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Introduction to Design Science Education

Nguyen Hoang Thuan
RMIT University Vietnam, Vietnam
Email: Thuan.NguyenHoang@rmit.edu.vn

Mary Tate
Victoria University of Wellington, New Zealand
Email: mary.tate@vuw.ac.nz

Andreas Drechsler
Victoria University of Wellington, New Zealand
Email: andreas.drechsler@vuw.ac.nz

Pedro Antunes
Faculty of Sciences of the University of Lisbon, Lisbon, Portugal
Email: padantunes@fc.ul.pt

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 intrigued with. We address this question 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.

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). Despite the variety of viewpoints, 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 spirals, 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).

DS literature has been dominated by its role 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 some steps to redress this imbalance. 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 (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 into 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, where 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 role links with research where 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 where teaching DS education can prepare students for professional works (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 where different mixes of research/practice are distilled under different educational foci.

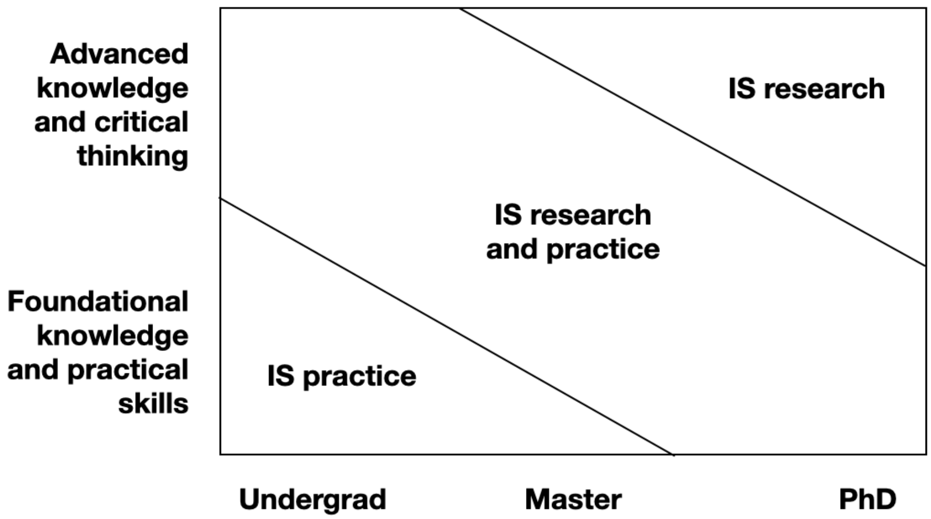

Figure 1. The balance between research and practice in IS education (Goldkuhl et al. 2017)

We are particularly interested in DS education within the scope of IS education. IS professionals are expected to acquire and develop knowledge to design and realize various IS initiatives (Carlsson et al., 2011). As noted above, the educational focus can range between foundational knowledge, where 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, where students acquire reflective and methodological capabilities for the conceptualization and theorization of IS artifacts (Herselman & Botha, 2020; Knauss, 2021; Pérez Contell, 2020). 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 will also be required, such as abstracting problems, exploring possibilities, and generalizing solutions. 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. 24f). The science of design concerns the study of the practice of design (Cross, 1982). All these discourse streams are relevant to understand design. They also have rich intersections. However, DS stands out as technology-oriented (March & Smith, 1995). This characteristic enables us to position 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 intends to gather 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, creating 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.

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.

2 Design Science Education Framework

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.

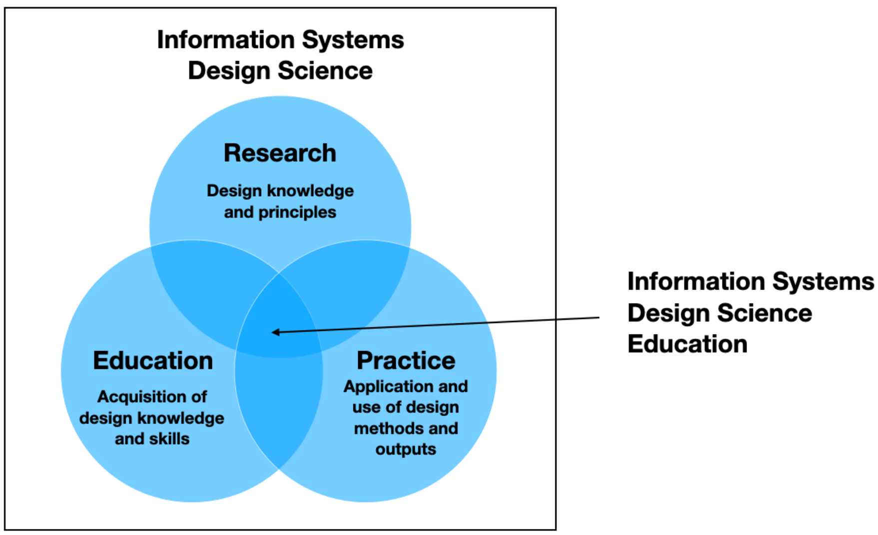

Figure 2. DS education framework

Next, we use this simple framework to further discuss DS education at the various 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 about technology 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 and rigorous evaluation and identification of the knowledge contribution as an outcome (e.g., Drechsler & Hevner, 2016; 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 evaluation of the artifact.

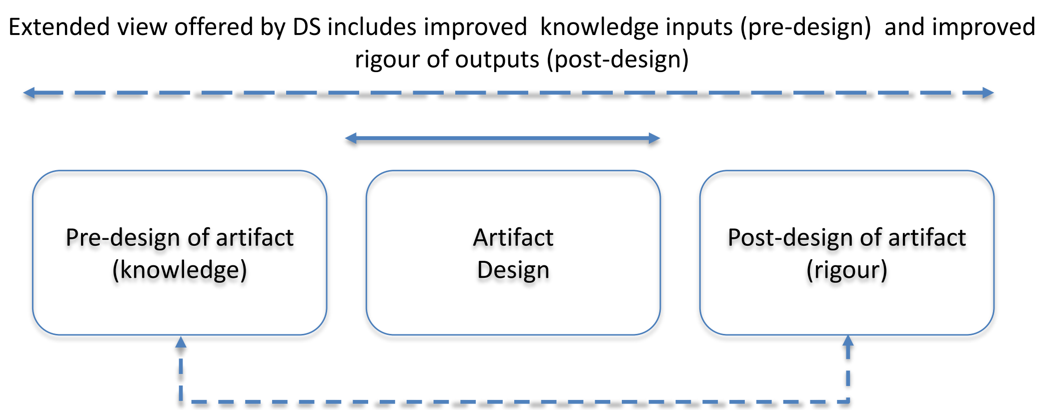

Figure 3. Artifact design life cycle

Design science should be informed by solid theoretical background. This does not automatically mean that DS projects are automatically 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, concepts, constructs, conceptual frameworks, classifications, and taxonomies (Akoka et al., 2017).

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 and need for the artifact, 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 literature analysis, focus groups, surveys, experiments, and simulations (Sonnenberg & vom Brocke, 2012).

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 rigorously evaluated.

2.2 Intersection research-practice

DS needs an adequate balance between research and practice, but it seems impossible to stipulate. 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, the authors 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, where the x-axis considers the maturity of the application domain, and the y-axis assesses the solution’s 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 opportunity (breakthroughs) and knowledge contribution. The combinations of high and low maturities must be understood as existing between the two boundaries, where 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 (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, where 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 learners 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 feed the learners with abstract design knowledge and the design process experience (Goldkuhl et al., 2017). This is particularly important for master’s students and Ph.D. candidates adopting DS, where 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 an 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) by example. 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 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 practical-based pedagogy. We base our suggestion on a real story experienced by one of the authors. The story context concerns a master's thesis where 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). The student engaged in learning about DS and selected Peffers et al's. (2007) methodology to structure the thesis. However, the project work was quite different from the thesis work. 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). Therefore, DS had a superficial role restricted to the thesis. 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 practical-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 practical-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 theoretical contributions in scientific publications. The effort and expertise required to make a theoretical 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 undergrad 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 above discussion has specific replicated arguments, highlighting the crossing nature of the intersections regarding DS education conceptualization. Second, depending on the levels of education and 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 issue, 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 the six articles.

In "A Proficiency Model for Design Science Research Education", Hevner and vom Brocke (2023) propose a proficiency model for DS education. The model identifies six proficiencies that DS researchers should master. The six proficiencies are bolt-on in 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.

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. (2023), 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 help students acquire DS skills.

The third article, "Methodological 'Learning-by-Doing': A Teaching Technique for Action Design Research", by Nagle et al. (2023), 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 Visual Inquiry Tool for (Young) DSR Researchers,” Schoormann et al. (2023) 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 teaching tip, “Teaching Tips for Supervising the Postgraduate Students’ Design Science Research Thesis”, Pekkola (2023) 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 Students” by Schlimbach et al. (2023) showcases the teaching of DS research in an MSc seminar course. The authors discuss the course design and report on the course evaluation.

Article in the Special Issue	**Intersection among research, practice, and education**	**Key contributions**
Hevner and vom Brocke (2023)	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. (2023)	Intersection of research and practice	- An AI tool to support students in developing conceptual design in DSR - Support DS students to address ill-structured wicked problems
Nagle et al. (2023)	Intersection of practice and education	- A learning-by-doing technique - Practice has been integrated to class through problem formulation and guest speakers
Schoormann et al. (2023)	Intersection of research and education	- Propose a tool that helps neophyte DSR researchers to capture, communicate and reflect on design principles. - The tool was designed based on inquiry-based learning
Pekkola (2023)	Intersection of practice and education	- Use DSR 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. (2023)	Intersection of research and education	- Showcase a DSR course for master’s students - Course design evaluation by participant evaluations and a workshop evaluation

Table 1. Overview of articles in the special issue

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 engagement 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, where learners engage with DS knowledge and practical experiences.

References

Akoka, J., Comyn-Wattiau, I., Prat, N., & Storey, V. C. (2017). Evaluating knowledge types in design science research: an integrated framework. *Proceedings of International Conference on Design Science Research in Information System and Technology*, *LNCS*, 201-217.

Akoka, J., Comyn-Wattiau, I., Prat, N., & Storey, V. C. (2023). Knowledge contributions in design science research: paths of knowledge types. *Decision Support Systems*, *166*, 113898.

Antunes, P., Thuan, N. H., & Johnstone, D. (2021). Nature and Purpose of Conceptual Frameworks in Design Science. *Scandinavian Journal of Information Systems*, *32*(2), 3–40.

Apiola, M., & Sutinen, E. (2021). Design science research for learning software engineering and computational thinking: Four cases. *Computer Applications in Engineering Education*, *29*(1), 83-101.

Baloh, P., Desouza, K. C., & Hackney, R. (2012). Contextualizing organizational interventions of knowledge management systems: A design science perspective. *Journal of the American Society for Information Science and Technology*, *63*(5), 948-966.

Baskerville, R., Baiyere, A., Gregor, S., Hevner, A., & Rossi, M. (2018). Design Science Research Contributions: Finding a Balance between Artifact and Theory. *Journal of the Association for Information Systems*, *19*(5), 358-376.

Baskerville, R., Pries-Heje, J., & Venable, J. (2009). Soft design science methodology. Proceedings of the 4th international conference on design science research in information systems and technology,

Beck, K., Beedle, M., Van Bennekum, A., Cockburn, A., Cunningham, W., Fowler, M., Grenning, J., Highsmith, J., Hunt, A., & Jeffries, R. (2001). The agile manifesto. In.

Carlsson, S. A., Henningsson, S., Hrastinski, S., & Keller, C. (2011). Socio-technical IS design science research: developing design theory for IS integration management. *Information Systems and e-Business Management*, *9*(1), 109-131.

Carstensen, A.-K., & Bernhard, J. (2019). Design science research–a powerful tool for improving methods in engineering education research. *European Journal of Engineering Education*, *44*(1-2), 85-102.

Conboy, K., Gleasure, R., & Cullina, E. (2015). Agile design science research. New Horizons in Design Science: Broadening the Research Agenda: 10th International Conference, DESRIST 2015, Dublin, Ireland, May 20-22, 2015, Proceedings 10,

Cross, N. (1982). Designerly ways of knowing. *Design studies*, *3*(4), 221-227.

Drechsler, A., & Hevner, A. (2016). A four-cycle model of IS design science research: capturing the dynamic nature of IS artifact design. Breakthroughs and Emerging Insights from Ongoing Design Science Projects: Research-in-progress papers and poster presentations from the 11th International Conference on Design Science Research in Information Systems and Technology (DESRIST) 2016. St. John, Canada, 23-25 May,

Fischer, C., & Gregor, S. (2011). Forms of reasoning in the design science research process. International Conference on Design Science Research in Information Systems,

Fischer, C., Winter, R., & Wortmann, F. (2010). Design theory. *Business & Information Systems Engineering*, *2*(6), 387-390.
Goldkuhl, G., Ågerfalk, P., & Sjöström, J. (2017). A design science approach to information systems education. In M. A., v. B. J., & H. A. (Eds.), *International Conference on Design Science Research in Information System and Technology* (pp. 383-397). Springer.
Goldkuhl, G., & Sjöström, J. (2018). Design science in the field: practice design research. Designing for a Digital and Globalized World: 13th International Conference, DESRIST 2018, Chennai, India, June 3–6, 2018, Proceedings 13,
Gregor, S., & Hevner, A. (2013). Positioning and presenting design science research for maximum impact. *MIS quarterly*, *37*(2), 337-355.
Gregor, S., & Jones, D. (2007). The anatomy of a design theory. *Journal of the Association for Information Systems*, *8*(5), 312-335.
Grisold, T., Wurm, B., vom Brocke, J., Kremser, W., Mendling, J., & Recker, J. (2022). Managing process dynamics in a digital world: integrating business process management and routine dynamics in IS curricula. *Communications of the Association for Information Systems*, *51*(1), 5.
Herselman, M., & Botha, A. (2020). Applying Design Science research as a methodology in post graduate studies: A South African perspective. *Conference of the South African Institute of Computer Scientists and Information Technologists 2020*, 251-258.
Hevner, A., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS quarterly*, *28*(1), 75-105.
Hevner, A. R. (2021). Pedagogy for Doctoral Seminars in Design Science Research. In *Engineering the Transformation of the Enterprise* (pp. 185-198). Springer.
Holloway, S. S., van Eijnatten, F. M., Romme, A. G. L., & Demerouti, E. (2016). Developing actionable knowledge on value crafting: A design science approach. *Journal of Business Research*, *69*(5), 1639-1643.
Holmström, J., Ketokivi, M., & Hameri, A. P. (2009). Bridging practice and theory: A design science approach. *Decision Sciences*, *40*(1), 65-87.
Johansson-Sköldberg, U., Woodilla, J., & Çetinkaya, M. (2013). Design thinking: past, present and possible futures. *Creativity and innovation management*, *22*(2), 121-146.
Kelley, T., & Kelley, D. (2013). *Creative confidence: Unleashing the creative potential within us all*. Currency.
Keskin, D., & Romme, G. (2020). Mixing oil with water: How to effectively teach design science in management education? *BAR-Brazilian Administration Review*, *17*.
Knauss, E. (2021). Constructive Master's Thesis Work in Industry: Guidelines for Applying Design Science Research. 2021 IEEE/ACM 43rd International Conference on Software Engineering: Software Engineering Education and Training (ICSE-SEET),
Lyytinen, K., Topi, H., & Tang, J. (2023). MaCuDE IS Task Force Phase II Report: Views of Industry Leaders on Big Data Analytics and AI. *Communications of the Association for Information Systems*, *52*(1), 18.
March, S. T., & Smith, G. F. (1995). Design and natural science research on information technology. *Decision Support Systems*, *15*(4), 251-266.
Mullarkey, M. T., & Hevner, A. R. (2019). An elaborated action design research process model. *European Journal of Information Systems*, *28*(1), 6-20.
Nagle, T., Sammon, D., & Doyle, C. (2017). Insights into Practitioner Design Science Research. In A. Maedche, J. vom Brocke, & A. Hevner, *Designing the Digital Transformation* Cham.

Nunamaker, J. F., Chen, M., & Purdin, T. D. (1990). Systems development in information systems research. *Journal of management information systems*, *7*(3), 89-106.
Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of management information systems*, *24*(3), 45-77.
Pérez Contell, J. (2020). *Design science research in PhD education: designing for assistance tools* the University of the Basque Country].
Rohde, M., Brödner, P., Stevens, G., Betz, M., & Wulf, V. (2017). Grounded Design-a praxeological IS research perspective. *Journal of information technology*, *32*(2), 163-179.
Scales, J. (2020). A design science research approach to closing the gap between the research and practice of project scheduling. *Systems Research and Behavioral Science*, *37*(5), 804-812.
Schön, D. A. (1992). The theory of inquiry: Dewey's legacy to education. *Curriculum inquiry*, *22*(2), 119-139.
Sein, M., Henfridsson, O., Purao, S., Rossi, M., & Lindgren, R. (2011). Action design research. *MIS quarterly*, *35*(1), 37-56.
Shameem, M., Kumar, R. R., Nadeem, M., & Khan, A. A. (2020). Taxonomical classification of barriers for scaling agile methods in global software development environment using fuzzy analytic hierarchy process. *Applied Soft Computing*, *90*, 106122.
Simon, H. A. (1996). *The Sciences of the Artificial*. The MIT Press.
Sonnenberg, C., & vom Brocke, J. (2012). Evaluations in the science of the artificial–reconsidering the build-evaluate pattern in design science research. In K. Peffers, M. Rothenberger, & B. Kuechler (Eds.), *Design Science Research in Information Systems. Advances in Theory and Practice. LNCS* (pp. 381-397). Springer.
Thuan, N. H., & Antunes, P. (2022). Positioning Design Science as an Educational Tool for Innovation and Problem Solving. *Communications of the Association for Information Systems*, *51*(1).
Tremblay, M. C., Hevner, A. R., & Berndt, D. J. (2012). Design of an information volatility measure for health care decision making. *Decision Support Systems*, *52*(2), 331-341.
vom Brocke, J., Gau, M., & Mädche, A. (2021). Journaling the design science research process. Transparency about the making of design knowledge. The Next Wave of Sociotechnical Design: 16th International Conference on Design Science Research in Information Systems and Technology, DESRIST 2021, Kristiansand, Norway, August 4–6, 2021, Proceedings 16,
vom Brocke, J., Winter, R., Hevner, A., & Maedche, A. (2020). Special Issue Editorial–Accumulation and Evolution of Design Knowledge in Design Science Research: A Journey Through Time and Space. *Journal of the Association for Information Systems*, *21*(3), 9.
Walls, J. G., Widmeyer, G. R., & El Sawy, O. A. (1992). Building an information system design theory for vigilant EIS. *Information systems research*, *3*(1), 36-59.
Wieringa, R., & Moralı, A. (2012). Technical action research as a validation method in information systems design science. Design Science Research in Information Systems. Advances in Theory and Practice: 7th International Conference, DESRIST 2012, Las Vegas, NV, USA, May 14-15, 2012. Proceedings 7,
Winter, R., & vom Brocke, J. (2021). Teaching Design Science Research. *ICIS 2021 Proceedings*, *4*, Paper 2265.
zur Heiden, P. (2020). Considering context in design science research: A systematic literature review. Designing for Digital Transformation. Co-Creating Services with Citizens and

Industry: 15th International Conference on Design Science Research in Information Systems and Technology, DESRIST 2020, Kristiansand, Norway, December 2–4, 2020, Proceedings 15,

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Appendix

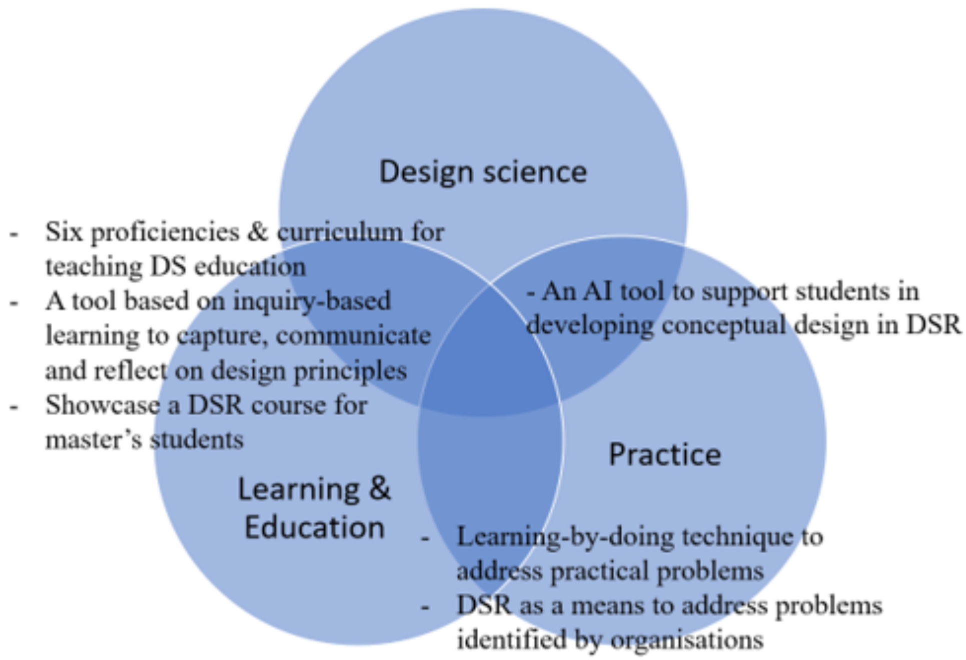

Figure 2. Position the papers in the special issue into DSE conceptualization (Note to our team: not sure whether we should add this figure in the final version of the writing, yet it gives us an overview of the papers in the special issue)