Creativity in Design Science Research: how to use divergent and convergent methods effectively[1]

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Abstract. While many recognize the relevance of creativity in design science, there is a lack of guidance in the field on how to use creativity methods effectively. In this article, we draw on the creativity literature to provide guidance on choosing effective creativity methods in the DSR process. A Creativity-Methods-Fit Framework suggests that the fit of creativity methods depends on the structuredness of the problem and the solution space. Furthermore, it outlines which divergent and convergent creativity methods should be used. This paper contributes in two main ways. First, the framework provides guidance on the use of creativity methods in DSR. Second, the paper complements previous frameworks discussing fitting evaluation methods, by introducing the notion of fitting creativity methods to the DSR discourse.

Keywords: Design Science Research, Creativity, Divergent Thinking, Convergent Thinking, DSR Methods

1 Introduction

It is increasingly recognized that a key component to Design Science Research (DSR) is creativity. Creativity is defined as "the interaction among *aptitude, process, and environment* by which an individual or group produces a *perceptible product* that is both *novel and useful* as defined within a *social context"* [1]. Early on, Thompson and Loran [2] have argued that creativity in DSR is essential to create new ideas and to produce suitable solutions for a given problem [2]. Similarly, others have argued that creativity is crucial in the process of designing artifacts and therefore creating innovative solutions [3–6]. And vom Brocke and Maedche [7] have made a strong argument that creativity is the source of progress in DSR. They argued that potential solutions for

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perceived problems are continuously created and evaluated, to create design knowledge [7]. Thus, it can be argued that creativity is at the core of the DSR strategy of inquiry.

Despite its essential role, there is yet little guidance on the use of creativity methods in the DSR literature. Most methodological contributions emphasize rigor in DSR, and none of the established DSR process models or methodologies consider phases or tools to support creativity in DSR. A reason for that may be that the role of creativity had initially been neglected by scholars [8]. We see this lack of guidance as a missed opportunity. The creativity literature suggests that using fitting creativity methods is important, and without guidance the creative work of DSR scholars may be less impactful than it could be.

In this paper, we propose a Creativity-Methods-Fit Framework (CMFF). Building on the creativity literature, we suggest that the use of divergent and convergent thinking methods depends on the structuredness of the problem space and the solution space. We outline each of the four combinations and explain relevant creativity methods that can be used. This paper is of direct utility for DSR researchers and practitioners as it provides support to systematically leverage creativity in DSR projects. The paper also opens many research opportunities in further developing and evaluating techniques for DSR in combination with divergent and convergent DSR activities.

2 The need for Creativity in DSR

The concept of DSR originated from Simon's [9] efforts to teach artificial matter to engineering students and help them acquire the skills necessary for designing objects with specific properties. This includes teaching them how to think creatively and familiarizing them with different methods and techniques for creativity. According to Simon, design is a creative process, and DSR involves identifying problems and finding solutions by combining different components. This allows for a wide range of potential solutions, from which a new, feasible system can be developed using DSR processes [10]. Creativity methods in general are tailored to enhance the power of thinking in broad terms. Thus, creativity is considered as a form of intelligence that is used when facing open-ended questions. Nevertheless, managers responsible for innovation might find it challenging to understand these methods [11].

Creativity in DSR is an area of study that focuses on understanding the role that creativity plays in the DSR process and how it can be fostered and incorporated into DSR projects. Thinking about Design Theories, there have already been some research focusing on the perspective for Design Management. The scholars identified, that the study of creativity uncovers limitations, known as fixation effects, which are then targeted by new design theories. These theories develop new ways of thinking to overcome these limitations, but in turn, the new design theories can also create new limitations that will be identified by creativity research [12]. One of the main benefits of considering creativity in DSR is that it allows for the generation of novel and unique solutions to problems. This is particularly important in DSR, where the goal is to develop new and feasible systems [13]. Incorporating creativity into the DSR process can

also lead to more efficient development of artifacts. Another benefit of creativity in DSR is that it allows for the development of more user-centric solutions. When a wide range of potential solutions is generated through creative techniques, it increases the chances of finding a solution that is more tailored to the needs and preferences of the end-user [7]. However, there are also some potential downsides to incorporating creativity into DSR. One of the main challenges is balancing the need for analytical processes and creativity. DSR belongs to the field of business information systems, which typically involves logical structure and well-defined processes. Excessive structure and specifications can stifle creativity. Therefore, DSR processes must find a balance between analytical processes and creativity in order to generate even more unique solutions. In comparison to other research areas, creativity in DSR is a relatively new field of study with an already growing body of literature on the topic and it is gaining increasing attention in the field. Overall, incorporating creativity into DSR can lead to the generation of novel and unique solutions to problems and can improve the efficiency of the development of artifacts. In the future it will be important to balance the need for analytical processes and creativity to ensure that the results are both rigorous and practical.

The first step in DSR is to thoroughly define the problem in order to solve it. Runco [14] believes that all problem-solving is creative, as problems can be well-defined or ill-defined, with the level of creativity required varying depending on how clear the problem is. The same applies to the desired outcome or solution. DSR is a part of the field of business information systems, which typically involves logical structure and well-defined processes. However, excessive structure and specifications can stifle creativity. Studies in DSR have shown that regular evaluations and iterations are vital for the efficient development of artifacts [13] and allow for more creative freedom. In Design Theory there are some methods introduced, which differ from classical creativity technics. The success of this method is attributed to its departure from traditional creativity techniques. It encourages the sharing of information, improves the design process within businesses, and not only generates and evaluates ideas, but also helps to establish a design strategy [15]. The DSR research process must find a balance between analytical processes and creativity in order to generate unique solutions [6]. A successful DSR project requires a balance of both scientific rigor, involving technical approaches, science and convergent thinking and creative activities, which includes room for creativity, invention, design and divergent thinking. The key question in DSR is how to balance these two elements depending on the specific project.

3 The Role of Divergent and Convergent Thinking for Creativity

Starting with Guilford [16] many associate two types of thinking with creativity: divergent thinking, and convergent thinking (see **Fig. 1**). Divergent and convergent thinking complement each other in the process of finding novel problem-solution combinations. While divergent thinking leads to the generation of novel ideas, convergent thinking is related to evaluating their usefulness. Creativity research suggests that both processes

are necessary to come up with creative, that is, novel and useful ideas [17]. Below we discuss these two types of thinking in more detail.

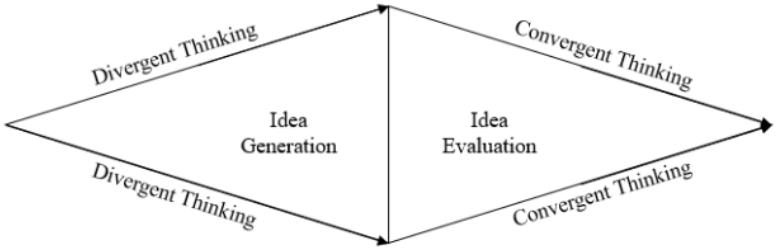

Fig. 1. Divergent and Convergent Thinking in DSR

First, divergent thinking is defined by Krampen [17] as being multitracked as well as innovative action whose characteristics are suitable for open-ended problems and unstructured end states. Divergent thinking is the innovative process and can be used in DSR for open structured problems and solutions to generate new ideas. Cropley [18] differs the characteristics of divergent thinking based on typical processes and results. He further characterizes typical processes as thinking unconventionally, combining the disparate, seeing new possibilities or shifting perspectives. Characteristics of typical results are alternate or multiple solutions, opening exciting up or risky possibilities and deviating from the norm. In the creativity literature there are a variety of methods that positively influence the abilities of divergent thinking and acting. Among the best known are intuitive methods such as brainstorming, brainwriting and synectics, as well as systematic-analytical methods, such as morphological methods [19].

Convergent thinking on the other hand is defined as single-track, deductive, and "intelligent" thinking and acting, and is therefore applicable for highly structured problem definitions and the search for the one correct solution [17]. Convergent thinking is suitable for clear, structured requirements with many restrictions regarding the problem or given solution [14]. According to Cropley [18], the characteristics of convergent thinking in typical processes are logical thinking, combining what belongs together, preserving the already known, and seeking accuracy and correctness. For typical results, the characteristics are quick answers, closure on an issue and a better grasp of the facts. Techniques such as scoring models, utility analysis, decision tables, or risk analysis are helpful for convergent thinking and action approaches [19].

4 The Creativity-Methods-Fit Framework (CMFF)

To provide guidance for DSR scholars using creativity techniques, we introduce the CMFF (**Fig. 2**). Building on Krampen [17], the CMFF suggests that the use of creativity techniques in DSR depends on the structuredness of the problem situation, and the final state (solution). By structuredness, we mean the available information, development opportunities, and the clarity of the initial situation. For both the problem and the solution, we distinguish between open and closed situations [17]. Open refers to problems

that have few restrictions and thus offer a lot of room for interpretation and an open-end state where many different solutions are conceivable [17]. Closed refers to a problem situation with many restrictions as well as an end state that refers to a specific solution [17]. For each of the four resulting combinations distinct creativity thinking patterns (divergent/convergent) should be used which are further explained below.

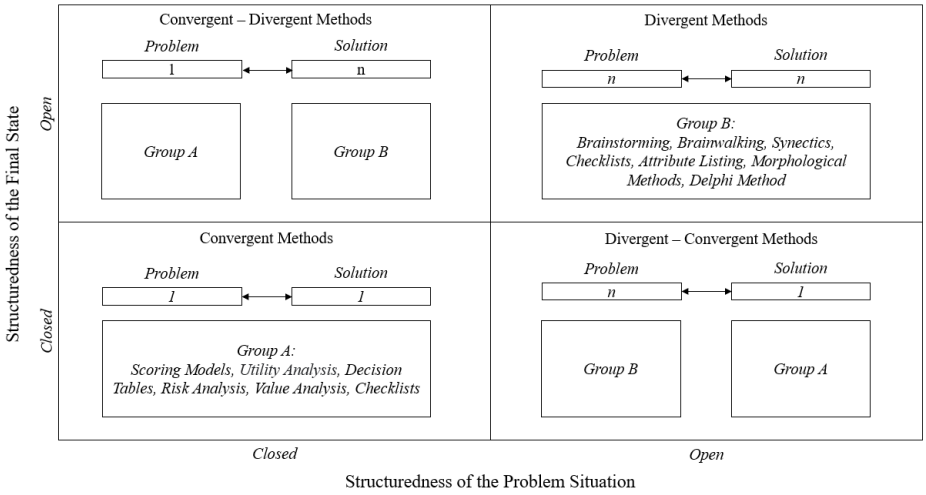

Fig. 2. The Creativity-Methods-Fit Framework (CMFF)

First, in structured problem and solution situations, it is appropriate to use *convergent thinking*. For example, when a company wants to use blockchain (solution) specifically for supply chain tracking (problem). The general conditions have been established and the issue is about optimal choice of a problem-solution combination. In this case convergent thinking is required to make deductive and intelligent decisions based on available options to match a defined problem with a known solution. Related methods that can be used are for instance scoring models, utility analysis, decision tables, checklists, or risk analysis (labelled Group A in Fig. 2). In the blockchain example from above, a decision table could be an appropriate method to make a choice for the most useful problem-solution combination.

Second, in case of a structured problem and an open solution, it is fitting to use methods of convergent and divergent thinking. A combination of *convergent-divergent* thinking can be described in relation to the model of Peffers et al. [20], where first the problem is defined, in order to then develop various solutions. Unlike the previous example, there are now several possible solutions to the transparent supply chain problem, as the end state is open. The blockchain would be just one of many possibilities. Convergent thinking defines clear constraints such as the requirements for the solution. Divergent methods like brainstorming, brainwalking, synectics, checklists, attribute listing, morphological methods or delphi method (labelled Group B in Fig. 2) can be used to develop a wide range of solutions based on this problem definition. One divergent method that can be considered for the above example is the morphological method, the

goal of which is to logically decompose the current problem into its constituent parts and assign all possible solutions in an orderly manner[19].

In the third field, the final state is defined and the problem is open for which *divergent-convergent* methods are most suitable. For example, in case scholars want to find novel applications for an existing blockchain solution, divergent methods such as the delphi method can be used. This method is based on expert interviews and can be used to predict problems of a more complex nature [19]. This includes, for example, predicting technical changes to the blockchain and thus identifying potential new problem areas, which are then evaluated and tested for blockchain feasibility using convergent methods such as the value analysis to determine the optimal cost-benefit ratio.

In the fourth quadrant, both the problem space and the solution space are rather unstructured, so that *divergent methods* are most useful for both areas [18]. Creativity is especially important because there is neither a defined problem nor a structured end state, so there is no clear starting point to narrow down the potential possibilities. The ideas developed will be radical breakthroughs and are not yet as common in DSR models [21] because the first step in the DSR process is to define the problem [20]. For example, brainstorming and brainwriting are suitable because the focus is on the quantitative aspect of idea production, the knowledge of several people can be included, and an immediate evaluation of the idea (and thus possible exclusion) is avoided [17].

5 Concluding Discussion

This paper was motivated by a lack of guidance on the use of creativity methods in the DSR field. Using fitting creativity methods can increase the effectiveness of artifact development and enhance the quality of the outcome while expanding the application areas of the developed solutions.

By introducing the CMFF, we provide guidance for selecting appropriate creativity techniques based on the different thinking patterns in various DSR projects. Taken together, this paper has two main implications for the DSR field.

First, with this paper we start to provide guidance for DSR scholars on how to use creativity methods effectively. More specifically, The CMFF provides guidance for using divergent and convergent methods based on the initial situation, which can be either unstructured or structured problems or solutions. Thus, the CMFF complements previous work providing frameworks related to evaluation methods. We think this is important because the development of design knowledge is often associated both with creative and evaluative processes [13, 22–26].

Second, we introduce the notion of creativity-method-fit to the DSR field. While the idea of methodological fit has strong roots in organizational research and fitting evaluation methods have been discussed in the IS field [27, 28] the idea of fitting creativity techniques is new to the DSR discourse.

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