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Knowledge Paths in Design Science Research

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Knowledge Paths in Design Science Research

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ABSTRACT

Ralph Waldo Emerson brilliantly said, "Life is a journey, not a destination." As researchers, we travel on paths of knowledge throughout life. The outcomes of rigorous scientific investigation are contributions of new knowledge to the world. By integrating the conceptual and methodological advice of extant design science research (DSR) publications, this review provides a comprehensive framework for understanding the roles of knowledge in DSR journeys. We position DSR at the intersection of science and technology where the interplay of descriptive and prescriptive knowledge is most active. We delineate the various forms of prescriptive design knowledge and we examine the knowledge paths that utilize and produce the varied forms of knowledge in a DSR project. Six knowledge paths describe how knowledge is manipulated in different ways to grow new design knowledge (e.g., artifacts, design theories). We apply this framework to define, analyze, and expand the ideas of knowledge gaps and knowledge journeys. We further argue that more attention to design postulates (e.g., design principles, design features) in DSR along the outlined knowledge paths can contribute

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to an increase in actionable and sustainably useful and impactful digital innovations within the information systems (IS) discipline.

Keywords: design science research; design knowledge; knowledge paths; knowledge journeys; design entities; design postulates; knowledge bases; knowledge gaps; knowledge contributions

1

Knowledge at the Intersection of Science and Technology

> Science owes more to the steam engine than the steam engine owes to science.
>
> Lawrence Joseph Henderson, The Order of Nature (1917)

The Information Systems (IS) discipline is particularly suited for contributing to digital innovations and the corresponding knowledge growth that scientific innovation provides (Grover and Lyytinen, 2015; Hevner and Gregor, 2020; Yoo *et al.*, 2010). IS research develops not only knowledge in the form of understanding and designing digital technologies but also the implementation and use of actual socio-technical systems in organizations and society (Galliers, 2003; Hevner *et al.*, 2019; Nunamaker and Briggs, 2011; Sarker *et al.*, 2019).

There are two major genres of inquiry in the IS discipline that contribute to knowledge growth in the IS discipline (Baskerville *et al.*, 2015; Gregor and Hevner, 2013; Seidel and Watson, 2020): science-oriented research activities that grow descriptive knowledge or Ω-knowledge (comprising propositional and explanatory knowledge), and design-oriented research activities that grow prescriptive knowledge or Λ-knowledge. Contributions to Ω enhance our understanding of the world and the phenomena our technologies harness (or cause). Contributions to Λ

comprise knowledge about technological innovations that are or can be useful for individuals, organizations, or society – and also to the development of future technological innovations. Research projects may combine both genres of inquiry and contribute to both knowledge bases.

Technology harnesses phenomena – which could be natural, behavioral, mathematical, or logical – for a particular purpose (Arthur, 2009). Ω-knowledge concerns the existence and the nature of such phenomena and is therefore an important prerequisite for technological inventions and innovations – and thus contributions to Λ-knowledge – beyond trial-and-error. In turn, technological innovations may enable entirely new phenomena to occur. Figure 1.1 illustrates the evolutionary exchanges between the objectives and activities of science and technology and the positioning of design science research (DSR) in the interplay between the two.

The goals of science are to grow the descriptive knowledge bases of the natural world and human behavior through the application of the scientific method. The goals of technology are to grow the prescriptive knowledge bases of purposefully designed artifacts to improve human capabilities both physically (e.g., tool use) and mentally (e.g., decision-making). As both science and technology advance and evolve, they display a complex set of interactions and relationships. New technologies are driven and enabled by science, but, more often, scientific advances are driven and enabled by the emerging uses of technology.

(1) The evolution of science is slow and is marked by gradual paradigmatic shifts (Kuhn, 2012). Growth of scientific knowledge is driven by the scientific method via the development of relevant research questions, careful experimentation, the collection of empirical evidence, and rigorous hypothesis testing.

(2) Science informs technology via rigorous grounding in the application domains' descriptive knowledge bases and theories. The search for feasible solutions is constrained by the laws of nature and applicable kernel theories in the appropriate fields of application.

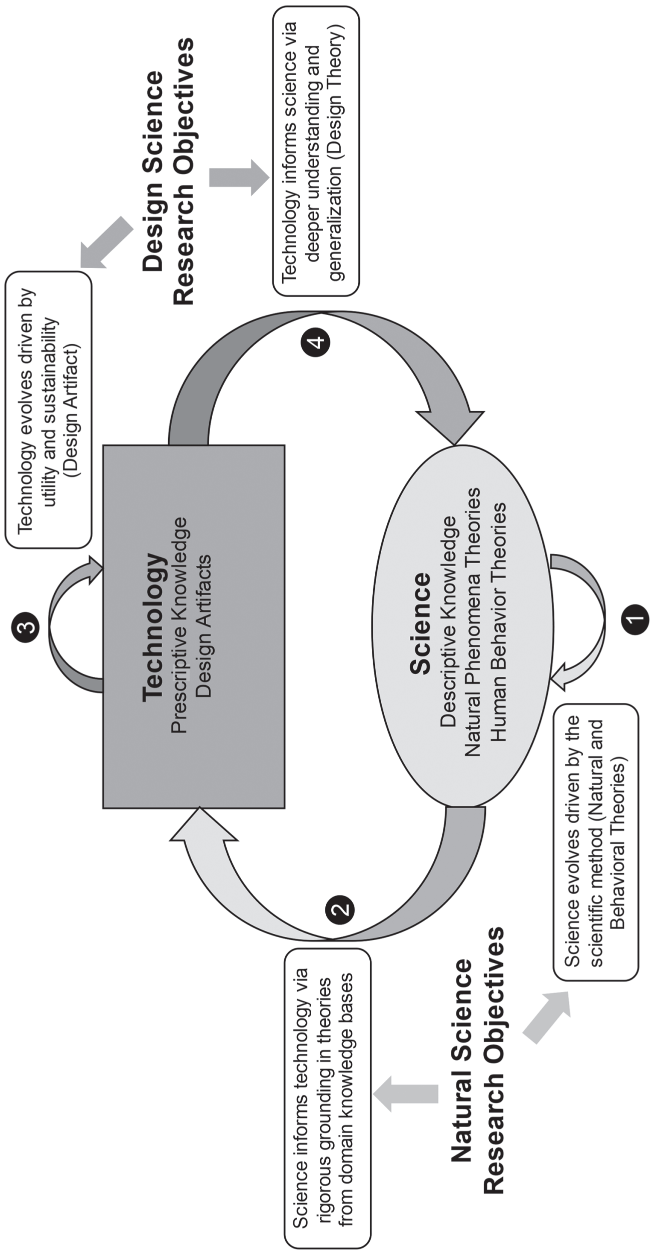

Figure 1.1: Technology and science interplay.

(3) The evolution of technology can be very rapid and is marked by pervasive artifact improvements across all human fields of endeavor (Arthur, 2009). Technology innovations are driven by the goals of enhancing human experiences, maximizing economic utilities, and building sustainable environments (Gill and Hevner, 2013).

(4) Technology informs science via an emerging understanding of why human-built artifacts succeed or fail to achieve their intended goals in a domain problem space. Mid-range design theories grow to capture this evolving knowledge from specific uses (idiographic) to more general applications (nomothetic) (Baskerville *et al.*, 2015).

For example, historically, the invention and adoption of mechanized cotton spinning machinery was followed by the building of factories and then subsequently by novel organizational and social technologies that comprised means how to staff and manage these factories, to include worker unions and legislation to regulate factory working conditions. A modern-day equivalent would be social media practice and theory which would not exist without the social media technology. These new phenomena require further investigations (contributing to Ω-knowledge) to fully understand them and, potentially, to develop subsequent innovations on how to manage or even enhance them (contributing to Λ-knowledge). These examples point towards a continuous cycle of growing Ω and Λ-knowledge until both our understanding and our options for action have become sufficiently refined, or the phenomenon itself has become irrelevant.

In this review, we integrate the current thinking in the DSR literature around the conceptual and methodological foundations of these high-level topics into a conceptual knowledge path framework. With this framework, we aim to guide and inspire design-oriented IS researchers to actively and deliberately consider and incorporate a greater variety of existing knowledge into their designs, reflect even more thoroughly and systematically on their knowledge usage and contributions, and explicate and document these reflections in their publications.

We structure the remainder of the review as follows. Section 2 provides a description of the DSR project as a foundation for its interplay with the Ω and Λ knowledge bases. In the next two sections, we introduce our conceptual design knowledge framework and its knowledge paths that relate the multiple forms of knowledge. We then further use the framework to define and study the ideas of knowledge gaps and knowledge journeys. Finally, we discuss the implications of our synthesis for DSR researchers to enhance their research practices and propose future research directions.

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