The Science of Design and the Design of *The Sciences of the Artificial*

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Herbert Simon's seminal book, *The Sciences of the Artificial* (1969), stands as one of the most influential texts in the 50-year evolution of design theory. Simon's vision of establishing a science of design positioned the book as a foundational reference for subsequent academic writing and encouraged the emergence and development of design thinking.

Following Simon's Vision of Establishing a Science of Design

Over the past half of the 20th century, the three editions of *The Sciences of the Artificial* (1969, 1981, 1996) encouraged many scholars to explore the possibility of developing systematic and formalised design methodologies across various fields, such as architecture (Schön, 1988), public policy (Jones, 2002), and computer sciences (Kruchten, 2004). Among design professionals, particularly those in engineering, Simon's ideas have inspired the work of scholars like Dym (1994) and Adams, Turns, and Atman (2003), who have contributed to establishing scientific design methodologies in their fields. Their success is not surprising, considering that engineering, as a discipline, is characterised by a high degree of prescriptive knowledge (Pandza & Thorpe, 2010), in which objectivity is moderately attainable in practice (Cross, 2001). These explorations in engineering have helped to shape a research paradigm that frames design as a scientific activity (Cross, 2001).

Furthermore, Simon emphasizes the routine practices of engineers in designing technical artefacts. This focus has inspired management scholars to explore the concept of a design science to find an answer for the enduring debate about management studies' relevance to practice (Hatchuel, 2001). As Pandza and Thorpe (2010) point out, some management scholars –such as Tsang and Kwan (1999), Romme (2003) and Van Aken (2005)– have proposed ways to link science and design by redefining research hypotheses as design propositions or technological rules, which can be tested in real–world settings through replication methods– like how engineers traditionally solve problems. Similar ideas are also popular among design thinking scholars, particularly those with a background in management education. For instance, Martin (2009), who introduced the "knowledge funnel" model, claims that design thinking is an ongoing cycle of generating ideas, predicting outcomes, testing, and generalizing.

The Prominent Criticisms of Simon's Epistemological Views of Establishing a Science of Design

Since the 1970s, professional designers in other design-relevant disciplines, such as architects (e.g., Alexander, 1971), have rejected the idea of grounding design in positivism and technical rationality as its foundational epistemology. Some engineering designers, like Jones (1977), also aligned with this view. They became pragmatists and borrowed John Dewey's concepts of reflexivity, intentional operations, and the interplay between science, art, and practice.

Their main argument, inspired by Rittel and Webber (1973), is that scientific design methods developed for addressing "tame" problems have proven inadequate when dealing with real-world "wicked problems," such as those found in social policy. This argument has been enriched by several design scholars, including Archer (1979), Cross (1982), and Rowe (1987), some of whom explicitly challenge Simon's epistemological view on design in *The Sciences of the Artificial.*

One of the most distinguished scholars among them is Schön (1983), whose theory of "reflection-in-practice" is often juxtaposed with Simon's "rational problem solving" approach (Dorst & Dijkhuis, 1995). Schön argues that the technical rationality perspective sees professional practice as a process of problem-solving, but ignores problem-setting process by which the designer defines the decision to be made, the means to be employed, and the goals to be achieved. He also points out that, in real-world practice, problems do not present themselves to practitioners as given, and must be constructed from puzzling, troubling, and uncertain problem situations.

Finally, Schön introduces his theory of reflection-in-action, which highlights a designer's specific capability for reflection-in-action, featuring a willingness to frame new questions and new ends in the midst of design. He writes, "let us search, instead, for an epistemology of practice implicit in the artistic, intuitive processes which some practitioners do bring to situations of uncertainty, instability, uniqueness, and value conflict" (Schön, 1983, p. 49).

Another significant scholar is Buchanan (1992), author of "Wicked Problems in Design Thinking" (1992). He suggests understanding design as a liberal art and an integrative discipline that merges theory and practice for new productive purposes. Buchanan holds that "the significance of seeking a scientific basis for design [...] lies in a concern to connect and integrate useful knowledge from the arts and sciences alike, but in ways that are suited to the problems and purposes of the present" (Buchanan, 1992, p. 6).

As a pragmatist following Dewey's thought, Buchanan affirms Simon's contribution to the early understanding of design disciplines in the contemporary world. However, he criticised Simon's positivist and empiricist views, arguing that they limited his ability to fully grasp the radical sense of how designers explore the meaning of the artificial in human experience. Buchanan (1992, p. 6) suggests that "designers are exploring concrete integrations of knowledge that will combine theory with practice for new productive purposes, and this is the reason why we turn to design thinking for insight into the new liberal arts of technological culture".

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Cross (2001) is another influential design scholar who explicitly questioned Simon's underlying epistemology of positivism and technical rationality. Much as Buchanan does, he agrees with Simon's proposal for developing a science of design as a fundamental common ground for interdisciplinary study aimed at creating an artificial world. He also points out that there are forms of knowledge special to the awareness and ability of a designer –what he refers to as "designerly ways of knowing"– that are independent of the various professional domains of design practice. Then, building on Schön's theory of reflection-in-action, Cross advocates for "a science of design based on the reflective practice of design: design as a discipline, but not design as a science" (Cross, 2001, p. 54), meaning design studied on its own terms and within its own rigorous cultural framework.

These scholars' contributions have established a new research paradigm in design studies: design activities as the subject of scientific investigation (Cross, 2001). This paradigm has also become a foundation for research in design thinking, in which pragmatism serves as a conceptual framework (Dalsgaard, 2014). Consequently, Simon's book is often regarded as one of the starting points for design thinking. The critiques offered by these scholars are directed at the first edition (1969) of *The Sciences of the Artificial*, and from this perspective, they are, indeed, fair and objective evaluations.

Some Academic Voices Supporting Simon's Epistemological Position

Several design researchers –like Lloyd, Lawson, and Scott (1995), and Kimbell (2011)– have noted that Simon advanced his account of problem-solving by including ill-defined and ill-structured problems, which resemble wicked problems, in his later works, starting in 1972: *Human Problem Solving* (Newell & Simon, 1972), "The Structure of Ill Structured Problems" (Simon, 1973), and the second and the third editions of *The Sciences of the Artificial*.

Some of those scholars –Coyne (2005), Dorst (2004), Hatchuel (2001) and Lloyd *et al.* (1995)– maintained their impression of Simon as a technocratic designer. They argue that Simon (1981) conceptualized problem-solving tasks –an example is the making of discoveries– as composed of the same repertoire of heuristics used to solve well-structured problems. However, it is noteworthy that, in the later editions of *The Sciences of the Artificial,* Simon's understanding of design evolved in many other aspects, which could alter their impression of him. In fact, based on these changes, some academic voices have emerged against the critiques of Simon's epistemological views.

For instance, Restrepo and Christiaans (2004) argue that Simon's problem-structuring for ill-defined or ill-structured problems involves drawing upon knowledge or searching for external information that may contribute to the construction of the problem space. As they note, this process is not fundamentally different from what is described in the paradigm of design as a reflective practice initiated by Schön.

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Meng (2009) holds a similar view with Restrepo and Christiaans. Upon revisiting all three editions *The Sciences of the Artificial,* Meng found that Schön overlooked Simon's description of the limitation of human rationality, or "bounded rationality", that challenges people's wish to optimise, his suggestion to the designer to "satisfice" as an alternative, and his openness to the contributions of our intuitive faculties.

Another design scholar, Huppatz (2015), observed that Simon left a small opening in the second edition of his book for social involvement and creativity in the new chapter "Social Planning: Designing the Evolving Artifact". Additionally, Simon stated that his aim in social planning was "to leave the next generation of decision makers with a better body of knowledge and a greater capacity for experience. The aim here is to enable them not just to evaluate alternatives better but especially to experience the world in more and richer ways" (Simon, 1996, pp. 163-164). Huppatz conteds that "Simon's [*The*] *Sciences of the Artificial* confirms a shift away from his technocratic designer ideal to an acknowledgement of design's ethical foundation" (Huppatz, 2015, p. 40).

These compelling academic voices are insightful, because many design scholars –such as Harrison, Back, and Tatar (2006), Hassi and Laakso (2011) and Johansson-Sköldberg, Woodilla, and Çetinkaya (2013)– influenced by the mainstream view of Simon as a technocratic designer, have underestimated the significance of *The Sciences of the Artificial*, especially the revised editions. Moreover, some scholars –Bayazit (2004), Dorst (2004) and Hatchuel (2001)– have cited different editions of Simon's book in their works. This allows the misleading information concerning Simon and his ideas to continue to spread. However, this situation has not been recognised by most of the design scholars. Re-evaluating the latest edition of The Sciences of the Artificial and reassessing its significance for design research should be put on the list of research priorities in the future years, especially considering that design theory has been progressing amidst a degree of ambiguity about Simon's contributions. Notably, the revisions Simon introduced in the later editions are particularly valuable for researchers who intend to establish a "science of design", and reflect on the concept of design thinking, which has been fiercely criticised in recent years among design scholars such as Norman (2010) and Nussbaum (2011).

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