most of the knowledge produced by these prototypes cannot be easily implemented marketwise. This is because the vast distance between the actionable policies of the company and the possible future scenarios where the image of the system is produced, does not allow for easy, accessible, market actions.

Despite the difficulties that this type of prototype produces for implementation at a professional level, its ability to produce a better understanding of the plausible structure of a preferred state of the system, presents a valuable asset for researchers. Based on the theoretical arguments of previous papers, the ones presented here and the functional traces observed on the previously mentioned case studies (de la Rosa, Köhler & Ruecker, 2017), this paper argument is that this knowledge can generate actionable models of knowledge, that can be used for researchers and system oriented designers to facilitate large scale transformations on diffuse and complex systems.

New experimental research might be required to test this process as a viable action of inquiry for design research, and a possible positive response to this question could represent a need to validate and define it as a standardized possible process to produce designerly knowledge of complex dynamic systems.

References

Akrich, M. (1992). The de-scription of technical objects. *Shaping technology/building society*, 205-224.

Akrich, M., & Latour, B. (1992). A summary of a convenient vocabulary for the semiotics of human and nonhuman assemblies.

Alexander, C. (1964). *Notes on the Synthesis of Form* (Vol. 5). Harvard University Press.

Banathy, B. H. (1991). Systems design of education: A journey to create the future. Educational Technology.

Bauman, C. (1958). Accuracy Considerations for Capital Cost Estimation. *Industrial*

& Engineering Chemistry, *50*(4), 55A-58A.
Bødker, S. (1998). Understanding representation in design. *Human-Computer Interaction*, *13*(2), 107-125.
Brandt, E. (2004). Action research in user-centred product development. AI & SOCIETY, 18(2), 113-133.
De la Rosa, J. (2016), The concept of displacement in prototypes for design research: A proposal of a framework for design research that uses prototypes to investigate possible future scenarios. *Proceedings of 6th STS Italia Conference*. Trento, Italy.
De la Rosa, J. (2017), Prototyping the non-existent as a way to research and innovate: a proposal for a possible framework for design research and innovation. *Proceedings of EAD12 Conference*. Rome, Italy.
De la Rosa, J., Kolher, K. & Reucker S. (2017), Prototyping as a resource to investigate future states of the system. *Proceedings of RSD6 Conference.* Oslo, Norway.
Flood, R. L., & Carson, E. (2013). Dealing with complexity: an introduction to the theory and application of systems science. Springer Science & Business Media.
Galey, A., & Ruecker, S. (2010). How a prototype argues. *Literary and Linguistic Computing*, *25*(4), 405-424.
Gallagher, S. (2010). Merleau-Ponty's phenomenology of perception. *Topoi*, *29*(2), 183-185.
Godin, D., & Zahedi, M. (2014). Aspects of Research through Design: A Literature Review. *Proceedings of DRS*
Frayling, C. (1994). Research in Art and Design (Royal College of Art Research Papers, Vol 1, No 1, 1993/4).
Heidegger, M. (1971). Building dwelling thinking. *Poetry, language, thought*, *154*.
Kumar, V. (2012). 101 design methods: A structured approach for driving innovation in your organization. John Wiley & Sons.
Latour, B. (1990). Technology is society made durable. *The Sociological Review*, *38*(S1), 103-131.
Laour, B. (2010) Offene Objekte. IKKM Jahrestagung 2010 [Online video]. April 29th. Available from: https://vimeo.com/15451465.
Maturana, H. R., & Varela, F. J. (1987). *The tree of knowledge: The biological roots of human understanding*. New Science Library/Shambhala Publications.
Maturana, H. R. (2007). Systemic versus genetic determination.
Merleau-Ponty, M., & Smith, C. (1996). *Phenomenology of perception*. Motilal Banarsidass Publishe.
McConnell, S. (2006). Software estimation: demystifying the black art. Microsoft press.
Muratovski, G. (2015). Research for Designers: A Guide to Methods and Practice. Sage.
Polanyi, M. (1958). Personal Knowledge: Towards a Post-Critical Philosophy. London: Routledge.
Polanyi, M. (1967). The tacit dimension.
Rittel, H. W., & Webber, M. M. (1973). 2.3 planning problems are wicked. *Polity*, *4*, 155-
169. Simon, H. A. (1969). *The sciences of the artificial*. MIT press.
Simondon, G. (1958). Du mode d'existence des objets techniques.
Verganti, R. (2009). Design driven innovation: changing the rules of competition by radically innovating what things mean. Harvard Business Press.
Voros, J. (2003). A generic foresight process framework. *foresight*, *5*(3), 10-21.
Zeigler, B. P., Prähofer, H., & Kim, T. G. (2000). Theory of modeling and simulation:

integrating discrete event and continuous complex dynamic systems. Academic press.

Author Biography

Juan de la Rosa

Juan is a full time Associate Professor of design at the Graphic design department of Universidad Nacional de Colombia, teaching on different areas of design: from illustration to interaction design, and recently design theory and research. He was Director of the Design Department at the same university for four years. Before that, he also taught at Universidad Jorge Tadeo Lozano for more than five years.

His current research is on the values that designer unconsciously embed into the things they design and the possible impact that it can generate on public infrastructure. As part of this research, Juan has been working on the development of design research methodologies based on the use of prototypes as research tools.

He has presented and published in several international conferences regarding design research methodologies and the theoretical bases to support new models. He also co-author the book “Methodologies for the design of social poster in Latin America” with two of the major universities in Colombia.