Design and Its Processes:

A Literature Review Through a Scientific Lens

Nikki An

Simon Fraser University

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The term, *Design,* may take on diverse interpretations depending on the context, purpose and one's mental representation of the word. A fashion designer draws rough sketches to sell attire concepts to executives of a clothing brand; a professional chef organizes his restaurant kitchen to maximize work efficiency; and before a building can be constructed, an architect produces blueprints to strategies structural and functional spaces. Depending on one's experience with any kind of design-related work, an association with a specific practice may influence their perception and understanding of design. It is possible that different design objectives require different techniques of execution to reach a desired result, and perhaps such is the case when an objective requires investigation of numerous distinct factors. Nonetheless, there may be a commonality towards the nature of design and the processes involved. Thus, this paper details readings of the subject from a scientific perspective and lays out some of design's major ideological underpinnings, as well as probable ways in which they can evolve.

In his book, *The Sciences of the Artificial*, Herbert A. Simon (1969), a leading social sciences and philosophical thinker of the early 20th century, describes design as "[aiming to change] existing situations into preferred ones" (p. 111) with the "[concern of] how things ought to be" (p. 114). This definition implies that anyone who strategizes and executes a plan to achieve a goal partakes in some form of design process. Although it appears that any human creation falls under this design description, Simon chooses to explore the concept of design and its processes through a scientific lens with principles from computing and psychology. He does this by focusing on the relationship between an artifact's inner system: its goal, and the outer

system: its environment, and argues that designing any artifact involves connecting the goals of these two factors such that one affects the other (Simon, 1969, p. 6). Simon takes this model from the brain's neural network and compares it to a computer by describing the afferent and efferent systems in terms of input: the taking in of stimuli information from the environment, and output: the motor control of the inner system to act on the environment (Simon, 1969, p. 121). This means a system achieves a goal based on its inner workings to exhibit certain behaviors to manipulate its surroundings, and likewise, the environment influences the system's behavior through stimulation. Thus, Simon emphasizes understanding the workings of a design's interface interaction with the changing environment (Simon, 1969, p. 53), which requires a wider analysis beyond the artifact. For instance, an architect would not only study the form of a building they design, but also its location, and a fashion designer may consider the settings in which their clothes will be worn. This means the design process considers not just the object to be created, but also the environment that the object will interact with. The more factors are involved in a design, the more sophisticated the research and planning process becomes because of the increase in interaction between design components (Simon, 1969, p. 122). Since Simon's description of design implies a goal: a means to an end, the complexity and result of a design will depend on the objective and measure that is set at the start of a project (Simon, 1960, p. 121). This means that consideration to the goals of both artifact and environment, as well as resources available, plays a major role in shaping the outcomes of a design.

W. Brian Arthur (2009), economic and technological theorist, details the conception and evolution of technology in his book, *The Nature of Technology: What it Is and How it Evolves*. Arthur describes the purpose of design as ultimately meeting a need that "proceeds from an

overall concept, to the [details] of the assemblies and parts that will accomplish this, to their manufacture or construction (along with some necessary feedback among these stages)" (p. 91). His insight on technological growth displays a form of design approach to creating and problem solving, and it parallels Simon's definition of design in terms of artificiality and man-made productions that carry a purpose. An example of this production is the water filtration technology that functions to purify water in order to meet human's basic need for clean water: the design ultimately allows water to pass through a membrane but sifts larger solids like sediments. Any design, then, is considered a technology according to Arthur's theory (Arthur, 2009, p. 91), from kitchen utensils to processes of execution like the scientific method (Arthur, 2009, p. 63). More specifically, new technologies are created through the process of combining existing technologies, which Arthur calls innovation (Arthur, 2009, p. 105). The scientific method, for example, fosters the creation of new technologies like medicine. Thus, it is interesting to point out that at the base level, the design process is synonymous with the innovative process. Arthur's other insight that may be central to a design process is the idea that technology is fueled by natural manifestations of energy, which he terms phenomena (Arthur, 2009, p. 22), and that different phenomenons can fuel the same technology (Arthur, 2009, p. 121). For example, gas cars run on gasoline, such that the workings of gas on a vehicle's machinery is the phenomenon fueling the vehicle to move, whereas solar cars run on the sun's heat radiation, so that harnessing the sun's energy propels it. This example reveals technology's distinct ways of fulfilling requirements with the same objective (Arthur, 2009, p. 110). And that overall, a design process involves combining structural components with phenomena, as well as testing and refining them to maximize a technology's efficiency with the sole aim of meeting a need.

Arthur's description of innovation through combining technologies suggests that creativity can take on a logical and step-by-step approach. Stanford University's d.School developed a design course for engineering students called, ambidextrous thinking, which values "the creative act" as "[involving] combining pre-existing ideas" (Faste, 1994) to form new ones. The course aims at teaching creative techniques in visualization to encourage viewing problems from different perspectives. These techniques include mind-mapping, diagramming and storyboarding (Faste, 1994). The idea of using these techniques to innovate parallels Simon's design theory of problem solving, which he describes as "representing [a problem] so as to make the solution transparent" (Simon, 2969, p. 132). In other words, visualization techniques, like mind-mapping, display drawn relationships in such a way that helps the mind reorganize and retain information to better support the problem solving process. Thus, a major part of the design process involves drawing to communicate because ideas are outputted as illustrations which can then be used as references of communication among designers and stakeholders.

Another creative technique encouraged in the course is need-finding, which encompasses the notion of empathy for human interests. According to Donald Norman ("Rethinking Design Thinking," n.d., para. 9), leading design author and professor of cognitive engineering, empathy in design approaches understanding users of systems and products through observation, which is key to constructing technologies that cater to their goals and needs. This view is influenced by humanism, which is an Ancient Greece philosophical view that champions the "rights and responsibilities" of individuals "to shape their own lives" ("Humanism," n.d.). In a way, the concept of empathy parallels Simon's argument that a successful design is one where an inner system matches its outer system (Simon, 1969, p. 6), so recognizing a user's goals equates to

understanding their inner system, which in turn aids the designing of the outer system: the service or product of interaction. This is the core value of the design methodology, User Centered Design (UCD) or Human Centered Design (HCD), that aims to consider user needs and emotions at every design decision mark ("Rethinking Design Thinking," n.d.).

HCD is a modern design methodology that is advocated by leading design thinkers, like Norman, and practiced by top design teams, like IDEO, a design consulting firm that approaches innovation with a business, psychology and engineering mindset. It is important to remind readers that according to Arthur, HCD is considered a method technology because it is synthesized to help create new technologies more efficiently. The design team at the U.S. Department of Veteran Affairs (VA), a government organization that provides federal benefits to veterans, studied the efficacy of the HCD approach in enhancing their products and services for veterans. In their report, *Toward a Veteran-Centered VA: Piloting Tools of Human-Centered Design for America's Vets* (2014), anthropological research methods like contextual inquiry were used to envision main user adoptions. As a result, the VA design team found that creating visualizations, such as customer journey maps and personas, allowed them to better identify pain points in their services, as well as veteran needs and desires (p. 5). These methods ultimately gave them insight on how to tackle the right problems and improve their services, including reduction of medical expenses or follow-ups with veterans after a service to ensure their sense of value (p. 17). Their design approach breaks down into three major steps with the first being the focus of their report: discover, design and develop (p. 3). In the discovery stage, the VA design team learned that most veterans wanted to feel more in control of their health care options (p.

17). The team was then able to focus on this specific issue through investigation of research questions that either reinforced their suspicions or falsified their assumptions (p. 2).

In his book, *The Reflective Practitioner: How Professionals Think in Action*, Donald A. Schön (1983), a philosopher and pioneer of the reflective practice, distinguishes practitioners from researchers by defining practitioners as "professionals in the labor force" (p. 7), and researchers as those engaged in basic and applied sciences (p. 26). He stresses the importance of knowledge through research that practitioners can glean from to make informed decisions in their work (Schön, p. 26). One such example may involve designers of a virtual reality system who encounter a question regarding human balance pertaining to walking with a headset, and so researchers studying vestibular perception may offer results from their scientific inquiry on the biological components of the human perceptual system that commands a sense of balance (Rosenzweig, 2015). The designers can then assess how they want to apply the research findings to their design, and so the interchange between research and practical application allows design decisions to be formed with carefully gathered evidence based on scientific rigor, which makes research a key aspect of the design process.

It is intriguing how design perspectives have developed from the focus on technological functions to users of these technologies. What is more interesting is that design endeavors may become more challenging as factors increase, particularly factors that extend beyond a product and its intended users. Kevin Slavin (2016), entrepreneur and professor at Massachusetts Institute of Technology (MIT), writes in his article, *Design as Participation*, on the limitations of HCD. Slavin sees designing technologies around users as narrow-sighted because it considers only users' interests and not the goals of other systems that may be affected (para. 15). He

describes this chain of connected events as an ecosystem and highlights one domino effect example: Amazon's e-commerce solution and its detrimental influence on smaller bookstore businesses (para. 14). He argues that because Amazon's design focuses solely on their users, they do not see how their direct solution contributes to change outside their functions. From a business perspective, outperforming the opponent may be the objective, but from a social perspective, taking away a personalized in-store experience also changes the way a business runs and how customers perceive and interact with a brand.

John Wood (2012), a professor of design at the University of London, urges designers to look beyond innovating systems around immediate user wants and needs in his article, *Why User-Centered Design is Not Enough*. Like Slavin, Wood believes that a design should focus on the larger picture, and he explains: "This means rethinking everything, including the way humans feed, clothe, shelter, assemble, communicate and live together. It means designing at the level of behaviors, habits, beliefs and language. In short, it entails re-designing design itself" (Wood, 2012, para. 10). It appears that Wood is calling for a redefine of the needs that technologies are created to meet. As well, perhaps his view on design reveals what it means to design when supporting elemental human needs is the goal. This would require defining human needs and questioning of the artifacts used and produced on a daily basis. Material possessions may add some kind of value, but it is important to question whether they also take away from life's absolute necessities. Nonetheless, analyzing the implications of technology and the philosophy of life is beyond the scope of this paper. It is interesting, however, to speculate a strong correlation between design methodologies and the current state of society that is very much defined by technology (Arthur, 2009, p. 11) because the way designers approach a solution

reveals the kinds of problems they try to solve or assumptions they make about a technology's potential to enhance lifestyle. Thus the goals of a design can be traced down to underlying factors like human nature and their collective behavior.

In response to Wood, one approach to rethinking design from the current HCD approach is the idea of designs that automatically adapt to changing environments. Joichi To (2016), entrepreneur and director of the MIT Media Lab, supports the concept of design as participation versus the control of a system as elaborated in his article, *Design and Science*. He believes that designers will be faced with greater design challenges as social systems become more complex: "too many designers work for companies or governments developing products and systems focused primarily on making sure that society works efficiently" but the problem is that "the scope of these efforts are not designed to include–nor are they designed to care about–systems beyond [the] corporate or governmental needs" (To, 2016, para. 18). For instance, in a study on the effects of mobile phone use on prosocial behavior by Anastasiya Pocheptsova (2014), results revealed that mobile phone use and prosocial behavior were negatively correlated (p. 12). In other words, participants who used their phones more were less concerned about helping others both in attitude and action. The study shows how the use of mobile phones can influence an individual's behavior, or lack thereof, which consequently influences their social circle. Thus, To's argument about designing for a larger system is what makes design more challenging because it requires looking way beyond the user and their goals. It may also require increased participation between corporations, the government and other organizations in a community.

Slavin also mentions an example to To's point on design as participation: the Fun Palace (1961), an adaptive house concept by Cedric Price that changes on interaction with residents,

where the "essential role for its designer [is] to create a context for participation" (Slavin, 2016, para. 27). The difference between this design approach versus a functionality or HCD approach is that a designer designs "not for the uses he [wishes] to see, but for all the uses he [can not] imagine" (Slavin, 2016, para. 28). One way to view this method of design is its ability to support the changing behavior-environment dynamic rather than usurp or manipulate it. Although Wood thinks that focusing on users exalts them because they are given too much power in determining the fate of a design (Wood, 2012, para. 4), there may be a healthy level of knowing when to listen to users and when to base decisions on tested knowledge, particularly those from scientific research. Additionally, it may also be essential to consider whether HCD should be completely disregarded as practice that disrupts the social ecosystem or practice that could naturally integrate itself within the design scope of the larger social system because ultimate, individuals have varying needs, goals and perceptions. On the other hand, it may also be possible that by meeting the needs of the larger system, the needs of the individuals are also met, such that solving an overarching problem automatically solves its subproblems.

According to Arthur's theory on technology of innovation through combination, it can be deduced that the amount of technologies naturally increases with time, and perhaps this increase makes modern design even more challenging because not only are there numerous components available to consider, trying to account for exponential variables does not seem sustainable. The existing economic and social structure also makes the current design approach seem inevitable to flip completely, even for radical design thinkers like Slavin and Wood, who are eager to see design as participation come to fruition. Nonetheless, technological progression in history seemed to have developed naturally along with social changes and scientific advancements, so

perhaps changes to the current preferred User Centered Design methodology is not as imminent as it appears. Technology has grown rapidly throughout history: from the rise and fall of the iron age, to the discovery of concrete by the Roman Empire which created more technologies like roads and bridges, and the use of steam during the Industrial Revolution to power trains that changed the mode of transportation. Likewise, HCD can be traced from humanism (Wood, 2016, para. 3) and the result of the capitalistic business model, so perhaps this design methodology will also progress naturally along with social and technological changes.

As I progressed through my readings, the terms *Technology*, *Design* and *Innovation*, began to carry more meaning to me. At the same time, they appeared more synonymous because of their similar characterizations of the concept of creation and forward progression with use of current resources. I would like to explore design method terminologies I came across in the readings, including *Participatory design* and *Service design*, which are rooted in sociology and ethnography ("Toward A Veteran Centered VA", 2014). Further readings on design as participation proposed by Slavin would help to cement my understanding of its application in current practices. Other areas of opportunity for further exploration on aspects of design includes teamwork, since the design process often engages a group of people to accomplish a goal. Readings in social psychology and teamwork dynamics can contribute to this additional investigation. In conjunction with my readings on design and technology, my studies in Behavioral Neuroscience contributed greatly to my understanding of Simon's input/output model of computers. This was the most profound moment of enlightenment I had as I better understood the impact that the relationship between the human brain and the computer has had in the development of technology. Just as a windmill is able to harness wind energy and convert it to

electrical energy, the human body can take a sound stimulus and convert it to electrical energy via neurons that travel to the brain where information gets interpreted. This connection reveals the powerful synergy between science and technology, and the possibilities of growth for both that comes about from research and experimentation. Furthermore, I am learning that design is not a secluded practice because it intersects every aspect of life: from psychological units of analysis of an individual's perception, to socio-economics and relationships within communities and cultures. Although the readings were initially conceptually challenging to grasp, understanding the terminologies and design approaches from a scientific perspective gives me deeper appreciation for the work that designers do to plan and execute concepts. As well, these newly gained insights encourage me to be more intentional in observing the world around me and to question ideas and occurrences even when it seems easy to simply accept them as truths. Eliminating false assumptions that my mind may form or testing propositions stated by others is the approach I want to take as I grow in my academic and professional development.

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