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Special Issue Editorial: Introduction to Design Science Education

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Special Issue Editorial
Introduction to Design Science Education

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ABSTRACT

We propose conceptualizing design science education in the information systems (IS) discipline. While design science has become a robust research paradigm, well-recognized in solving practical problems, how design science should be taught is a question that IS scholars, academia, and practitioners are only now addressing. We do so by considering design science education as a pedagogical tool that engages IS students in design knowledge creation and authentic learning. We conceptualize design science education as three intersections: research-education, research-practice, and education-practice. We further use this conceptualization to introduce six new studies in design science education.

Keywords: Design science, Design science education, Information systems (IS), IS education

1. INTRODUCTION

Design Science (DS) has gained popularity in the Information Systems (IS) discipline as a research paradigm that seeks to create new and innovative IS artifacts (Hevner et al., 2004). A variety of DS methodologies and processes have been suggested to apply DS in a variety of research scenarios, including action design research (Mullarkey & Hevner, 2019; Sein et al., 2011), agile approaches (Conboy et al., 2015), practice-initiated and research-initiated problem-solving (Goldkuhl & Sjöström, 2018; Peffers et al., 2007; Rohde et al., 2017), improving human organizations (Baskerville et al., 2009), and technology development (Wieringa & Moralı, 2012). The variety of viewpoints notwithstanding, a defining aspect of DS is that it involves three main activities: 1) abstraction of socio-technical problems, 2) exploration of design possibilities, and 3) generalization of IS artifact solutions. As the complexity of socio-technical problems in organizations has risen, DS has been increasingly applied to develop novel IS artifacts to address a variety of identified organizational problems (Antunes et al., 2021; Hevner et al., 2004; vom Brocke et al., 2020).

Most DS literature has been created in the research landscape, and its importance for pedagogy and practice has yet to be consolidated. To fully realize the potential of the DS body of knowledge for practice, it must be embedded in pedagogy so that graduates can seamlessly carry DS knowledge into their practice. This special issue takes steps to address that necessity. The relevance for practice arises from three primary sources. First, the main objective of DS is to generate workable IS artifacts. As put by Nunamaker et al. (1990), DS contributions are expected to have "wide-ranging applicability" (p. 92), serving as a proof-of-concept, demonstrating feasibility, practical application, and fostering technology transfer. Second, DS is committed to real-world problems. As noted by Hevner et al. (2004), the IS artifacts generated by DS are "intended to solve identified organizational problems" (p. 77). The organizational environment provides the problem space "in which reside the phenomena of interest" for the DS research (Hevner et al., 2004, p. 79). Finally, another critical reason for grounding DS in practice is that DS generates prescriptive knowledge. As noted by Walls et al. (1992), DS "can never involve pure explanation or prediction" (p. 41). Instead, DS integrates prescriptive and normative aspects, which describe how an IS artifact can be created and put to practical use. Because of its nature and purpose, DS has been established as a rigorous and relevant approach for engaging researchers and practitioners to solve real-world problems.

The adequate balance between research and practice has significant implications for IS education, in which DS can and should play an essential role in learning and teaching. The critical role of DS in education can be traced back to the seminal work by Simon (1996), who noted that "design, so construed, is the core of all professional training [education]" (p. 111) and "the proper study of [hu]mankind is the science of design, not only as the professional component of a technical education but as a core discipline for every liberally educated person" (p. 137). Multiple academics and educators have recently re-emphasized this importance in the IS discipline (Goldkuhl et al., 2017; Hevner, 2021; Thuan & Antunes, 2022).

We further identify two other vital roles of DS education. The first links with research in which DS education can facilitate the creation of capabilities for master and doctoral studies (Herselman & Botha, 2020; Knauss, 2021; Pérez Contell, 2020). In particular, DS education can be applied to guide postgraduate and Ph.D. research (Herselman & Botha, 2020; Hevner, 2021). The second role links with the practice in which teaching DS education can prepare students for professional work (Goldkuhl et al., 2017; Thuan & Antunes, 2022; Winter & vom Brocke, 2021). Goldkuhl et al. (2017) relate DS research and practice with IS education. The authors note that the primary purpose of IS education is to prepare students for professional work, which comprises reading pertinent academic literature and learning by doing. These two capabilities can vary according to educational level (Figure 1). Undergraduate studies are expected to focus more on practice (applying foundational knowledge and practical skills). In contrast, postgraduate studies are expected to focus more on research (involving advanced knowledge and critical thinking). As such, the links between research, practice, and education are established within a continuum in which different mixes of research/practice are distilled under different educational foci.

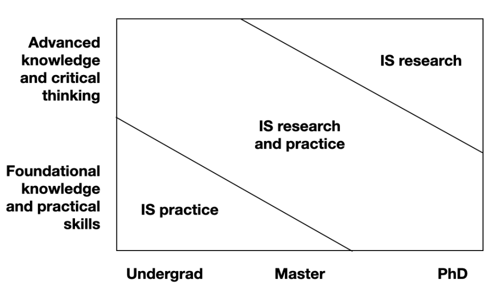

Figure 1. The Balance between Research and Practice in IS Education (adapted from Goldkuhl et al., 2017)

We are particularly interested in DS education within the scope of IS education. As noted above, the educational focus can range between foundational knowledge, in which students acquire skills about the design, development, and evaluation of IS artifacts (Goldkuhl et al., 2017; Thuan & Antunes, 2022; Winter & vom Brocke, 2021); and advanced knowledge, in which students acquire reflective and methodological capabilities for the conceptualization and theorization of IS artifacts (Herselman & Botha, 2020; Knauss, 2021; Pérez Contell, 2020). IS professionals are expected to acquire and develop knowledge to design and realize various IS initiatives (Carlsson et al., 2011). Notably, the pace of technological change means that acquiring technical knowledge and experience alone will often be insufficient for effective technology practice. DS-based competencies, such as abstracting problems, exploring possibilities, and generalizing solutions, will also be required. Beyond our immediate focus on IS education, we should note that DS education can be relevant in other professional areas, including the engineering field (Carstensen & Bernhard, 2019; Knauss, 2021) and the management field (Keskin & Romme, 2020).

We should also acknowledge that DS competes with other "designerly ways of knowing" (Cross, 1982) developed in domains other than IS. In particular, we account for design thinking and the science of design. Design thinking has been conceptualized across multiple disciplines, including management, design, architecture, and engineering (Johansson-Sköldberg et al., 2013). Design thinking concerns "a way of finding human needs and creating new solutions using the tools and mindsets of design practitioners" (Kelley & Kelley, 2013, p. 24). The science of design concerns the study of the practice of design (Cross, 1982). All these discourse streams are relevant to understanding design. They also have rich intersections. However, DS stands out as technology-oriented (March & Smith, 1995). This characteristic enables us to distinguish DS education from other design-related educational foci. In particular, DS education focuses on teaching and learning how to find socio-technical solutions for organizations based on IS artifacts and asking questions about how the artifact performs.

This special issue gathers scholars' and educators' perspectives regarding DS education, encompassing its inherent relationships with research and practice. We consider DS education for two aims: 1) focusing on knowledge and skills, teaching students how to do DS that creates IS artifacts that solve organizational problems; and 2) focusing on reflective and methodological capabilities, teaching students how to conceptualize and theorize about IS artifacts. It seeks to explore Schön's (1992) remark that "there is a great potential for learning through design" (p. 131) while simultaneously bringing to the fore vital characteristics and critical thoughts on DS research, education, and practice.

2. DESIGN SCIENCE EDUCATION FRAMEWORK

We propose a simple DS education framework highlighting the relationships between DS research, education, and practice, to position the perspectives presented in this special issue. We understand DS education as existing at the intersection of three domains: 1) the DS research domain, which essentially concerns knowledge, along with paradigmatic, ontological, theoretical, and methodological principles associated with the creation of new and innovative IS artifacts; 2) the DS practice domain, which concerns the relevance, application, and usage of DS methods and outputs for addressing practical problems; and 3) the DS educational domain, which concerns the acquisition of knowledge and development of DS skills by doctoral, master, and undergraduate students. Figure 2 shows the three domains and their intersections.

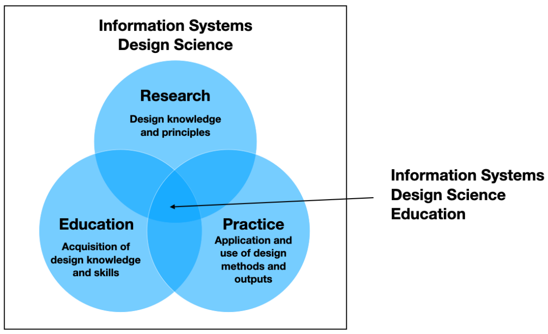

Figure 2. DS Education Framework

Next, we use this framework to further discuss DS education at the intersections of the three identified domains.

2.1 Intersection Research-Education

From the authors' experience, programs in tertiary institutions have embraced significant knowledge for IS students, including agile methods, big data analytics, and multiple applications of artificial intelligence (Lyytinen et al., 2023). What contribution to learning remains to be made by DS education? In a partial answer to this question, we note that a recent literature review on the limitations of agile methods (Shameem et al., 2020) focuses on a wide range of factors, including human resource management, technology, project management, coordination, and software methodology. None of the sources cited observed solving the wrong problem (an error made before the beginning of the artifact design) or inadequate evaluation (failure to capture insights after construction and implementation) as possible limitations.

We argue that DS knowledge needs to be integrated into learning because it extends the boundaries of relevant knowledge at the beginning and end of the artifact design life cycle (Figure 3). In particular, DS education teaches the importance of relevant contextual and theoretical knowledge as an input to design along with rigorous evaluation and identification of the knowledge contribution as an outcome (e.g., Drechsler & Hevner, 2022; Sonnenberg & vom Brocke, 2012). We do not claim that existing methods ignore these steps entirely. However, we focus here on the particular contribution of DS education to these stages. DS education at all levels (e.g., doctoral, master, and undergraduate levels) must contribute to thinking more broadly about the artifact design life cycle. It involves a socio-technical process of applying knowledge of multiple types to inform the artifact design, and using rigorous methods to contribute to knowledge following the artifact evaluation.

Design science should be informed by solid theoretical background. This does not automatically mean that DS projects are research focused. In pre-design, we must teach that artifact construction does not happen in a vacuum or even within the confines of a burn-down chart (Beck et al., 2001). We should encourage students to broadly view what constitutes relevant knowledge informing design. DS research scholars have advocated for rich contextual knowledge of people, systems, and technology (zur Heiden, 2020) and relevant conceptual knowledge, including theories, models, concepts, constructs, conceptual frameworks, classifications, and taxonomies (Akoka et al., 2017; Thuan et al., 2019).

DS tells us that post-design (at a minimum) should be characterized by rigorous evaluation and identification of contributions to knowledge. This is much broader than "software testing" or the "fail fast" view of design thinking approaches. In DS education, we must encourage students to approach evaluation as a highly iterative process. We teach students that cycles of rigorous evaluation can begin at the conceptual stage, even before the artifact properly takes shape. Theory-based evaluation, which asks questions like "is there a need for this artifact?", "what is the evidence of need?", and "how can we tell when the design goals are achieved?' ensures that the development is clearly relevant and rigorous. Further rigorous evaluation continues throughout the DS life-cycle, including ex-ante evaluation of the concept, evaluation of the design specification, evaluation of the artifact in an artificial setting, and evaluation of the artifact in a naturalistic setting (Sonnenberg & vom Brocke, 2012). Depending on the level of education and the nature of the design artifact, we can teach students different evaluation methods, including logical argument, literature analysis, focus groups, surveys, experiments, case studies, simulations, action research, and field research (Peffers et al., 2012; Sonnenberg & vom Brocke, 2012; Venable et al., 2016).

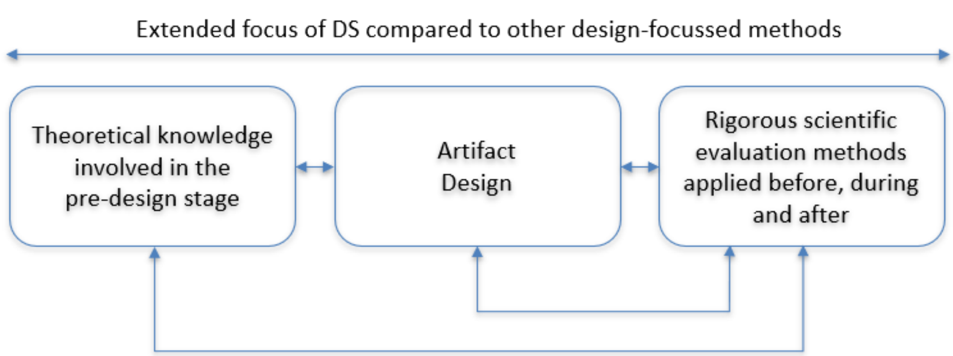

Figure 3. Artifact Design Life Cycle

Overall, introducing DS education in IS programs encourages a broad view of designed artifacts as socio-technical systems informed by a broad knowledge base and rigorous evaluation.

2.2 Intersection Research-Practice

DS needs an adequate balance between research and practice, but it seems impossible to specify how that should be achieved. Baskerville et al. (2018) note that the newness and usefulness of an IS artifact can compensate for insufficient research (in terms of conceptualization and theorizing). Therefore, they suggest a continuum in two dimensions: "from very novel artifacts to rigorous theory development, and from early visions of technology impact to studies of technology impact on users, organizations and society" (p. 369). Gregor and Hevner (2013) present a 2 x 2 matrix of DS contexts, in which the x-axis considers the application domain maturity, and the y-axis assesses the solution maturity. According to this view, if both the solution and application domains have high maturity, they essentially pertain to the practice domain. If the solution and application domains have low maturity, they emphasize the research domain regarding opportunities (e.g., breakthroughs) and knowledge contributions. The combinations of high and low maturities must be understood as existing between the two boundaries, in which research is balanced with practice, e.g., identifying minor improvements compared to living situations or minor knowledge contributions. The balance between research and practice has been further discussed in other DS papers (e.g., Holmström et al., 2009; Scales, 2020).

In this intersection, we are concerned with what aspects of DS education can help learners link research and practice. We identify four possible elements. First, DS education enables learners to identify problems in the application domain as the subject of study. Recent efforts have been dedicated to this enabler, in which students identify and frame industry problems for their projects and use DS as a method to address these problems (Knauss, 2021). This enabler is essential for students who take internships and projects from industry partners.

Second, DS education can facilitate learning with a theory-informed DS process, using academic knowledge to solve real-world problems (Nagle et al., 2017). Multiple DS researchers apply theory-informed processes to solve real-problem (Apiola & Sutinen, 2021; Tremblay et al., 2012). In DS education, we must prepare students for similar applications, acknowledging that their design processes should be theory-informed (e.g., theoretical foundations, state-of-the-art, and best practices) and are simultaneously shaped by the problematic context of the application setting and intervention defined by the learners.

Third, DS education can encourage learners to acquire knowledge through design. In particular, outcome artifacts from the design process furnish the learners with abstract design knowledge and design process experience (Goldkuhl et al., 2017). This is particularly important for master's students and Ph.D. candidates adopting DS, in which their thesis needs to demonstrate knowledge contributions targeting both the knowledge base and the empirical knowledge of the learners. By learning through design, DS education enables learners to integrate academic, abstract knowledge with concrete experiences from the design process to form actionable knowledge (Baloh et al., 2012).

Finally, DS education can enhance the communication between research and practice. We note that we may not yet have DS communication mechanisms adequate for educational experiences and with significant resonance in practice. DS has been focused on communicating with the research community, traditionally using scientific publications. This is usually done by focusing on theoretical statements, clarifying the context of justification, and providing justificatory knowledge (Fischer & Gregor, 2011; Fischer et al., 2010; Gregor & Jones, 2007). However essential these elements are, they do not seem sufficient. Here, DS education can contribute at least two points. First, DS education can enhance communication about the context of discovery, which appears essential for students to learn the underlying design processes (e.g., creativity, exploration, and generalization). Second, it is necessary to communicate about the process of turning a practical problem into an abstract one, then turning a generalized solution into a contextualized one. Research in this area suggests using dynamic mechanisms, such as journaling and knowledge paths, which make the details of DS crafting more transparent and actionable to students, academics, and practitioners (Akoka et al., 2023; Holloway et al., 2016; vom Brocke et al., 2021).

2.3 Intersection Practice-Education

It is widely agreed in IS education that preparing students for professional practice is valuable. There are two directions: one facilitates learners with subjects reflecting professional practices while the other pulls the practices to the learners. In the former direction, IS curriculum has integrated multiple subjects reflecting professional practices, including dynamic processes, agile methods, data analytics, and artificial intelligence applications (Grisold et al., 2022; Lyytinen et al., 2023).

In the latter direction, DS education can help learners address practice through practice-based pedagogy. We base our suggestion on a real story experienced by one of the authors. The story context concerns a master's thesis in which students work on a project in a company. The company supervises the project, while the faculty supervises the thesis. From the outset, this type of project fits DS very well. On the one hand, the student tackles a problem in a real-world environment. On the other hand, the student elaborates and positions a solution against the knowledge base. In our story, one author was involved as the thesis supervisor. The project required adding web services to the company's portfolio. The faculty supervisor noted that it would benefit the student to adopt DS, as it would fit the project's goals and confer an appropriate structure to the thesis (abstraction-exploration-generalization). However, the project work was quite different from the thesis work, and the student needed to balance these two aspects. On the one hand, the student engaged in learning about DS and selected Peffers et al.'s (2007) methodology to structure the thesis. On the other hand, the project followed the traditional waterfall process (requirements definition, analysis, design, integration, and testing, supported by use cases, component diagrams, sequence diagrams, and package diagrams). At its core, the project followed the company's rituals and practices and the student's educational background. The result reflected how DS education could support practice-based pedagogy by identifying authentic problems and facilitating knowledge for students to address real-world problems. Still, it also highlighted the challenges faced by DS against prevailing practices and educational backgrounds.

While suggesting DS education for supporting practice-based pedagogy, we note that achieving this goal is challenging. One critical element DS education promotes is making contributions to the knowledge base. This is usually associated with making artifact-independent contributions of explanatory and/or predictive knowledge (Drechsler & Hevner, 2022). The effort and expertise required to make a knowledge contribution may be less attractive to most businesses. The community still debates the right balance between theoretical design contributions and artifact contributions in DS (Baskerville et al., 2018). One problem is that there may be too much guidance on DS, and most advice is more focused on research than on education and practice (Peffers et al., 2018).

Addressing the problem, for DS education to thrive, it needs to become more embedded in both the educational background and practice environments of professionals. One way to accomplish this goal is to expose undergrad students to DS and let the acquired knowledge and skills spill over to practice settings. Another way is for DS to achieve recognizable success in practice environments and allow it to be picked up by educational backgrounds, especially at the undergraduate level. In any case, widespread success requires embedding DS in professionals' educational experiences and practice environments.

In summary, we position DS education at the intersections of research, practice, and education. We further note three essential points. First, the previous discussion has specific replicated arguments, highlighting the crossing nature of the intersections regarding DS education conceptualization. Second, depending on the levels of education and the nature of teaching courses, DS education may rely more on one intersection than the others. Finally, we view the three intersections as exploratory (rather than confirmatory) to further explore and develop the concept of DS education. The idea's development will also be offered in the articles in this special issue, which are presented in the next section.

3. THE ARTICLES IN THE SPECIAL ISSUE

Addressing DS education at the intersections of research, practice, and education, the special issue contains six articles. Table 1 provides an overview of them.

In "A Proficiency Model for Design Science Research Education," Hevner and vom Brocke propose a proficiency model for DS education. The model identifies six proficiencies that DS researchers should master. The six proficiencies are based on the highly influential DS framework proposed by Hevner et al. (2004). The article elaborates on how educators can apply the proficiency model in three educational contexts: academic (BSc, MSc, and Ph.D.), short training, and executive. The authors identify strengths, challenges, and teaching strategies for each educational context. The authors also discuss the balance between artifact and theoretical contributions across the three educational contexts. They note that undergraduate students should focus more on the artifact, as they may not be equipped to generate theoretical contributions.

Article in the special issue	Intersection among research, practice, and education	Key contributions
Hevner and vom Brocke	Intersection of research and education	- Six DS education proficiencies - Curriculum for teaching DS education according to doctoral, DBA, master, and bachelor programs
Memmert et al.	Intersection of research and practice	- An AI tool to support students in developing conceptual designs - Support DS students to address ill-structured wicked problems
Nagle et al.	Intersection of practice and education	- A learning-by-doing technique - Practice has been integrated in classes through problem formulation and guest speakers
Schoormann et al.	Intersection of research and education	- Propose a tool that helps neophyte DS researchers to capture, communicate and reflect on design principles - The tool was designed based on inquiry-based learning
Pekkola	Intersection of practice and education	- Using DS as a means to address problems identified by organizations - Approaching project-based learning, which students learn by engaging in real-world projects
Schlimbach et al.	Intersection of research and education	- Showcase a DS course for master's students - Course design evaluation by participant evaluations and a workshop evaluation

Table 1. Overview of Articles in the Special Issue

The second article, "Learning by Doing: Educators' Perspective on an Illustrative Tool for AI-generated Scaffolding for Students in Conceptualizing Design Science Research Studies" by Memmert et al., emphasizes that DS education may benefit from tool support. The authors designed an AI tool that helps scaffold solution designs by structuring the identification of issues, design requirements, and design principles. The article opens the door to developing AI-assisted DS, which is particularly relevant to helping students acquire DS skills.

The third article, "Methodological 'Learning-by-Doing' for Action Design Research" by Nagle et al., showcases an action design research course taught at the master level. The article details the course design, its rationale, and its evaluation. An interesting aspect of the proposition is that it was designed using DS. Another exciting part is that the paper supports authentic learning, which processes knowledge from practice to academia.

In the article "Guiding Design Principle Projects: A Canvas for Young Design Science Researchers," Schoormann et al. propose an interesting tool: a principle constructor, which helps neophyte DS researchers to capture, reflect, and communicate about design principles. The tool design is based on inquiry-based learning, and it helps learn the intricacies of building design principles and allows systematic communication of a relevant DS concept.

In the article "Reflections on Supervising the Postgraduate Students' Design Science Research Thesis," Pekkola reflects on his extensive experience supervising MSc projects in DS. The author's reflections emphasize the practical nature of DS education. The author also shares several challenges and constraints, noting, in particular, the difficulties caused by employing DS on short-term projects compared to longer-term projects such as Ph.D. research. The paper promotes project-based learning, which processes practice to support authentic learning.

Finally, the article "A Teaching Framework for the Methodically Versatile DSR Education of Master's Students" by Schlimbach et al. showcases the teaching of DS research in an MSc seminar course. The authors discuss the course design and report on the course evaluation.

In summary, the six articles in this special issue further contribute to the development of DS education. With them, DS education will receive more attention from the IS community. We frame the attention by conceptualizing DS education at the intersections of research, practice, and education. Based on our conceptualization, researchers, practitioners, and educators can further develop learning and teaching initiatives related to DS education, in which learners engage with DS knowledge and practical experiences

4. ACKNOWLEDGEMENTS

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