Addressing the Dichotomy of Theory and Practice in Design Science Research Methodologies

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Abstract. Design Science Research (DSR) has emerged as a methodological approach for conducting research whose overarching goal is to develop new means, referred to as artifacts, in the form of constructs, models, methods, and instantiations to improve reality. Due to their context dependent nature and the growing interest in the rapid development of new technical solutions, DSR approaches have increased in diversity, leading to different specific methodologies. In this paper, a dichotomous view of theory and practice in DSR projects is taken to categorize individual research activities from a range of six methodologies into these two areas. A structure proposal based on the DSR methodology of Peffers et al. is presented that includes specific methods and outcomes of each step to help researchers and practitioners manage the duality of this type of research and organize their workflows and textual elaborations. The visualized scheme provided is intended to be adaptable and reusable for this purpose, with the possibility of being extended to other DSR methodologies in the future.

Keywords: Design Science Research, Structure Proposal, Structural Guideline, Research Organization Support, Theory and Practice.

1 Introduction

The research paradigm of design science has given rise to the methodological approach of *design science research* (DSR) for investigations based on the development of innovative solutions called *artifacts* in order to generate utilizable design knowledge [2–4]. Since the digital world is rapidly evolving with more and more people gaining access to it and with the constantly increasing technical capabilities of today's hardware, the number and diversification of computer-based engineering projects are likely to expand. The main focus of DSR can be summarized as the pursuit of new means to change and hopefully improve the real world by the provision of solutions to identified important organizational or business problems [1, 2, 4, 5]. However, due to the variety of solvable issues in the respective domains, DSR is highly context-dependent [2] and thus, a wide range of competing methodologies for conducting DSR exists [5]. While Sonnenberg and vom Brocke [6] state that *building and evaluating* are the two primary activities within DSR, where each activity may consist of more precise research steps, adding another layer of granularity, Peffers et

al. [1] explicitly note that the "*development of the artifact should be a search process that draws from existing theories and knowledge to come up with a solution to a defined problem*". Although it can be argued whether preparatory work (e.g., the examination of literature to identify a problem) is part of the *build* activity, it seems undisputable that DSR projects encompass, to a certain degree, a dichotomy between a theorical part and a practical development.

In this paper, first, DSR activities from several methodological guidelines, inspired by the DSR comparison framework by Venable et al. [5], are abstracted as rather theoretical or practical parts of the research process. The former includes a spectrum of activities ranging from problem identification and design thinking, while the latter encompasses activities such as artifact building and evaluation. Secondly, a structuring proposal for selecting appropriate methods for both comprising parts and the communication of DSR outputs is provided based on the DSR methodology of Peffers et al. [1] with the potential of being extended to other DSR guidelines. The decision to start with this particular methodology is based on its popularity: A search for *"design science research"* in titles in the database *Scopus*, which claims to be the largest database of abstracts and citations [7], shows that the article by Peffers et al. [1] is ranked first, with more than 3200 references at the time of writing, when sorted by the number of citations. Furthermore, the proposal of a structural guide will help researchers organizing the communication of workflows and results. This would address the criticism by vom Brocke et al. [2] that space limitations prevent researchers from publishing DSR results in reasonable detail due to the iterative character of the research.

2 Related Work

In this section, the research steps and activities of six DSR methodologies adopted from Venable et al. [5] are briefly outlined and abstracted into a theoretical and a practical category, taking into account the possibility of cycling back to comply with the evolutionary nature of DSR. This process is intended to illustrate that, at a high level, DSR comprises these two essential parts which, in turn, partially require vastly different methods in order to be performed. For example, Sonnenberg and vom Brocke [6] state a number of evaluation methods for each of the four phases *problem identification*, *design*, *construct*, and *use*, ranging from literature reviews and expert interviews to experimentation and case studies. In the following considerations, the abstract term *theory* covers research steps that refer to the formalization of rules, ideas, design thinking, elaboration of design principles, and statements that cannot be verified for correctness before the artifact is constructed. In other words, the accumulation of required knowledge, whether it results from interaction with practitioners, from observations, or from descriptions of ongoing active processes, is considered *theory*. The term *practice*, on the other hand, covers steps related to the execution of a theory or idea and its evaluation. However, since it could be debated whether the design of an artifact already includes the embedding of knowledge in a practical outcome, these activities are crosshatched in the summary in Fig. 1 and placed in the area

of the presumed focus. Furthermore, a column for rather post-research activities is added, including tasks such as reflecting and communicating the results obtained.

The (1) *systems development research methodology* (SDRM) as described by Nunamaker et al. [8] encompasses five steps building on the four research strategies of *theory building*, *experimentation*, *observation*, and, pivotal to these, *systems development*. The (1.a) *construction of a conceptual framework* that is assumed to lead to theory building and the (1.b) *development of a system architecture* that specifies high-level functionalities and dynamic interactions can be viewed as collecting ideas and placing them in context, thus meeting the stated definition of theory work. In the phase of (1.c) *analyzing and designing the system*, the insights acquired are used to generate a blueprint of the system, including data structures and knowledge bases. Hence, this activity represents the demarcation between theory and practice, with an emphasis on the former part. Consequently, the steps of (1.d) *building the system* and (1.e) *experimentation, observation, and evaluation of the system* are positioned in the practice column in Fig. 1 with the possibility of cycling back, as observations from testing the system and the assessment of its impact may lead to a conceptual redesign.

Similar to SDRM, the (2) *DSR process model* (DSRPM) proposed by Vaishnavi and Kuechler [9] consists of five steps. Moreover, raising (2.a) *awareness of a problem* and elaborating a (2.b) *suggestion* for a tentative design might be viewed as equivalents of (1.a) and (1.b) in SDRM, since (2.a) is intended to propose the general research effort and (2.b) aims on composing a provisional configuration of elements of a solution. However, since (2.b) yields a design of examined new or existing components ready for implementation, this step is considered as partially crossing the line to the execution of an idea. The (2.c) *development* and (2.d) *evaluation* of the artifact are the ultimate realization and assessment of the designed concept, including the option to go back to the first step for a reevaluation of the problem that potentially has been altered by the deployment of the artifact. The (2.e) *conclusion* includes the publication of the research findings and the justification of their knowledge contribution, thus being outside the theory-practice schema and inside the post-research column.

The (3) *design science research methodology* (DSRM) introduced by Peffers et al. [1] contains six activities that follow a similar pattern as the DSRPM. The first two activities, (3.a) *problem identification and motivation* and (3.b) *definition of objectives of a solution*, seek to utilize existing knowledge and theories about a problem to describe what objectives a solution should satisfy in either quantitative or qualitative terms. The (3.c) *design and development* encompasses the determination of aspired functionalities and the architecture of the artifact, thus rather fitting the stated definition for theory building, and its actual creation. Therefore, this activity is considered to be twofold, with an emphasis on the practical application of previously acquired knowledge. The (3.d) *demonstration* serves to test the artifact by employing it to solve a set of specific instances of the identified problem, while the (3.e) *evaluation* includes accurately observing and measuring its capabilities. Finally, the (3.f) *communication* activity aims to share and discuss the developed solution with the research community and practitioners from the field, therefore this step is considered as post-research, in line with the conclusion in the DSRPM.

The (4) a*ction design research* (ADR) approach consists of four stages, whereby only the (4.a) *problem formulation* has a clear theory focus. Sein et al. [10] state the principle that in this stage the "*researcher actively inscribes theoretical elements in the ensemble artifact*" and that the "*initial design of the theory-ingrained artifact […] is then subjected to organizational practice*". The subsequent (4.b) *building, intervention, and evaluation* stage yields the realized design of the artifact with the possibility of cycling back. While (4.c) *reflection and learning* aims at generalizing the specific instance to a solution for a class of problems, the (4.d) *formalization of learning* also includes communicative tasks such as sharing outcomes and articulating design principles. Both are considered here as retrospective post-research activities.

The (5) *soft design science methodology* (SDSM) [11] emphasizes social aspects in the research process. With the (5.a) *specific problem identification*, the (5.b) *expression as a specific set of requirements*, the (5.c) *abstraction into a general problem*, a (5.d) *general solution design*, a (5.e) *comparison of the general solution with the specific problem*, and the (5.f) *search for specific components*, six out of seven activities can be designated as at least theory focused. The (5.g) *construction and deployment of an instance* concludes the SDSM with the practical design knowledge application.

Combining action research and DSR, (6) *participatory action design research* (PADR) [12] focuses on the field of urban informatics, proposing a methodology for developing new technological means as well as studying the social impacts of their application. PADR starts with (6.a) *diagnosing and problem formulation*, thus adopting significantly the first step of ADR. While in the (6.b) *action planning* phase "*an idea for a suitable new technology to address the issues at hand is identified*" [12], thus complying with the established definition of theory building, the following (6.c) *action taking* encompasses the design, active development and testing of the artifact. The (6.d) *impact evaluation* satisfies the overall goal of urban informatics by examining the social effects of the solution proposed. Finally, (6.e) *reflection and learning* yields feedback for the accomplished results from the community and is therefore considered a post-research activity similar to the same activity in ADR. Fig. 1 summarizes the assignments of all activities into the three categories.

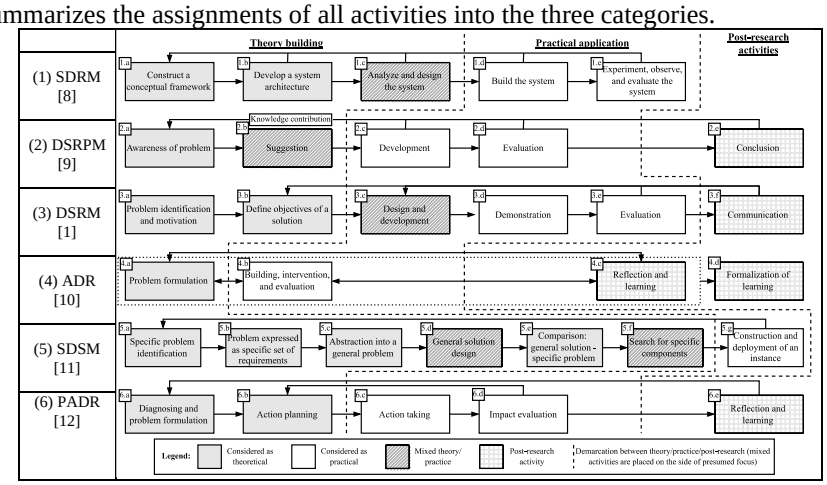

Fig. 1. Activities of exemplary DSR methodologies abstracted as theory and practice-based

3 Framework Proposal for Structuring DSR Projects

By its very nature, research consists of two fundamental elements: its objectives or desired results, and the methods necessary to achieve them [8]. In this section, a reusable structure proposal for DSR projects following the DSRM of Peffers et al. [1] is presented, which aligns the respective research activities with appropriate methods and a selection of common results. As mentioned in the introduction, the DSRM was selected for study due to its popularity for this type of research.

Fig. 2 divides the DSRM as well as the assigned methods for each activity into a theory and a practice segment with an additional post-research segment. Regarding theory building, common methods for sound identification of a problem and important features of a possible solution that can be derived from existing literature [6] include systematic literature reviews (SLRs), document analysis, surveys, expert interviews, focus groups, observations, and logical reasoning based on these. For the practical application of the collected theoretical knowledge, in turn, methods such as prototypical implementations, experiments, simulations in artificial or real-world scenarios, case studies, benchmarking, and accurate measurements of the artifact's properties are typically used [6]. For the purpose of increasing the scientific rigor when following this approach, we highly recommend to adopt specific guidelines for the respective methods such as established works on SLRs (e.g., Kitchenham and Charters [7], Okoli [13]) and artifact design and evaluation strategies (e.g., Hevner et al. [4], Sonnenberg and vom Brocke [6]). For the post-research communication, academic exchange and discussion in conjunction with result publication or corresponding conference participation are encouraged.

The structure proposal furthermore provides an exemplary range of potential outcomes for each segment. While the theory part might consist of descriptive statements on key points of the subject of investigation, the research motivation, or a preliminary conceptual solution proposal, the practical part can contain specific scenario descriptions for the application of the artifact, test results, or illustrations of the artifact in operation. Sections on the *design and development* activity, as a link in the transition from theory to practice, might include more concrete remarks on the theoretical elaborations as well as first impressions of the practical work. The visualization presented in Fig. 2 can be modified and integrated in other research projects to provide the reader with a quick and comprehensive overview of the methods used, objectives, and where to find the respective results in the text body.

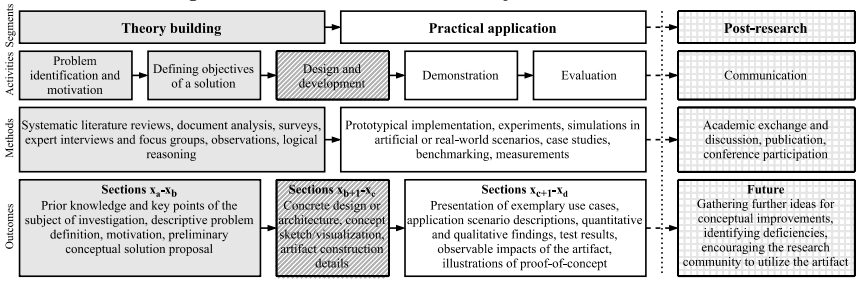

Fig. 2. Structure proposal for research projects with DSRM according to Peffers et al. [1]

4 Future Research

In this research-in-progress, a categorization of research activities of different DSR methodologies into the dichotomous areas of theory and practice is presented. Moreover, a scheme for structuring elaborations following the DSRM of Peffers et al. [1] is presented. The following steps to further pursue efforts to provide a comprehensive structural proposal are, first, to identify currently emerging DSR methodologies beyond the comparison framework and, second, to apply the schema in Fig. 2 to them to extend its applicability to the specialized needs of researchers and practitioners.

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