IMAGINATION FROM EVALUATION

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DOI (link to publication from Publisher):
229505063

Publication date:
2016

Document Version
Også kaldet Forlagets PDF

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A DESIGN THEORY FOR CREATIVITY ENHANCING SYSTEMS

BY
FRANK ULRICH

DISSERTATION SUBMITTED 2015

AALBORG UNIVERSITY
DENMARK

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Dissertation submitted September 01, 2015

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Dissertation submitted:	September 01, 2015
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PhD Series:	Faculty of Engineering and Science, Aalborg University

ISSN (online): 2246-1248
ISBN (online): 978-87-7112-526-9

Published by:
Aalborg University Press
Skjernvej 4A, 2nd floor
DK – 9220 Aalborg Ø
Phone: +45 99407140
aauf@forlag.aau.dk
forlag.aau.dk

Printed in Denmark by Rosendahls, 2016

ENGLISH SUMMARY

Creativity is a complex endeavor for most organizations. Creativity Enhancing Systems (CES) help organizations collect and organize ideas, whereas idea evaluation allows organizational actors to identify the value of the collected ideas. However, idea evaluation accounts for a small proportion of the Information system (IS) literature on creativity. Moreover, management research has criticized existing idea evaluation approaches for discouraging creativity by imposing strict management regimes. Idea evaluation is known to only encourage convergent production (that narrows many ideas into a few tangible alternatives) while ignoring divergent production (resulting in many different ideas from wild and unconventional thoughts patterns). This PhD study reports on how CES can help organizational actors use the knowledge obtained during idea evaluation and use it to encourage divergent and convergent thinking. This research is based on two literature reviews on, respectively, creativity in the IS research field and an extended review on CES. Moreover, the PhD thesis reports on extensive theory development related to idea evaluation. To support the propositions from the theoretical development, the PhD study also reports on a multiple case study that illustrates the developed theory in practice. In addition, a laboratory experiment measures the effectiveness of CES using knowledge from idea evaluation to encourage divergent production. Finally, a field experiment reports on the development of a CES prototype that uses idea evaluation to encourage divergent and convergent production. To merge the findings from the PhD study into one unit, the individual research articles are synthesized into a design theory for CES-supported idea evaluation.

The PhD study adds several contributions to the current understanding of idea evaluation and CES. Among these contributions is a new design theory that increases the limited amount of CES design theories within the IS literature. Centered on design science, this PhD study demonstrates how a theory-focused conceptualization of the initial problem leads to theory development and creates the foundation for design theory. This approach offers new inspiration to future studies within design science. Theory development in the PhD study also includes a new theory on organizational creativity based on Scandinavian institutionalism and a unified operationalization of creativity that is free from ambiguity. Moreover, the PhD study includes an alternative idea evaluation approach. By encouraging both divergent and convergent production, this approach challenges the common belief that idea evaluation only supports convergent production. Through these findings, the PhD study shows that conventional idea evaluation approaches are designed specifically to encourage convergent production and exclude divergent production. Overall, this PhD study provides new insights into idea evaluation, organizational creativity, and CES. These insights are synthesized into a design theory that may contribute to future work in the above areas of research.

DANSK RESUME

Kreativitet er komplekst for de fleste organisationer. Kreativitetsunderstøttende systemer (CES) hjælper organisationer med at indsamle og organisere ideer, imens idéevaluering hjælper organisatoriske aktører med at identificere værdien af de indsamlede ideer. Men idéevaluering tegner sig for en lille del af litteraturen omhandlende informationssystemer (IS) og kreativitet. Desuden har ledelsesforskning kritiseret eksisterende tilgange til idéevaluering for at påskynde en rigoristisk ledelsesform, der demotiverer kreativ tænkning. Idéevaluering er desuden kendt for kun at understøtte konvergent produktion, der indsnævrer mange ideer til et par håndgribelige alternativer. Samtidigt er idéevaluering kendt for at ignorerer divergent produktion, der ellers kunne resultere i mange forskellige ideer fra vilde og utraditionelle tankemønstre. Dette PhD-studie undersøger hvorvidt CES kan hjælpe organisatoriske aktørers divergente og konvergente tænkning, ved at bruge den viden som bliver skabt gennem idéevaluering. Denne forskning er baseret på to litteraturstudier. Det første studie kortlægger kreativitet i IS-forskningsfeltet, hvorefter det andet studie tilføjer en udvidet gennemgang af litteraturen omhandlende CES. I tillæg til litteraturstudierne, inkluderer PhD-studiet også omfattende teoriudvikling relateret til idéevaluering. Den teoretiske udvikling er derefter fortolket gennem to case studer der illustrerer teorien i praksis. Desuden er empirisk data fra et laboratorieforsøg og et felteksperiment inkluderet. Laboratorieforsøget måler effektiviteten for divergent produktion, når CES bruger viden fra idéevaluering i den kreative proces. Felteksperimentet omhandler udviklingen af en prototype for et CES, der bruger idéevaluering for at understøtte divergent og konvergent produktion. Afslutningsvis, er resultaterne fra de individuelle forskningsartikler blevet samlet i en design teori for et CES, der understøtter divergent og konvergent produktion.

Dette PhD-studie tilføjer en række bidrag til vores nuværende forståelse af idéevaluering og CES. Blandt disse bidrag er et ny design teori, der øger den begrænsede mængde CES design teorier indenfor IS litteraturen. Centreret omkring design science, viser studiet hvordan en teorifokuseret konceptualisering af det oprindelige problem kan føre til teoriudvikling og derved skabe et grundlag for designteorien. Denne fremgangsmåde kan give ny inspiration til fremtidig forskning inden for design science. Teoriudviklingen i PhD-studiet indeholder også en ny teori om organisatorisk kreativitet baseret på skandinavisk institutionalisme, samt en operationalisering af kreativitet som er fri for tvetydighed. Desuden indeholder PhD-studiet en alternativ tilgang til idéevaluering. Ved at tilskynde både divergent og konvergent produktion, udfordrer denne tilgang den gængse opfattelse; at idé evaluering kun kan understøtte konvergent produktion. Gennem disse resultater, viser PhD-studiet, at konventionelle idéevalueringstilgange er designet specielt til at fremme konvergent produktion og ekskludere divergent produktion. Samlet, tilføjer forskningsartiklerne i PhD-studiet ny indsigt til kreativitet, idéevaluering og CES. Denne indsigt er herefter blevet syntetiseret i en design teori, der kan bidrage til fremtidig udvikling i de overstående forskningsområder.

ACKNOWLEDGEMENTS

During my three years of Ph.D. studies, I had the fortunate experience of meeting many whole-hearted and inspiring people. I would especially like to thank my two supervisors; Jeremy Rose for putting up with me during the first year; Peter Axel Nielsen for surviving me the last two years and for his valuable input during our talks. Moreover, I thank Nis Bornoe and Jane Billestrup for laughs and inspiring talks during the three years we shared the same office. I also thank my current and past colleges at the Center for Socio-Interactive Design.

The research articles included in this Ph.D. thesis was created in collaboration with a number of different people. I thank Sune Dueholm Müller, Shegaw Anagaw Mengiste, and Peter Axel Nielsen for their collaboration on research articles during my Ph.D. studies. I also thank Jan Pries-Heje and Richard Baskerville for introducing me to Design Science. Finally, I thank my mom Hjørdis and Niels for always caring, and those friends who supported my endeavors during my stay in Aalborg.

Frank Ulrich

Aalborg. August, 2015

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CHAPTER 1. INTRODUCTION

This chapter considers the motivation for conducting the research, the subject area, and the objectives of the PhD study. Moreover, this chapter outlines the structure of the thesis. The motivation for conducting the research is grounded on the management need for exploring new ideas in the increased hypercompetitive environment of global information technology (IT). In this environment, public and private organizations need novel ideas to create innovative technology products and services. Such efforts require idea evaluation approaches and supporting systems that increase, rather than decrease, their innovation efforts. Hence, this PhD study explores how idea evaluation can motivate creative thinking and be integrated in an information system (IS) artifact for creativity support.

1.1. MOTIVATION

Organizational creativity is highly complex (Stacey 1996; Ulrich and Mengiste 2014), and it is a requirement for surviving in the hypercompetitive environment of global IT controlled by rapid innovation and moving technology trends. Organizations use idea evaluation to identify the value of those ideas that are transferable to innovative products and services (Amabile et al. 2005; Di Gangi and Wasko 2009; Girotra et al. 2010). However, determining the value of ideas is highly complex (e.g., Dean et al. 2006), and to support organizational creativity, organizations must use systems that can support the collection and sharing of input from users and experts (Di Gangi and Wasko 2009; Kletke et al. 2001). Such systems are commonly known as Group Creativity Support Systems (GCSS) for group support (e.g., idea portals) and Individual Creativity Support Systems (ICSS) for individual support (e.g., Adobe Photoshop). Unified, this specific class of systems can be defined as Creativity Enhancing Systems (CES). As such, CES are specifically designed for the purpose of enhancing individual or group creativity, for example, using electronic brainstorming or embedding other creativity techniques into the electronic idea-generation process. In addition, CES has several advantages over analog (pen and paper) approaches and non-specialized software (e.g., word processors). For example, CES is known to lead to better management decisions by producing more quality-ideas over analog approaches (Massetti 1996) and non-specialized software (MacCrimmon and Wagner 1994).

However, from the early days of IS creativity management and support, idea evaluation has been prominent as a neglected area of research (c.f., Research Article 1). As such, IS researchers have only added five dedicated journal publications (Chan et al. 2011; Connolly et al. 1990; Dean et al. 2006; Gomes et al. 2006; Reinig et al. 2007) and three conference papers (Blohm and Riedl 2011; Couger and Dengate 1992; Riedl et al. 2010) to the subject over the last 15 years. The literature also reveals another interesting attribute. Although IS creativity support, such as electronic brainstorming, can improve creative group work (Elfvengren et al. 2009; Kohler et al. 2011) and facilitate knowledge sharing (Greene 2002), no IS contributions have explored how idea evaluation practices can be transferred into an IS artifact, or whether it can even support creative thinking. In fact, early creativity research has suggested that critical thinking should be omitted from the creative process (Osborn 1953). This suggestion has influenced researchers and practitioners to conclude that idea evaluation should be external to the creative process (Elam and Mead 1990; Osterwalder and Pigneur 2010). However, during the last four years of researching the subject, I have been unable to find any empirical evidence to support this claim. In fact, later research has shown that evaluative thinking is an important component in the overall creative thinking abilities of individuals (Moeran and Christensen 2013; Runco 2002). Because idea evaluation have been removed from the creative process, the creativity management literature has heavily criticized existing evaluation practices for introducing strict management regimes that motivate biased thinking (Amabile 1983; Blair & Mumford 2007; Licuanan et al. 2007; Mueller et al. 2012), and for demotivating incentives to act creatively within the organization (Amabile 1996, 1998; Amabile et al. 2005). Hence, there is need within the literature to explore new avenues for alternative idea evaluation approaches centered on enhancing creative thinking within the organization using IT.

Creativity is a complex and often chaotic process (Stacey 1996), and idea evaluation is no different when explored in depth. The first research challenge of this PhD study was to gain a fundamental understanding of the inner system dynamics of creativity and idea evaluation, and how these two social constructs are interconnected in an organizational and technological context. This inherent complexity of the research subject makes it both intriguing and challenging to comprehend. As many other PhD projects before this, it started by asking a simple “what if?” question. The question was “What if idea evaluation could enhance creative thinking?” This question emerged after reviewing the literature. However, operationalizing this question proved to be a significant research challenge. The main bulk of existing research is centered on viewing idea evaluation as a measurement or benchmarking process. Hence, understanding the initial question required the development of a new theory that could explain idea evaluation as an IS artifact and the interrelationship between organizational creativity and evaluative thinking. The second research challenge was the evaluation of this new theory. Because the PhD study is technology-based, this evaluation of the proposed theoretical constructs require design and development of novel software prototypes that can support idea evaluation and creative thinking simultaneously. The main body of research suggests that such setup will have a negative outcome. Hence, the research challenge was to follow my intuition and thereby take a calculated risk, given that the project might not produce any significant results. The third and final challenge was to synthesize the theoretical constructs into a unified design theory for CES. This merge required the use of design science to synthesize knowledge from individual research articles into a unified design theory.

Hence, this PhD study seeks to enrich the state-of-the-art research by adding some of the missing pieces through four objectives: The first is the development of an alternative idea evaluation approach that differs from the existing by encouraging creative thinking. This approach is framed as dynamic idea evaluation. The second is the integration of dynamic idea evaluation into an IS artifact. The third is an empirical test of the IS artifact. The fourth is the collection of learning from theory development and empirical testing, and the synthesis of such learning into a unified design theory for a new class of CES.

1.2. THESIS STRUCTURE

This PhD study synthesizes five individual research articles into a design theory for an IS artifact that supports dynamic idea evaluation. The five research articles are as follows:

1. A literature review of creativity in the IS research field.
2. A framework that addressed the organizational and sociotechnical aspects of idea evaluation and creativity. The framework was illustrated through a multiple case study.
3. Theoretical work that addressed the system dynamics of idea evaluation. Chaos theory is used to compare and contrast two opposing idea evaluation approaches, and provide new insights for future research in CES-supported creativity and idea evaluation.
4. A laboratory experiment that used Amazons' Mechanical Turk. This experiment measured whether knowledge obtained during CES-supported idea evaluation is effective in encouraging creative thinking.
5. A field experiment concerning the development and use of CES-supported idea evaluation. The field experiment was conducted in a Danish research department.

Chapter 2 of the thesis includes a theoretical background based on the state-of-the-art literature on creativity and idea evaluation. It provides the definitions of creativity and idea evaluation used in the thesis, and a review of current idea evaluation practices that include perceived knowledge gaps. Based on the theoretical backdrop and identified knowledge gaps within the literature, the alternative dynamic approach and research questions are presented. Chapter 3 introduces the overall research approach that answers the research questions. Chapter 4 presents a research summary of the five articles and their coherence. Chapter 5 synthesizes the five individual academic articles into a design theory for dynamic idea evaluation in CES. Finally, the contributions of the thesis are discussed in chapter 6 and concluded in chapter 7.

CHAPTER 2. THEORETICAL FRAMEWORK

This chapter considers the theoretical and conceptual framing of the thesis. Section 2.1 presents operational and complexity views on organizational creativity, followed by the definition of organizational creativity used in the thesis. In section 2.2., the state-of-the-art research on CES is outlined in detail. Furthermore, static and dynamic idea evaluation is reviewed in Section 2.3. From this combined body of knowledge, three guiding research questions are finally presented in Section 2.4.

2.1. ORGANIZATIONAL CREATIVITY

This study draws on two streams of organizational creativity research. The first is concerned with operational views on organizational creativity. This operational stream of research originates from early contributors to the field, such as Rhodes (1961) and Ackoff & Vergara (1981), who placed their organizational frames in the cognitive interpretations of individual creativity. To some degree, the operational stream of research shifted focus when Amabile (1983b, 1996) argued for changing focus away from personality traits to understanding the creative product, task motivation, and creativity and task-related skills.

The second stream of research is younger and interacts with organizational creativity from a holistic complexity view. This research is inspired by earlier work on creativity. However, at its core, the complexity literature is situated in organizational research on sensemaking (Drazin et al. 1999), IS design thinking (Avital and Te'eni 2009), institutionalization (Czarniawska and Joerges 1995), and complexity studies (Stacey 1996).

2.1.1. OPERATIONAL RESEARCH

Traditionally, there are no unified views on the inner workings of creativity, or a clear-cut definition of creativity. Couger (1996a) argued for over 100 different explanations of the subject of creativity, whereas Rhodes (1961) collected 40 definitions on creativity and 16 definitions on imagination. By examining the definitions and locating their overlaps, Rhodes (1961) identified four common operational nominators: Person, Process, Press, and Product (also called the 4P framework). *Person* refers to individual creative abilities. Rhodes (1961) positioned Person to the traits, behavior, and abilities of an individual. Hence, Person is about the existing creative gifts of an individual. *Process* is concerned with strategizing creativity through programs for learning, motivation, perception, thinking, or communication. Process is hence a nominator for issues connected to learning and motivating creativity, and for strategizing such learning and motivational patterns within the organization. *Press* is about the influence of the environment on creativity. Rhodes (1961) argued that individuals are influenced by internal and external sources when they produce ideas from their memories, daily experiences with others, and perception of the environment. As Rhodes (1961;308) argued, *"one man's meat is another man's poison and vice versa."* In essence, Press encompasses creativity as being sensitive to the surrounding environment. To accommodate this sensitivity, the environment must be adjusted toward creativity. *Product* is about the creative outcome, that is, creativity embodied into ideas or product and service innovations. In Rhodes (1961;309) view *"products are artifacts of thoughts."* Hence, products are the reflections of the inventor's creative thinking and are subject for reconstruction and investigation.

Ackoff & Vergara (1981) argued for two dominant views within the research field of creativity. These views position creativity as either *origin*-oriented or *processor*-oriented[1]. The *origin*-oriented view sees creativity as an individual characteristic influenced by his/her environment. The *origin*-oriented work originates from psychoanalysts, humanistic psychologists, and psychometricians. First, the psychoanalyst Freud (1970) argued that creativity arises through internal conflicts, or the natural creative potential in the individual. This form of creative thinking is unconscious, random, or impulsive. Second, humanistic psychologists (Fromm 1959; Maslow 1959; Rogers 1970) view creativity as a product of conflict-free individuals who thrive in healthy creativity-enabling environments supported by the removal of constraints that can inhibit individual creativity. In their view, creativity arises when no conflicts are present in the individual, who in return receives complete freedom to symbolize his/her creation. Third, psychometricians, such as Guilford (1956, 1950, 1959, 1967, 1977), view creativity as part of the genetic composition of an individual, and as being subject to measurement by formalized tests. Moreover, Guilford (1967, 1977) divided creativity into two types of creative production: divergent and convergent[2]. Divergent production is the result of wild and unconventional thought patterns that allow individuals to create many different ideas. Convergent production, however, narrows many ideas into a few tangible alternatives. Moreover, divergent production looks for many answers to a problem, whereas convergent thinking has clear-cut borders, encompasses critical judgment, and looks for single solutions. This PhD study uses divergent and convergent production in two ways: in thinking by

[1] Ackoff and Vergara (1981) used the term "process." In this thesis, this term is redefined to "processor" in order to avoid confusion with Rhodes' (1961) use of "process" in his 4P model.

[2] In some of research articles, divergent and convergent production is conceptualized as divergent and convergent thinking. However, in the merging of those research articles, thinking is replaced with production to adapt the conceptualization to the creative product.

understanding thought processes of human actors, and in product by understanding the outcome of human thinking.

The *processor*-oriented view sees creativity as information processing that can be improved through learning and practice (Ackoff and Vergara 1981). The *processor*-oriented work originates from cognitive science theorists, gestalt psychologists, and associationists. First, cognitive science theorists view human cognitive thinking similar to information processing in computer programs (Newell and Shaw 1972). Here, focus is on productive or novel ways for processing problematic situations (Ackoff and Vergara 1981). Second, gestalt psychologists view creativity as the cognitive identification of problem requirements in order to locate functional solutions for those requirements (Dunker 1945). Moreover, humans require new learning abilities or proper instruction to enhance their creative ability to reorganize past experiences that allow them to identify novel solutions to specific problems (Wertheimet 1959). Third, associationists, such as Mednick (1962), view creativity as the human ability to explore and evaluate responses to incoming problems. In this process, humans link and explore remote novel associations by drawing a mental line from a novel association to a specific problem, for example, by creating analogies of creating a novel solution to the problem (Mednick 1962).

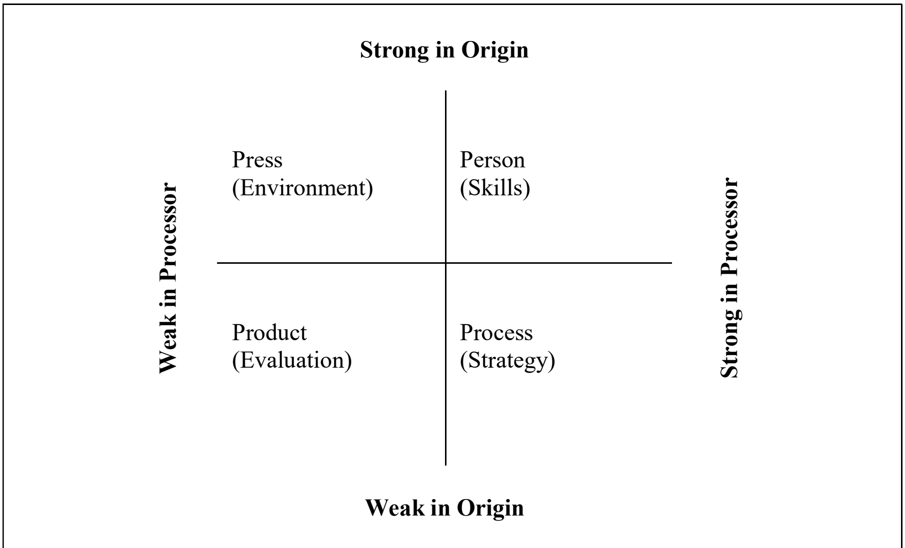

Figure 1: Model for Organizational Creativity

Combining Rhodes' (1961) 4P model with Ackoff & Vergara's (1981) dominant views (Figure 1), we can see that Press is weak in processor, but strong in origin orientation. As Fromm (1959) argued, the environment directly affects an individual's ability to cope with conflict. This ability to cope with conflict influences human imagination (Freud 1908). Person is strong in origin and processor by combining both orientations when including an individual's natural ability to form creative thoughts. Such abilities can be enhanced using creativity techniques (Couger et al. 1993). Product is traditionally weak in origin and processor. Products are, as Rhodes (1961) argued, artifacts of human thinking. Artifacts, including IS artifacts, are also the subject of judgment by others (Couger and Dengate 1992). Process is weak in origin, but strong in processor orientation because of its emphasis on using learning to drive creative organizations forward through organizational strategies. Such learning is achieved using deliberate programs and methods to enhance creative thinking (Couger et al. 1993).

Later operational views on organizational creativity originate from Amabile (1983b, 1996). Although Amabile (1983b) argued for social psychology of creativity, her later work demonstrated that her unit of analysis is situated in an organizational context (e.g., Amabile and Khaire 2008; Amabile 1988, 1989, 1998; Amabile et al. 1996, 2005).

Amabile (1983b) criticized earlier creativity research for being too focused on the creative person and he/hers natural endowment in any situation (e.g., Guilford 1967, 1977). For example, Amabile (1983b;373) stated that *"It can be argued that the strong emphasis on personality in creativity research have fostered a set of restrictive conceptions about creativity and a neglect of some important variables."* Instead, she was strongly inspired by traditional cognitive views that focus on process, press, and product by referring to social and environmental factors. In her view of organizational creativity, she emphasized that creativity is learnable and dominated by domain-relevant skills that include domain knowledge and technical skills. Moreover, she argued for creativity-relevant skills that involve work style and idea generation skills. In her press view, she argued for task motivation that involves attitudes and the perception of motivation toward the task. However, Amabile's (1983b) operational view on creativity originated from its outcome, namely, the creative product. Amabile (1983b) argued that for a creative product to be considered creative, it must be considered novel and useful by others. Moreover, the task to be solved must be heuristic and not algorithmic. If the task is algorithmic, the creator is simply following a recipe and the product is not creative. However, if the task is heuristic and there is no ready-made path or "algorithm" to the solution, the product is creative.

2.1.2. COMPLEXITY RESEARCH

The previous section is concerned with creativity in accordance to the creative product. It argued that creative products are manifestations of creative thinking (Rhodes 1961). As such, creative products can manifest themselves in physical forms through descriptive algorithms, processes, and implementations such as software and hardware. Creative products can also be manifested in conceptual forms through ideas. However, where the operational literature is concerned with the social psychology of organizational creativity, the complexity literature views organizational creativity as a chaotic entity that influences human behavior and changes established organizational structures. This section digs deeper into the conceptualization of ideas and complex knowledge processes and organizational issues associated with the creation of ideas.

Complexity and chaos theory attempt to explain how systems go from stability to being chaotic, and then back to stability (Schuldberg 1999). Stacey (1996) argued that creativity is inherently chaotic because it is non-linear and involves unforeseen outcomes. One reason for the chaotic nature of creativity is that creative products are sensitive to fluctuations (feedback) in the environment that amplify small changes over time (You 1993). Schuldberg (1999:187) argued in a similar vein that *"creative endeavors involve context-sensitive adaptation to fluctuating environments."* Hence, in Schuldberg's view, creativity adapts to psychical changes in the environment and to sociological changes in culture, norms, and practices.

New institutionalism has adopted a similar complexity view on creativity and its product. In this view of new institutionalism, creativity is shaped by human interaction that provides interpretations and meaning of the creative actions of others, and determines their level of engagement (Drazin et al. 1999). In such situations, human actors use sensemaking to create order out of the apparent chaos from the flux of new events and input (Weick et al. 2005). Novel and previously unknown ideas are equally reprehensive as chaotic flux to human actors. As such, creativity and sensemaking share chaos as a common starting point (Weick 1993; Weick et al. 2005). If ideas are to be institutionalized, they must undergo judgment by human actors (Drazin et al. 1999; Runco and Jaeger 2012). The creative production and its institutionalization is hence a product of sensemaking, and it is a compromise between human actors that attempt to derive meaning from the actions of others and the chaos represented by novel and previously unknown ideas.

Similarly to the operational view on creativity, Scandinavian institutionalism has adopted a product view of the creative output. Because ideas are built from human knowledge (Ward 2004), they eventually materialize (Czarniawska 2009) when transferred to social entities, such as documentation, models, and technologies (Valikangas and Sevon 2010). Moreover, ideas can travel across organizational boundaries where they are enacted and can be disruptive over time and space (Czarniawska and Joerges 1995). As Weick (2004: 657) argued, *"Ideas shape ideas, they lead on to other ideas, they enact their own contexts."* In a similar vein to generativity, Avital and Te'eni (2009) claimed that creative products contain a generative fit that encourages the generative capacity of human actors, thus provoking new ways of thinking that challenge the existing status quo. As such, from an institutional complexity view, organizational creativity is evolutionary by encouraging human action to create new knowledge from existing, and in the process, encourage new human action.

2.1.3. SUMMARY AND DEFINITIONS OF CREATIVITY

In summary, operational views on organizational creativity (Rhodes 1961) are situated within understanding how process and origin thinking influence or are influenced by the environment (Press), personality characteristics (Person), the creative outcome (Product), and learning and strategies (Process). Within the same lines, Amabile (1983b, 1996) argued for a framework that requires a range of different factors to make organizational creativity functional. Later creativity research supports this claim by showing that organizational creativity involves multifaceted structures to be successful (e.g., Ulrich and Mengiste 2014). Moreover, Amabile's (1983b) operational definition of creativity situated in the product is used in a range of modern organizational and IS research (e.g., Couger 1996a; Elsbach and Hargadon 2006; Mainemelis 2010; Sosa 2011).

However, Amabile's (1983b) operational definition of creativity has some limitations. First, her definition focuses on defining the creative product, motivation, and task-related skills. It does not tell much about the inner workings of creativity itself. Second, Amabile's definition is situated at a fixed point in time. Later research demonstrates that creative products are enacted and expanded, in addition to travelling and evolving over time and space (Czarniawska and Joerges 1995). Creative products are also disruptive, and can alter or remove existing equilibriums (Czarniawska and Joerges 1995; Ford and Sullivan 2004; Stacey 1996; Weick 1993). Hence, only to a limited extent can Amabile's definition explain this generativity of the creative product and its ability to be disruptive.

Accordingly, this PhD study initially uses a modified definition of creativity that is situated in the presented organizational model (Figure 1), Amabile's (1983b) operational definition of creativity, and later views creativity as being disruptive and evolutionary. Hence, creativity is initially defined on three different levels:

- Cognitively, by being a product of either divergent or convergent production (Guilford 1967, 1977).
- Operationally, by involving the entire organization (Rhodes 1961) and by being measurable through its outcome and task-sensitivity (Amabile 1983b).
- Evolutionally, by being enacted from existing knowledge and being disruptive over time and space (Czarniawska and Joerges 1995; Ford and Sullivan 2004; Stacey 1996; Weick 1993).

In this thesis, this definition is reevaluated in context to the presented results. In the following section, IS support of creativity is reviewed.

2.2. CREATIVITY ENHANCING SYSTEMS

Using IS to enhance creativity is known with many names. Common definitions are Group Creativity Support Systems (GCSS) and Individual Creativity Support Systems (ICSS) (Müller-Wienbergen et al. 2011), Electronic Brainstorming (EBS) (DeRosa et al. 2007), and creativity support in Decision Support Systems (DSS) (Durand and Vanhuss 1992) or Group Decision Support Systems (GDSS) (Nunamaker 1987). In this thesis, these different definitions are unified into the term "Creativity Enhancing Systems (CES)."

In this section, the CES literature is systematically reviewed and synthesized into three dominant research streams. The purpose of the review is to organize the state-of-the-art literature in order to place the contributions of the PhD study within the current body of knowledge. The review contains a comprehensive literature search, synthesis of the CES literature, and summary of the findings.

2.2.1. LITERATURE SEARCH

This PhD study is built upon an initial literature review (c.f., Research Article 1). However, the literature for that review was collected in late 2011. Moreover, focus was not specifically on CES, but on systematically searching all the journals in the AIS journal list to map the creativity literature within the entire IS field. To update the review and perform an in-depth review on state-of-the-art CES literature, the original literature review was revisited. To ensure quality in the review, focus was on journal articles. First, 39 articles concerning CES were extracted from the original review. The keywords from titles and abstracts in those contributions resulted in a comprehensive Web of Science (WoS) search string[3].

The WoS search resulted in 315 "hits." Filtering by journal article reduced the search result to 177 hits. Reviewing the titles and abstracts from the search resulted in 31 new contributions. Finally, a forward/backward search (Webster and Watson 2002)

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[3] TOPIC: (creativ* NEAR "CSCW") OR TOPIC: (creativ* NEAR "Computer Supported Cooperative Work") OR TOPIC: (creativ* NEAR "support tool*") OR TOPIC: (creativ* NEAR "design theory") OR TOPIC: (creativ* NEAR "GSS") OR TOPIC: (creativ* NEAR "group support system") OR TOPIC: (creativ* NEAR "CSS") OR TOPIC: (creativ* NEAR "creativity support system") OR TOPIC: (creativ* NEAR "ICSS") OR TOPIC: (creativ* NEAR "individual creativity support system") OR TOPIC: (creativ* NEAR "DSS") OR TOPIC: (creativ* NEAR "decision support system") OR TOPIC: ("electronic brainstorming") OR TOPIC: ("idea processor*") OR TOPIC: ("idea portal*") OR TOPIC: ("creativ* software") OR TOPIC: (creativ* NEAR "groupware") Refined by: DOCUMENT TYPES: (ARTICLE) Timespan: All years. Search language=Auto

was conducted. This search resulted in 16 additional contributions. In total, the updated review consists of 86 CES journal contributions.

2.2.2. LITERATURE SYNTHESIS

The literature was synthesized by identifying reoccurring concepts or themes (Webster and Watson 2002). When contributions included multiple themes, the dominant theme was selected. As shown in Table 1, the CES literature was synthesized within three different research steams: CES *design*, *effectiveness*, and *adoption* literature.

First, the CES design literature is concerned with the design principles, guidelines, and testable propositions that provide prescriptions for practice and outline future research. Second, the CES effectiveness literature addresses the effectiveness of CES at a technical, methodological, and behavioristic level. Third, the CES adoption literature examines how to implement CES in the organization and the benefits contributed to CES.

Table 1: CES Literature

Research stream	Core idea	Representative studies
CES design literature	To provide general design principles, guidelines, and testable propositions for CES.	(Aiken and Carlisle 1992; Bond and Otterson 1998; Chen 1998; Clapper 1996; Elam and Mead 1987, 1990; Elfvengren et al. 2009; Gomes et al. 2006; Greene 2002; Hailpern et al. 2007; Hewett 2005; Hori 1994; Kerne et al. 2009; Kletke et al. 2001; Lubart 2005; MacCrimmon and Wagner 1994, 1992; Munemori and Nagasawa 1991, 1996; Nakakoji et al. 1999; Shibata and Hori 2002; Shneiderman 2000, 2002, 2007; Shneiderman et al. 2006; Sielis et al. 2011; Young 1987; Yuan and Chen 2008) (Marakas and Elam 1997)
	To provide design principles, guidelines, or propositions for CES aimed at specific platforms and/or settings.	(Abrams et al. 2002; Andreichicov and Andreichicova 2001; Gerber and Martin 2012; Javadi et al. 2013; Noguchi 1997).(Leimeister et al. 2009)
	To design CES through design rules that provide explanatory, explicit, and theory-based principles for constructing the artifact, its form and function, and its testable hypotheses.	(Müller-Wienbergen et al. 2011; Voigt et al. 2013)

Table 1: CES Literature – Continued		
Research stream	Core idea	Representative studies
CES effectiveness literature	To compare the effectiveness of CES over other methods, techniques, and approaches for creative thinking.	(Althuizen and Wierenga 2014; Dennis and Valacich 1993; DeRosa et al. 2007; Durand and Vanhuss 1992; Easton et al. 1990; Gallupe et al. 1994; Kerr and Murthy 2004; Massetti 1996; Nagasundaram and Dennis 1993; Ocker et al. 2013; Valacich et al. 1994; Wierenga and van Bruggen 1998)
	To compare the effectiveness of creative methods, techniques, and approaches embedded in CES.	(Aiken et al. 1996; Cheung et al. 2008; Dennis et al. 1996, 2011; Garfield et al. 2001; Hender et al. 2002; Malaga 2000; Michinov 2012; Potter and Balthazard 2004; Shaw et al. 1993)
	To examine whether CES effectiveness is influenced by group size and dynamics.	(Aiken et al. 1994; Barki and Pinsonneault 2001; Connolly et al. 1990; Cooper et al. 1998; Coşkun 2011; Dennis and Valacich 1999; Dennis et al. 1999; Dornburg et al. 2009; Gallupe et al. 1992; Ivanov and Cyr 2014; Klein and Dologite 2000; McLeod 2011; Michinov and Primois 2005; Michinov et al. 2014; Nunamaker 1987; Paulus et al. 2013; Pinsonneault et al. 1999; Ray and Romano 2013; Roy et al. 1996; Satzinger et al. 1999; Shepherd et al. 1996; Sosik et al. 1998a, 1998b)
CES adoption literature	To understand CES adoption.	(Dennis and Reinicke 2004; Di Gangi and Wasko 2009; Lindic et al. 2011; Siau et al. 2010)

CES design literature. The main bulk of studies within the CES design literature address the design principles, guidelines, and testable propositions that provide prescriptions for practice and guide future research. In this literature stream, empirical evidence is provided from design principles and/or their transfer into a design artifact. The CES design literature stream originates from the Decision Support Systems (DSS) literature. Young (1987) and Elam and Mead (1987, 1990) were the first to realize that IS can enhance creativity. In the process, these researchers created design principles for supporting it in decision support systems. Marakas and Elam (1997) later replicated and confirmed Elam and Mead's (1990) initial findings. Later CES studies follow Elam and Mead's (1987, 1990) ideas by including their own generative propositions and requirements to enhance creativity and guide future work (Hewett 2005; Hori 1994; Kletke et al. 2001; Lubart 2005; Shibata and Hori 2002; Sielis et al. 2011), whereas others proposed design principles for improving group-work (Aiken and Carlisle 1992; Elfvengren et al. 2009; Hailpern et al. 2007; Munemori and Nagasawa 1991, 1996). Other researchers focused on enhancing creativity using creativity techniques. Such electronic techniques include design analogies (Bond and Otterson 1998; Gomes et al. 2006), and visual and textual stimuli (Kerne et al. 2009; Nakakoji et al. 1999) such as metaphors (MacCrimmon and Wagner 1994, 1992) and brainstorming (Clapper 1996; Yuan and Chen 2008). Some of the early design principles were summarized in later studies. For example, Chen (1998) theorized that CES that encompasses the de-structuring and restructuring of problems and ideas is generative and explorative, and functions through the use of virtual aids, such as symbols, images, and diagrams. Greene (2002), Shneiderman (2000, 2002, 2007), and Shneiderman et al. (2006) created several generic principles for CES. These design principles include supporting exploratory searches and thinking, iterative learning and creation, collaboration, virtualization, and interface usability.

However, some design studies are platform or setting-specific. These design studies include CES design principles for Internet-based group-work (Gerber and Martin 2012), user interfaces for electronic brainstorming (Javadi et al. 2013), idea competitions (Leimeister et al. 2009), composing music (Abrams et al. 2002), virtual worlds (Kohler et al. 2011), artificial intelligence (AI) support for redundant tasks in creative work (Andreichicov and Andreichicova 2001), and idea sketching in industrial design (Noguchi 1997).

Within the last five years, researchers have turned their attention toward design science in order to construct and evaluate CES. Design science differs from other design studies by having design rules with explicit focus on explanatory and theory-based principles for constructing the artifact, its form and function, and its testable hypotheses (e.g., Gregor and Jones 2007). For example, Müller-Wienbergen et al. (2011) constructed a GCSS that retrieves knowledge to trigger users' divergent and convergent thinking, whereas Voigt et al. (2013) demonstrated design theory for a groupware system that supports contradictory properties of structuring workflow processes while maintaining creative freedom.

CES effectiveness literature. The second research stream is CES effectiveness literature. Researchers are placing great emphasis on examining how CES influences creative effectiveness compared with methods, techniques, and approaches for creative thinking. For example, Easton et al. (1990) compared and contrasted the creative effectiveness of two different electronic meeting systems, whereas Althuizen and Wierenga (2014) tested CSS using analogical reasoning from existing business cases to form novel solutions. Other studies showed that CES is more effective than pen-and-paper creativity support (Massetti 1996; Wierenga and van Bruggen 1998) and face-to-face interaction (Dennis and Valacich 1993; DeRosa et al. 2007; Gallupe et al. 1994; Kerr and Murthy 2004; Nagasundaram and Dennis 1993; Valacich et al. 1994). However, other studies showed that CES can inhibit creativity when the task is moderately complex (Durand and Vanhuss 1992), and that face-to-face interaction can have a positive effect on creative thinking in the initial and final stages of group work (Ocker et al. 2013).

Another stream of research focuses on creative effectiveness from creativity stimuli embedded in CES. For example, a CES study by Garfield et al. (2001) showed that intuitive creativity techniques outperform analytical creativity techniques by increasing the number of ideas that shift paradigm during the creative process. Another study by Cheung et al. (2008) used existing knowledge to stimulate creative thinking, whereas Shaw et al. (1993) examined how interactivity between humans and computers could motivate divergent thinking. Other studies have examined effectiveness from embedded creativity techniques, such as text and image stimuli (Malaga 2000), and alternative approaches to brainstorming (Aiken et al. 1996; Dennis et al. 1996, 2011; Hender et al. 2002; Michinov 2012; Potter and Balthazard 2004).

CES effectiveness (e.g., idea quality) has also been measured within small and large groups. Small-group research has demonstrated that CES slightly influences the effectiveness of group work (Barki and Pinsonneault 2001), and that individuals outperform a small group using the same treatment (Dornburg et al. 2009). However, when using CES, larger groups are more effective over smaller groups (Coşkun 2011; Dennis and Valacich 1999; Dennis et al. 1999; Gallupe et al. 1992; Pinsonneault et al. 1999). According to Paulus et al. (2013), larger groups are strongly influenced by having a greater set of ideas that influence their creative productivity. Satzinger et al. (1999) defined such sets of ideas as a form of group memory that stimulates creative thinking within the group. Moreover, Satzinger et al. (1999) showed that, dependent on the type of ideas in the group memory being paradigm-modifying or preserving, the group is equally stimulated to modify the existing paradigm or "piggyback on the work of others" (Satzinger et al. 1999; 149) by preserving the established paradigm. Other CES studies showed that the effectiveness of group creativity is influenced by the type of leadership (Sosik et al. 1998b), gender composition (Klein and Dologite 2000), anonymity and satisfaction (Aiken et al. 1994; Connolly et al. 1990; Cooper et al. 1998; Ivanov and Cyr 2014; McLeod 2011; Nunamaker 1987; Sosik et al. 1998a), and differences between individual creative styles (Ray and Romano 2013). Finally, another contributing factor to CES effectiveness is how individuals socially compare their results, and how social loafing causes individuals to place less effort on their productivity when working in a group (Michinov and Primois 2005; Michinov et al. 2014; Roy et al. 1996; Shepherd et al. 1996).

CES adoption literature. A few studies have addressed the issue of adopting CES in organizations. Siau et al. (2010) exhibit how a virtual world (Second Life) can be implemented in collaborative and creative design projects, whereas Di Gangi and Wasko (2009) examined issues connected to implementing and running an idea portal at Dell. In other studies, Lindic et al. (2011) outlined how CES plays a vital role in innovation activities by effectively managing ideas, whereas Dennis and Reinicke (2004) argued that CES adoption is influenced by well-being and satisfaction in the group.

2.2.3. SUMMARY OF CES LITERATURE

In summary, CES literature has placed great emphasis on providing design studies and examining the effectiveness of CES in various settings and situations. However, some research streams are more developed than others. In CES design literature, researchers primarily placed their emphasis on providing general design principles. Less focus is attributed to design principles for specific systems and settings. In addition, the design science literature is underdeveloped. This lack of design science research can be contributed to the fact that design science is a fairly new approach in IS. Consequently, design science has only surfaced in CES research within the last five years. Similarly to CES using design science, the CES adoption literature is underdeveloped. The literature review demonstrates that CES researchers have been more concerned with designing and fine-tuning CES than with its organizational adoption.

2.3. IDEA EVALUATION

Moeran and Christensen (2013) categorized idea evaluation into formative and summative. Formative evaluation is performed instantly throughout a project, whereas summative evaluation occurs at the end of the project. In the research articles contained in this PhD thesis, various definitions of idea evaluation are used to describe the processes of formative and summative evaluation. Formative idea evaluation is described as being informal and dynamic, whereas summative is described as being traditional, formal, and static. However, using formative and summative evaluation does not fully encapsulate the thesis findings, which also include the system behavior of idea evaluation. Hence, in the remaining thesis, idea evaluation is conceptualized as being either static or dynamic. The following subsections provide a review of static and dynamic idea evaluation to clarify the research questions in detail.

2.3.1. STATIC IDEA EVALUATION

Idea evaluation has been a subject of IS research since the early 1990s (Connolly et al. 1990; Couger and Dengate 1992; Lobert and Dologite 1994). Static idea evaluation is about separating the one best idea for testing and refinement from all possible alternatives (Girotra et al. 2010). As a result, existing studies on static idea evaluation in the IS setting focused on measuring idea quality. Dean et al. (2006) demonstrated in their literature review of idea evaluation the development of a multi-dimensional perspective on the measurement of ideas. Their study included novelty (the originality, newness, and radicalness of an idea), workability (the ability to be implemented and accepted), relevance (the ability to solve a problem effectively), and specificity (how it is worked out in detail, how it provides clarity on outcomes, and its impact). In similar research, Briggs and Reinig (2010) created a model, called

Bounded Ideation Theory (BIT), for evaluating idea quality in complex organizations. The BIT model suggests that organizations are extremely complex, and that idea quantity only influences idea quality under specific circumstances. Other brands of research are focused on collective intelligence from crowd-sourcing to evaluate large amounts of user-generated ideas using quantitative parameters (Blohm and Riedl 2011; Leimeister et al. 2009; Sakamoto and Bao 2011), or on design evaluation of new software products and services (Chan et al. 2011). Moreover, researchers have examined team-based evaluation (Kennel et al. 2013), including how the performance of creative employees is influenced by the tone in evaluation and feedback in computer-mediated groups (Connolly et al. 1990).

Elam and Mead (1990) exemplified the importance of leaving critical evaluation at the very end of software-driven idea development, when all other creative processes have progressed. Elam and Mead's (1990) argument is that convergent thinking in idea evaluation may bind ideas to a specific path before all possible solutions and possibilities are considered. Maccrimmon and Wagner (1994) went further and simply stripped the evaluation module from the ICSS they examined in order to focus on the benefits of idea generation. Maccrimmon and Wagner (1994) then added external idea evaluation to examine the value of the system. Unfortunately, this convergent, summative, and static paradigm have dominated IS and management research for the last 20 years. For example, Blohm and Riedl (2011), Bragge et al. (2005), Hesmer et al. (2011), Kohler et al. (2011), Leimeister et al. (2009), and Noguchi (1997) used idea evaluation to allow idea ranking through user comments and/or expert panels, whereas Chen (1998), Lindic et al. (2011), and Shneiderman (2000) used idea evaluation to refine and prioritize ideas before implementation. Other IS researchers have examined the importance of anonymity in evaluation in group-based systems (Connolly et al. 1990; Hailpern et al. 2007; Klein and Dologite 2000; Shepherd et al. 1996). For example, Shepherd et al. (1996) studied how evaluation apprehension or *"fear of negative assessment from other group members"* (Shepherd et al. 1996; 156) can influence creative brainstorming sessions in GCSS and cause *"social loafing"* (Shepherd et al. 1996; 168), or a general unwillingness to participate that can reduce productivity.

In management studies, researchers in new product management examined how various factors impact evaluation teams, including how the organizational climate and participating leadership influence decision-making and the quality of idea evaluation (Hammedi et al. 2011, 2013; Ozer 2005). Idea evaluation has often been criticized for implementing a strict regime, where fear of uncertainties and preferences of the unoriginal hinder truly novel ideas, thereby demotivating the willingness of employees to act creatively (Amabile and Khaire 2008; Amabile 1998; Blair and Mumford 2007; Mueller et al. 2012). Amabile et al. (2005) also found that the mood of employees and their creative performance are strongly connected to how others perceive their ideas. Amabile (1998) even went as far as accusing these rigorous idea evaluation approaches of *"killing creativity"* through the *"excruciating critique"* (Amabile 1998; 83) of new ideas.

Furthermore, in a theoretical proposition of the relationship between system design and learning, You (1993) argued that *"Learning outcomes that deviate from the original goal are considered as 'noise' or error variance which must be eliminated in order to achieve the pre-specified objectives efficiently and effectively… its elimination often leads to erroneous conclusions"* (You 1993; 27). In You's (1993) view, evaluation based on convergent thinking is, unfortunately, structured linearly because it seeks to reduce incoming input and stabilize the current equilibrium. You (1993) criticized such practices related to Chen's (1998) and Elam and Mead's (1990) work, where idea evaluation is only capable of narrowing the pool of ideas into a few useful selections. Instead, You (1993) and other researchers advocated for a divergent and dynamic alternative, which is elaborated in the following section.

2.3.2. DYNAMIC IDEA EVALUATION

Regardless of their origin, ideas shape our society. They are embedded in our technologies, social practices, culture, and our perception of the world (Osborn 1953; Pacey 1992). Moreover, as social beings, humans are constantly forced to make sense of the world in order to comprehend the vast number of new impressions (or background noise) they encounter (Weick 1995; Weick et al. 2005). Similar to sensemaking, idea evaluation can allow human actors to make sense of the chaotic noise, that is, to be consistent with the novelty embedded in those ideas they encounter. Because creative production can be divergent by allowing wild and creative thoughts patterns, and convergent by boxing the flow of ideas into a limited number of solutions (Chen 1998; Elam and Mead 1990; Guilford 1977), You (1993) argued for understanding evaluation in a non-linear way, where identified input is amplified to encourage learning that can clarify and solve identified problems. Hence, *"The focus of evaluation, then, is on divergent thinking, or the ability to go beyond the predetermined objectives, rather than on convergent thinking."* (You 1993; 27). In a similar work on chaos and creativity, Richards (2001) and Schuldberg (1999) argued that bifurcation (a qualitative change in a system's behavior that causes it to change behavior or be divided) can lead to creative leaps. For example, implementing a creativity improvement program might be the "tipping point" at which one or more creative systems (e.g., ideas) start to bifurcate and emerge into something more novel (Schuldberg 1999).

In this dynamic approach, idea evaluation is not a tool that selects the best ideas in the massive pool of incoming information through fixed quality parameters (e.g., Blohm and Riedl 2011; Girotra et al. 2010) or ratings from judges (Amabile 1983; Finke et al. 1992). Instead, this dynamic approach to idea evaluation is based on the divergent and convergent abilities of the participants to provide value that expands existing knowledge and allows divergent actions by creating new ways of seeing things, thus creating new chaotic noise that is potentially useful for others. In essence, where the static approach chooses a single quality idea from a pool of ideas, the starting point of dynamic evaluation may be a single idea that motivates convergent and divergent thinking through evaluation, thus spawning a multitude of interconnected ideas that lead to a viable solution or encourages new discoveries.

The ideas behind dynamic evaluation are not entirely new and have been explained earlier in various design and group creativity studies. For example, van der Lugt (2000, 2002, 2005) demonstrated how designers re-interpret sketch ideas from other artists, which leads to novel ideas that generate new concepts that are re-interpreted and so forth, thereby creating new knowledge. Such approaches have been shown to create design ideas that are more interconnected than using more commonly known brainstorming techniques (van der Lugt 2002). Moreover, Candy and Edmonds' (1996) case study on the Lotus bicycle show how knowledge from previous designs can be used to evaluate novel solutions. In group creativity research, Isaksen and Treffinger (1985;117) suggested several guidelines in their seminal work on how idea evaluation encourages creativity. These suggestions include modifying and improving ideas during the evaluation process. Isaksen and Treffinger's (1985) suggestions are extended by Couger (1996a), who in his book on creativity in the IS organization, argued that the “eureka” or “aha” moment of creativity is a biased myth. In Couger's (1996a) view, novel ideas do not emerge from this romantic idea of creativity, but through a careful and methodological exploration of alternatives to a given problem. Hence, *“good but underdeveloped ideas or even strange options may have real merit if a little time is taken for greater understanding”* (Couger 1996a; 202). Couger (1996a) and Couger et al. (1993) explained how ideas can be elaborated through specific creativity techniques aimed toward idea evaluation. Such techniques can be the force field analysis techniques that provide evaluators with *“different stimuli for thinking of new options or solutions”* (Couger et al. 1993;383) by listing strengths and weaknesses, and then identifying new ideas to exploit those strengths and solve identified weaknesses (Couger 1996a; Couger et al. 1993). This view of providing structure to enhance the creative process is supported by Amabile (1998) and Amabile and Khaire (2008). They criticized idea evaluation for *“killing creativity,”* while also arguing that it provides structures that can allow the necessary freedom for employees to explore and be engaged in finding solutions to selected problems. Likewise, Richards (2001) argued that creativity is active within specific structural patters, given that clusters of ideas can form self-similar clusters of ideas in a repetitive pattern. This PhD study combines and expands these earlier findings by examining whether idea evaluation has a positive influence on convergent and divergent production by providing an overview and structure to the creative process. When the structural properties of idea evaluation allow individuals and groups to act in both convergent and divergent ways, they can create incremental ideas of an original concept, or radical and novel solutions to an identified problem or benefit. As clusters of self-similar ideas emerge, a team can generate natural portfolios of interconnected ideas. However, neither IS nor management research has fully examined how idea evaluation can motivate divergent thinking using the knowledge obtained throughout the evaluation process. This PhD study argues for this dynamic evaluation process by making idea evaluation and creative processes iterative and by implementing creativity techniques in selected areas of the evaluation process.

2.4. RESEARCH QUESTIONS AND POSITIONING OF THE THESIS

This PhD study is about enhancing creativity through idea evaluation and designing a CES that supports such properties. Section 2.1 considered the view on creativity deployed in the thesis, whereas section 2.2 demonstrated key research gaps in the CES literature. Moreover, section 2.3 presented two different approaches for idea evaluation. The first approach is concerned with a static view on idea evaluation, where rating mechanisms are used to select appropriate ideas. The second approach is concerned with dynamic idea evaluation. In this approach, idea evaluation is used to enhance creative thinking through specialized techniques.

The combined body of knowledge shows that dynamic idea evaluation is fragmented, and hence vastly underdeveloped in comparison to its static counterpart. Moreover, the main body of knowledge within idea evaluation is slightly limited and views idea evaluation as an inhibitor of creativity. Idea evaluation is instead dominated by research that uses it to determine performance or facilitate convergent production (e.g., Elam and Mead 1990). A small amount of theoretical evidence also suggests a different perspective of idea evaluation that emphasizes the redesign of ideas by deploying creativity techniques (Couger 1996a; Isaksen and Treffinger 1985), thereby having the potential of facilitating divergent production iteratively throughout the evaluation process. However, this research is sparse. Hence, this PhD study aims to examine whether idea evaluation effectively supports divergent production. Correspondingly, the first research question of this thesis is:

RQ1: How can idea evaluation support divergent thinking?

In addition, this PhD study aims to build upon the first research question by designing a new class of CES capable of using idea evaluation to enhance divergent thinking. In section 2.2, two knowledge gaps were presented in the CES design and adoption literature. This PhD study attempts to add knowledge to one of those research gaps, namely, the design science literature. However, drawing on the results from Table 1, this thesis is also situated within the CES effectiveness literature. The PhD study aims to use several CES prototypes to measure and explore the creative effectiveness of dynamic idea evaluation over conventional evaluation approaches and existing recognized creativity techniques, such as image and picture stimuli. Correspondingly, the second research question of this thesis is:

RQ2: Will CES that supports idea evaluation be effective in encouraging divergent thinking?

Design science, which is the science of creating technological artifacts that serve human need (March & Smith 1995) can provide structure to this alternate view on idea evaluation through its strong emphasis on designing producible evidence (Walls et al. 2004). Design science is thus well suited to creating a comprehensive theory for a new class of CES that uses idea evaluation to motivate creative thinking. To add additional knowledge to the research gap of design science in the CES literature and merge individual research articles, the results of this PhD study are synthesized into a design theory. Correspondingly, the third and final research question of this thesis is:

RQ3: What are the characteristics of a CES design theory that uses idea evaluation to support divergent thinking?

Overall, the three research questions aim to correct some fundamental issues connected to idea evaluation and CES research. As such, this PhD study includes theorizing on the nature of organizational creativity and idea evaluation to create a new approach for CES that supports dynamic idea evaluation. This new evaluation approach is then tested in order to measure its effectiveness and real-world application by developing several CES prototypes. Finally, the collected results are synthesized into a design theory for a new class of CES that uses idea evaluation to support convergent and divergent thinking.

CHAPTER 3. RESEARCH APPROACH

This chapter considers the selected research approach for the thesis. This approach takes form as a design science study that synthesizes a dedicated literature review, theoretical development, and empirical research into design theory. How the literature was collected and reviewed, the theory developed, and the developed theory empirically evaluated are outlined in detail. Moreover, this chapter elaborates on the approach for synthesizing the developed theory and empirical evidence into design theory.

3.1. RESEARCH DESIGN

Because the purpose of this PhD study is to develop a new idea evaluation approach that encourages divergent and convergent production in a CES environment, the selected research design is constructed to be theory building. As shown in Figure 2, the selected research design is divided into the guiding research questions presented in the previous chapter. These research questions guide the theoretical development on the subject (RQ1), the empirical foundation based of the developed theory (RQ2), and the synthesis of those findings into design theory (RQ3). The combined body of knowledge is finally discussed in the concluding contributions.

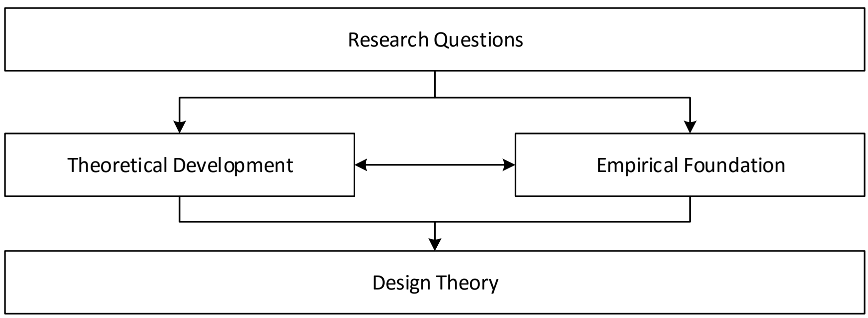

Figure 2: Research Design

The following sections include the methodological approach based on design science that is outlined in section 3.2. Thereafter, the theoretical approach is described in section 3.3, whereas the empirical approach is explained in section 3.4. Finally, the approach for synthesizing design theory is outlined in section 3.5.

3.2. DESIGN SCIENCE RESEARCH METHODOLOGY AND DESIGN ACTIVITIES

To investigate the research subject and ultimately create a usable design theory for IS-driven idea evaluation, this PhD study deploys design science as a methodological approach. Design science is described as a technology-oriented approach suitable for creating artifacts that serve human needs (March & Smith 1995). Furthermore, design science is about creating a product in the sense of designing something that can be produced, and a process in the sense of designing a plan and construction through a set of requirements (Walls et al. 2004). As such, the outcome of design science is the "design theory" that provides explicit guidelines for *"how to do something"* (Kuechler and Vaishnavi 2008;490) and the "design artifact" that can be put into use (Walls et al. 2004, 1992).

Peffers et al. (2008) describes six activities in a design project based on their Design Science Research Methodology (DSRM) process model (Figure 3). These activities are nominally sequenced from one to six. The *first* activity is problem identification and motivation to conceptualize the research problem and justify the importance of the problem to the audience. This activity is based on logical premises from existing knowledge. The *second* activity is to define the objectives for a solution that solves the identified problems. This activity is based on theory that defines the relevance or meta-requirements that can solve the problem. The *third* activity is design and development of an artifact where the research findings are embedded into the artifact. This activity involves theoretical knowledge that can be determined through the artifacts' design, architecture, and functionality. The *fourth* activity is a demonstration of the artifact to show how it solves the problem. The *fifth* activity is evaluation of the artifact by, for example, deploying quantifiable measurements of how the artifact performs in accordance to the identified problem. The fourth and fifth activity require knowledge "on how to use the artifact" (pp. 56), and the results can be iterated back to previous activities in the DSRM process model. Moreover, the fifth activity requires knowledge on how to measure the artifact. The *sixth* activity is communication of the artifact or its underlying knowledge, construction, novelty, rigor of its design, and its effectiveness. The final activity requires specific domain knowledge.

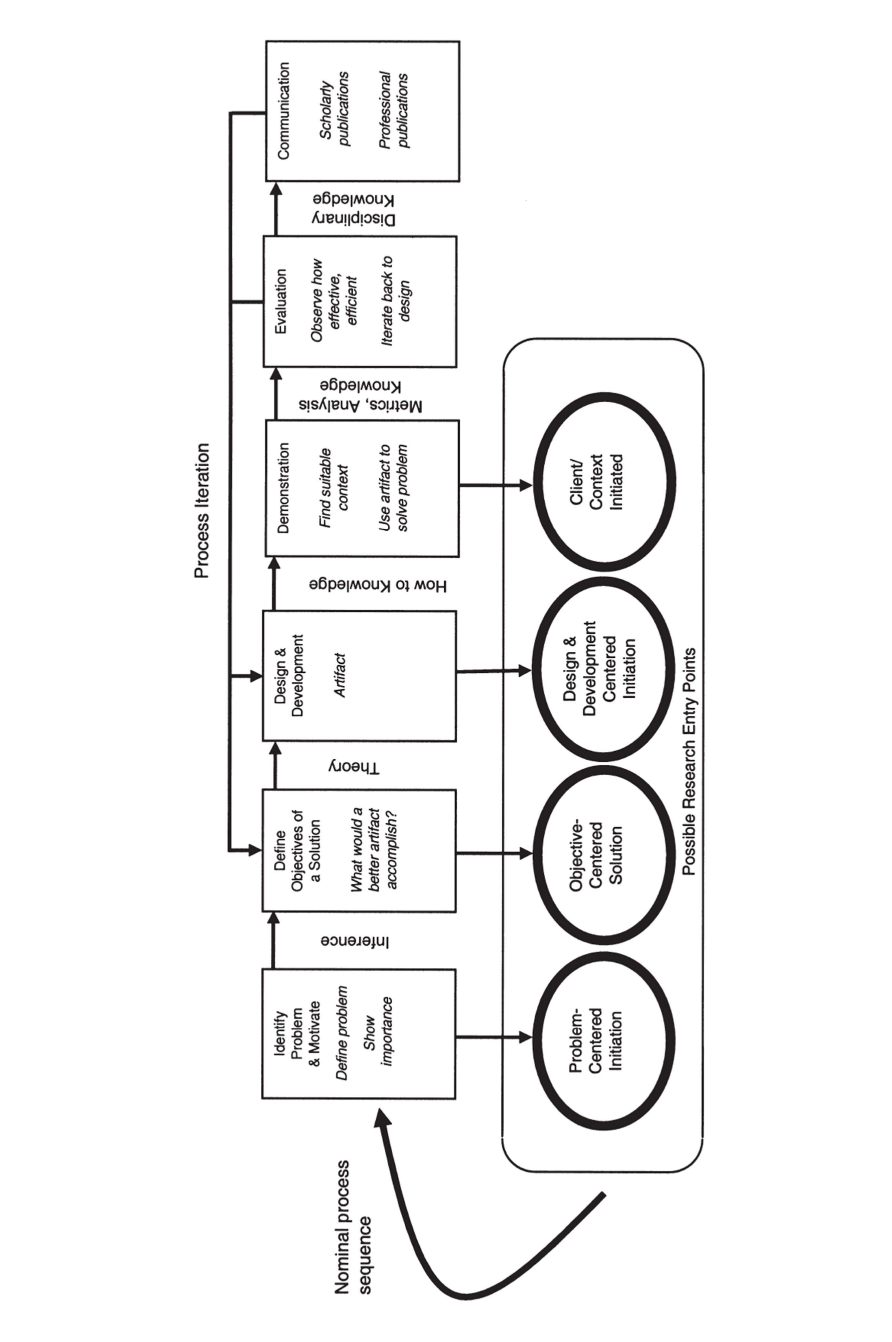

Figure 3: Peffers et al. (2008) DSRM Process Model

In addition to the six design activities, Peffers et al. (2008) explained that a design project can start from four different entry points. P*roblem-centered initiation* can start from the first activity if the observation problems are suggested from prior research. An objective-centered solution can start from the second activity if the industry or research triggers the development of an artifact. A design and development-centered initiation can start from the third activity if an artifact is already developed or exist as an analogical idea in a different research domain. Finally, client/context initiation can start from the fourth activity if observing an artifact that worked and is used in practice.

This PhD study follows Peffers et al.'s (2008) DSRM process model through a problem-centered initiation as the entry point (Table 2). In the *first* design activity, the design project initiates with three research questions (problems) that are extended from existing theory. Theory development from the research articles has further atomized the problem conceptually. This conceptualization leads to the *second* design activity where the objectives for the solution are defined through meta-requirements that fit the research questions. These meta-requirements are identified by developing a new theory that expands the current field of knowledge. In the *third* design activity, four design prototypes are developed from the meta-requirements and existing theory. A design theory is coordinated together with these prototypes. In the *fourth* design activity, the functionality of one of the prototypes is demonstrated through an appropriate field experiment and the results are iterated back to the design theory. In the *fifth* design activity, the remaining three prototypes are used in a laboratory experiment that uses relevant metrics to measure the effectiveness of the selected design approach over other approaches. Again, the results are iterated back to the design theory. In the *sixth* design activity, the results from the previous design activities are communicated through a design theory that merges the created theory with the empirical results.

Table 2: Overview of PhD Design Activities

Design activities (Peffers et al. 2008)	Design activities in the PhD study
Problem identification and motivation	Three research questions are extended from the existing literature and conceptualized using theory development.
Define the objectives for a solution	Meta-requirements or goals are identified by developing a new theory.
Design and development	Four different prototypes are designed and developed from the meta-requirements and existing theory. The design theory is coordinated together with the prototypes.
Demonstration	The functionality of one of the design artifacts is demonstrated through a field experiment. Results are iterated back to the design theory.

Table 2: Overview of PhD Design Activities – Continued	
Design activities (Peffers et al. 2008)	Design activities in the PhD study
Evaluation	The design artifact is evaluated through a laboratory experiment. Results are iterated back to the design theory.
Communication	The research results are communicated through five research articles synthesized into design theory.

3.3. THEORY DEVELOPMENT

This section considers the conceptual development of the theory in the PhD study. Gregor (2006) exemplified the five types of theories used in IS. *First*, there are theories for analyzing. The first type of theory is descriptive by summarizing the commonalities found through observation of individuals, groups, situations, or events. For example, theories for analyzing can be frameworks, classification schemas, or taxonomies. *Second*, there are theories for explaining. The second type of theory attempts to understand *"how the world may be viewed in a certain way"* (Gregor 2006; 634). Theories for explaining also refrain from generalizations and boundaries. Instead, focus is on how and why something happens under specific circumstances to provide insight over generalization. *Third*, there are theories for predicting. The third type of theory can predict future outcomes by understanding the underlying factors influencing it. An example of a predictive theory is Moore's Law, which suggests that the number of transistors of an integrated circuit doubles every 18 months. *Fourth*, there are theories for explaining and predicting (EP theory). Similar to the theories for explaining, the fourth type of theory attempts to explain the workings of the world. However, EP theories provide predictions and have testable propositions to justify casual explanations. *Fifth*, there are theories for design and action. The last type of theory uses design requirements, constructs, and principles of form and function to provide explicit recommendations on how to build something (the design artifact).

As explained in the following paragraphs, this PHD study involves three different types of IS theory. Initially, a theory for analyzing is used in the literature review. This theory is built from Rhodes' (1961) 4P model to classify commonalities found in the IS literature on the subject of creativity. Thereafter, two theories for explaining and predicting are created to clarify the inner working and connections between idea evaluation and organizational creativity. Moreover, these two theories provide explicit predictions for the outcome of idea evaluation, which is supported by empirically evidence. Finally, a theory of design and action is created to synthesize theory development and empirical evidence into design theory. An overview of the three first theories is summarized in Table 3. The theory of design and action is outlined in section 3.5.

Table 3: Theory Development				
#	Description	Purpose	Type of theory	Reference
1	Literature review of 88 IS research articles on the subject of creativity.	Mapping creativity in the IS research literature.	Theory for analyzing	Research article 1
2	Conceptual development of idea multiplication.	Development of key concepts to understand the influence of idea evaluation on creativity.	Theory for explaining and predicting	Research article 2
3	Conceptual development of dynamic idea evaluation by understanding the system behavior of idea evaluation and key concepts, such as idea bifurcation.	Development of key concepts to understand the system behavior of dynamic idea evaluation by combining existing theory with developed theoretical constructs.	Theory for explaining and predicting	Research articles 3, 4, 5, and section 2.3

A theory for analyzing through a literature review on creativity in IS research. The first theory is used to analyze the body of knowledge on creativity in the IS research field. The presented literature review shares the characteristics contained in a theory for analyzing using a classification schema to review the literature. This classification schema is based on comparing Rhodes' (1961) 4P framework within an IS perspective (c.f., section 2.1.1.)[4]. The literature review is the backbone of any research project by facilitating theory development, closing over-researched streams in the literature, and discovering new areas of concern (Webster and Watson 2002).

Relevant articles were identified by searching 110 journals from the AIS list of journal rankings and the ACM conference on Creativity and Cognition. A pilot search was initially conducted for the top 20 journals in the AIS list. The pilot search resulted in 714 hits. This initial pool of 714 articles was then reduced to 25 using a three-step screening checklist that captured the research subject through predefined criteria for selection (Okoli and Schabram 2010). The 25 selected articles were reduced to 18 through "check coding" (Fink 2009). Intercoder reliability was 80% and above the 70% boundary suggested by Miles and Huberman (1994). In the next stage of identifying relevant articles, the results from the pilot were analyzed in order to

[4] Ackoff and Vergara's (1981) view on origin and processor is not included in this framework.

redefine the search parameters. The redefined search parameters were reapplied to the same 20 journals in the AIS list, thus reducing the number of relevant articles from 714 to 359. In addition, the reduced poll of articles contained an additional 16 relevant articles. In the following stage, the new search parameters were applied to the remaining 90 articles in the AIS list. This search resulted in 761 hits that were reduced to 22 using the checklist for article screening. Moreover, the search was extended to the ACM Conference on Creativity and Cognition, which identified an additional 14 conference proceeding papers. Finally, 18 papers were identified by conducting a forward/backward search (Webster and Watson 2002) on the sampled articles from the top (ranked 1–5), middle (ranked 45–60), and bottom (ranked 100–110) of the AIS list. In total, 88 articles were selected for analysis.

To analyze the literature, a classification schema was created that combined Rhodes' (1961) 4P framework of Press, Person, Product, and Process with individual IS perspectives for each P. To create this classification schema, keywords and themes were identified for each components in the 4P framework and its individual IS perspective. Next, the articles were coded in SPSS. To strengthen the reliability of the coding effort, a three-stage qualitative process was used to perform multiple coding and quality control of the same data. In the first stage, each article was categorized according to Press, Person, Product, or Process using the identified keywords and themes. In the second stage, the results were recoded using identified themes to correct errors from the first stage. In the third stage, a bottom-up approach was used to gain insight into the research field by synthesizing each article according to the abstract, theoretical framework, and conclusion of each article. The third stage also corrected any errors in coding from the two previous stages. After the three-stage qualitative process, each article was coded according to Oh et al.'s (2005) Taxonomy of IS Research to identify needs for additional research in the selected areas of IS research.

A theory for explaining and predicting through a socio-technical theory of informal evaluation and institutionalization of technology ideas. The second theory explains the socio-technical dynamics of creativity in organizations when human actors informally evaluate technology ideas and institutionalize them. First, the theory reviews existing state-of-the-art literature concerning Scandinavian perspectives on the travel of ideas and institutionalization (e.g., Czarniawska and Joerges 1995; Modell 2006; Orlikowski 2000), general theory on idea evaluation (e.g., Dean et al. 2006; Elam and Mead 1990), and generativity (Avital and Te'eni 2009). From the theory, a new theoretical construct is created. This construct is called idea multiplication, which is the translation, transformation, consolidation, or radical redefinition of ideas. Second, a combined framework is created by consolidating this new theoretical construct with existing sociotechnical knowledge on how human actors reject or adopt technology ideas during informal evaluation. Third, a multiple case study is used to illustrate the theory in practice. Consequently, a framework is theorized that explains how technology ideas are rejected, adopted, or multiplied in organizations.

Although no testable propositions are presented, the theory shares the characteristics contained in a theory for explaining and predicting. First, the theory presents new explanations on how informal idea evaluation can influence creative thinking. Second, the presented framework predicts that technology ideas with a high level of generativity multiply into new technology ideas when the human actors experience conflict during negotiations between competing frames of reference.

A theory for explaining and predicting through a theory for dynamic idea evaluation. The third theory explains the inner workings of dynamic idea evaluation as an IS artifact. The theory indirectly inherits and extends the theoretical concept of multiplication by examining the system dynamics of idea evaluation. This theory development is extended over three research articles and summarized in Table 8 (see section 6.2.). Initially, a fundamental theory was created by conceptualizing the dynamic idea evaluation from the state-of-the-art-research. Next, using chaos theory as the foundation for understanding system behavior in idea evaluation as an IS artifact, dynamic idea evaluation was compared and contrasted with static approaches. Through this system analysis, a new theoretical construct was formed to explain how dynamic idea evaluation makes ideas bifurcate (split or change their qualitative state) and create strange attractors, for example, through metaphorical thinking. Finally, the theory was extended to two empirical research articles that explored dynamic idea evaluation and tested its effectiveness in contrast to static idea evaluation approaches and standard creativity techniques.

The developed theory on dynamic idea evaluation shares explicit characteristics to a theory for explaining and predicting. The theory explains in detail the system dynamics of the dynamic idea evaluation approach. Moreover, the theory puts forward explicit testable hypotheses to empirically test predictions on the effectiveness of dynamic idea evaluation.

3.4. EMPIRICAL EVALUATIONS

The PhD study considers three types of empirical evaluation. The first is a multiple case study, the second is a field experiment, and the third is a laboratory experiment. The empirical evaluations are elaborated in sections 3.4.1 to 3.4.3, and summarized in Table 4.

Table 4: Data Collection and Analysis				
#	Description	Data collection	Analysis	Reference
1	Multiple case studies on a municipality and software development firm.	Six one-hour qualitative interviews collected from two research sites. Six hours in total. Followed by workshops at each research site.	Interpretive analysis using a notation system to identify key themes according to the theoretical framework.	Research article 2
3	Laboratory experiment with 305 subjects over three groups.	628 ideas across the three groups.	3 × 1 factorial design. Analyzed with Cronbach's alpha, ANOVA, and Fisher's Least Significant Difference (LSD) post-hoc test.	Research article 4
2	Field experiment using software prototype. During 14 weeks, 15 subjects in an IS research department participated over five iterations.	294 entries collected from the software prototype. 35:12 hours of experiment and interview data.	Interpretive analysis using the subjects' ability to categorize their own data throughout the field experiment.	Research article 5

3.4.1. MULTIPLE CASE STUDIES IN TWO CREATIVE IS ORGANIZATIONS

Multiple case studies were conducted (De Vaus 2001; Yin 2003) and interpretively analyzed (Walsham 1993, 2006). The multiple case studies focus on providing empirical depth to the theoretical concept of idea multiplication. Data were collected during spring of 2012. Six one-hour interviews were conducted at two research sites. The first research site was a municipality, whereas the second site was a software development company. At the municipality, the CIO, project manager, and business developer were interviewed. At the software development company, the CIO, head of innovation, and head of product development were interviewed. The approach for questioning was semi-structured and open-ended (Saunders et al. 2003). In addition to the interviews, an informal workshop was held at each research site. Eight key informants from the IT management unit participated from the municipality, whereas the entire development and management team participated in the software development company.

The collected data were analyzed using an interpretive approach (Walsham 1993, 2006). To provide an overview of the interview data and capture key concepts, a notation system (Bryman 2004) was used to capture roles, themes, and in-depth notes on the subjects of discussion from each interview. From this notation system, each interview was divided into different categories that helped interpret the data using the developed theoretical framework.

3.4.2. EMPIRICAL EVALUATION 1: LABORATORY EXPERIMENT

A laboratory experiment was conducted to test whether CES would be effective in using knowledge from idea evaluation to encourage divergent production. The laboratory experiment involved a 3 × 1 factorial design with three different prototype treatments coded in PHP and MySQL. The prototype treatments were built to support static idea evaluation, dynamic idea evaluation, and traditional brainstorming. A total of 305 subjects from Amazon Mechanical Turk participated in the experiment. Mechanical Turk is a crowdsourcing platform that offers workers for human intelligence tasks (https://www.mturk.com). Each subject was given written instructions to guide him/her with each specific prototype treatment in the experiment. Moreover, the prototypes included safety measures that prevented subjects from participating multiple times.

A standardized measurement framework was used to test the level of divergent production (Lewis et al. 2011). First, the framework included measurements from each submission through *fluency* by the number of ideas, *elaboration* by counting the number of sentences, and *flexibility* by identifying the number of unique themes. Second, *originality* was measured by identifying the top 2% themes from all submissions. To void bias, elaboration, flexibility, and originality were divided with fluency. Last, the total score of each subject was calculated.

Results from the experiment were analyzed using Cronbach's alpha test, ANOVA tests, and Fisher's Least Significant Difference (LSD) post-hoc test. Cronbach's alpha test was used to measure inter-rater reliability. The ANOVA tests were used to measure differences between the test cases. The LSD post-hoc test was used to verify and expand the results of the ANOVA tests.

3.4.3. EMPIRICAL EVALUATION 2: FIELD EXPERIMENT

A field experiment was conducted (Bryman 2004) and interpretively analyzed (Walsham 1993, 2006). The field experiment focused on exploring dynamic idea evaluation in a real-world context. The field experiment involved 15 subjects from a Danish research department and was built around dynamic idea evaluation. This approach involved the design of a CES that used creativity techniques in an iterative evaluation process. Early in the experiment, subjects were asked to evaluate a simple idea (an ice cream flavor) for an equally simple challenge (A’s need for new ice cream flavors). In addition to evaluation, the subject also had the option of making improvements to existing ideas or new and alternative challenges and ideas. Midway through the experiment, a specific and “real-world” challenge was inserted into the system (requirements for a new travel expense system). At the end of the experiment, the subjects were instructed to act freely.

The data collection involved five iterations that lasted over 14 weeks. For the first iteration, an experimental Wizard of Oz (WoZ) (Dahlbäck et al. 1993; Hajdinjak and Mihelic 2003) HTML prototype was introduced to the subjects together with the simple idea and its challenge. The WoZ prototype also helped the subject learn the prototype and collect information for its redesign. In the second iteration, a redeveloped and fully functional PHP and MySQL prototype was introduced to the subjects. In the third iteration, the subjects were introduced to the real-world challenge. In the fourth and fifth iteration, the subjects acted at liberty. Finally, a post evaluation was conducted through interviews and a focus group where the subjects, other researchers, and university students were invited.

Throughout the five iterations, the subjects were asked about the origin of their ideas. Hence, the collected data were continuously reviewed by the subjects. Their directions were then transferred to a flowchart. In addition, improvement for existing ideas was identified or extracted from the subjects’ comments. To record data and time duration, a field experiment report (Yin 2003) was continuously used in the field experiment and the post-hoc interviews and focus group. The data were then interpretively analyzed (Walsham 1993, 2006) by identifying reoccurring themes (Layder 1998) connected to dynamic idea evaluation. The interpretive analysis included Sternberg's (1999) view on knowledge and the concurrent view on divergent and convergent thinking (Cropley 2006; Guilford 1967, 1977) in order to understand how the prototypes influenced the subjects’ creative actions.

3.5. SYNTHESIZING THE RESULTS INTO DESIGN THEORY

This section considers the synthesis of previous results into design theory. The design theory draws on all eight design components specified by Gregor and Jones (2007). The design theory is a theory for design and action because it provides clear prescriptions on “how to do something” (Gregor 2006;628). In this PhD study, the purpose of creating design theory is two-folded. The first purpose is to transfer the study findings into practice. Because design science is about creating technological artifacts that serve human needs (March and Smith 1995), the synthesized design theory brings the proposed theoretical constructs and empirical evidence from the five research articles into practice. The second purpose is concerned with internal and external validity (De Vaus 2001). The results and theoretical constructs from the research articles act as internal validity for the proposed design theory, and consequently, for the PhD study. More importantly, the design theory is a theory for design and action and can be used to replicate the proposed theoretical constructs and empirical evidence in alternative empirical settings from the study. This approach gives external validity to the proposed theoretical constructs and empirical evidence.

3.5.1. APPROACH FOR SYNTHESIS

The design theory is synthesized using Gregor and Jones (2007) eight design components for design theory. Gregor and Jones (2007) explained that design theory should contain: (1) The purpose and scope that specify the meta-requirements and explain the context of the design and boundaries within which they operate. (2) Specific constructs about items of interest to the theory that can either be in physical or theoretical abstract form. (3) An abstract description of the structural and functional properties of the IS artifact. (4) Artifact mutability that explains changes done to the system that were anticipated by the theory. (5) Testable propositions that verify whether a constructed artifact is consistent with the meta-requirement in the design theory. (6) Justificatory knowledge that serves as the foundation of the design. This justificatory knowledge is built from “kernel theories” and takes the form of natural and social science theories (Nunamaker et al. 1991; Walls et al. 2004, 1992); it is used to provide theoretical grounding (Goldkuhl 2004), meaning (Iivari 2007), and to govern design solutions (Walls et al. 2004, 1992) to the creation of the artifact. Furthermore, Gregor and Jones (2007) gave the option of (7), exemplifying principles of how the design is to be implemented into existence, and (8) demonstrating an expository instantiation of the design through a physical artifact, which can include scenarios and mock-ups or prototypes of real systems.

The design theory is synthesized iteratively over time between the definition of objectives of a solution, design and development, demonstration, and design evaluations as outlined by Peffers et al. (2008). As such, this PhD study includes all eight components of design theory. Six components are communicated in chapter 5, whereas the remaining two are communicated through research articles 4 and 5. Initially, the purpose and scope of the design is offered. Then different kernels on idea evaluation and creativity are presented to build the argument for the design. These kernels provide a gateway toward encouraging creativity through the evaluation process, rather than eliminating so-called “bad” ideas. From the state-of-the-art theories presented, the design theory subsequently presents a class of design requirements that can serve as the IS artifact. Next, these design requirements are translated into a system “blueprint.” Moreover, the core constructs and design principles are explained. Last, a set of principles for implementation followed by mutability characteristics of the design theory are discussed. Research article 4 provides a set of testable propositions evaluated, whereas a working prototype is communicated and evaluated in research article 5.

3.5.2. PROJECT VALIDITY

The purpose of the design theory is to strengthen the internal validity of the PhD study by synthesizing the separated kernel from the different research publications into one unit. In addition, the design theory provides external validity to the research findings by giving an explicit prescription on how to design a system that supports dynamic idea evaluation.

This PhD study works with one of two different categories of justifiable knowledge. The first category contains "kernel theories." Gregor and Jones (2007; 322) defined *"kernel theories as the underlying knowledge or theory from the natural or social or design sciences that gives a basis and explanation for the design."* This knowledge provides justification of why an artifact is constructed in a certain way and why it works (Gregor and Jones 2007). The second category contains "kernel abstractions" that are the underlying knowledge embedded in core themes, ideas, and constructs from existing theories and empirical data. In this context, it is important to clarify that the proposed design theory cannot be applied upon a unified kernel theory of dynamic idea evaluation because the justifiable knowledge is spread over multiple individual findings. Instead, unification of the different theoretical and empirical abstractions is the design theory. Hence, the design theory is synthesized from these kernel abstractions embedded in the research findings and the existing body-of-knowledge within the research field.

Moreover, external and internal kernel abstractions are used to form the design theory. External kernel abstractions are collected from the body of knowledge on organizational creativity, idea evaluation, and CES. Internal kernel abstractions are collected from the case-sensitive research findings. This internal kernel is developed specifically for the purpose of providing the missing justificatory knowledge to the design theory not provided by external kernel abstractions.

The selected approach strengthens the internal and external validity of the PhD project by applying external and internal kernels to create the design theory, and using the design theory to generalize the research findings. Hence, internal validity is achieved by triangulating (Layder 1998) diverse theory and empirical evidence from external and internal sources into design theory. External validity is obtained by creating a unified design theory for a technological artifact that can be used to replicate the results from the PhD study in various research scenarios.

The following chapter outlines the contributions of the five research articles in the PhD thesis.

CHAPTER 4. RESEARCH SUMMARY

This chapter outlines the contributions of the five research articles: The articles provide a combined answer to two of the research questions (section 2.4.) through developed theory and empirical elaboration. The third research question is addressed using the design theory in chapter 5.

4.1. OVERVIEW OF THE RESEARCH ARTICLES

Table 5 provides an overview of the five research articles included in the appendix. The table includes details on each article title, authors, selected research approach, and status.

Table 5. Overview of Research Articles

#	Title	Authors	Research approach	Status
RA1	Creativity and Information Systems in a Hypercompetitive Environment: A Literature Review	Müller, S. D. (1) Ulrich, F. (1)	Literature review	CAIS (Published)
RA2	Informal Evaluation and Institutionalization of Neoteric Technology Ideas: The Case of Two Danish Organizations	Ulrich, F. (1) Mengiste, S. A. (2) Müller, S. D. (3)	Theoretical study supplemented with two case studies	CAIS (Accepted)
RA3	The Evaluation of Ideas for Innovative IT Products and Services: Chaos and Creativity	Ulrich, F. (1) Nielsen, P. A. (2)	Theoretical study	IT&P (In Review)
RA4	Encouraging Divergent Thinking from Knowledge Generated during Idea Evaluation: A Design Experiment with Creativity Enhancing Systems	Ulrich, F. (1) Müller, S. D. (2)	Laboratory experiment of dynamic idea evaluation using three treatments	JMIS (First revision and resubmit)
RA5	A Group Creativity Support System for Dynamic Idea Evaluation	Ulrich, F. (1)	Field experiment	SCIS/LNBIP (Published)

The first research article addresses RQ1 by mapping the literature and identifying several research gaps for creativity in the IS research field, including research in idea evaluation and the economics of creativity. The second research article is equally focused on RQ1 by closing one of the research gaps identified in the literature review through the exploration of the socio-technical interrelation between idea evaluation and creativity in an organizational setting. The third research article is an extension of the second research article, and hence remains within RQ1. It uses chaos theory to break down static and dynamic idea evaluation into smaller components to theorize about their inner workings. The fourth research article addresses RQ2 through a laboratory experiment that tests how static and dynamic idea evaluation influence divergent thinking. Finally, the fifth research article gathers the findings from previous articles into a working prototype. Hence, it explores dynamic idea evaluation through an interpretive field experiment in a Danish research department.

4.2. RA1: CREATIVITY AND INFORMATION SYSTEMS IN A HYPERCOMPETITIVE ENVIRONMENT: A LITERATURE REVIEW

Müller, Sune Dueholm and Ulrich, Frank. (2013). "Creativity and Information Systems in a Hypercompetitive Environment: A Literature Review," Communications of the Association for Information Systems: Vol. 32, Article 7.

The first research article addresses RQ1 by mapping the creativity research within the IS field through a systematic literature review. The purpose of the article is to map the state-of-the-art creativity research within the entire IS field, which previous literature reviews have neglected by focusing on a specific area of creativity research or being limited to reviewing a sample from top journals (e.g., Couger 1996b; Dean et al. 2006; Seidel et al. 2010a). *The article is a comprehensive demonstration of creativity research in the IS field by including all 110 journals from the AIS list. Moreover, it illustrates several underdeveloped areas of research, including work on idea evaluation.*

A total of 88 journal and conference papers were selected by searching 110 journals in the AIS journal list and a selected conference on creativity. These papers were collected through a systematic and rigorous process. Collection screening of relevant literature occurred by doing an initial pilot study of the top 20 journals in the AIS list. The results were then screened using three specific selection criteria that determined whether the papers' focus was on IS and creativity. Using Fink's (2009) process of "check coding," 18 papers were identified. Intercoder reliability was estimated to be 80% and above the 70% margin suggested by (Miles and Huberman 1994). Next, in light of the pilot study, the search parameters were changed and reapplied to the 20 journals from the first search. This process reduced the search results from 714 to

359 and produced 16 additional papers. Finally, the process was repeated on the remaining 90 journals in the AIS list and the ACM Conference on Creativity and Cognition, and forward-backward searches were conducted on selected samples from the AIS list. This process resulted in an additional 52 papers, and 88 papers in total.

After the collection and screening process, the results were analyzed through a three-stage process. The analysis used Rhodes' (1961) 4P model of Press (the creative environment), People (motivation and techniques for creativity), Products (evaluation of creative products), and Processes (strategy and planning for creativity) to navigate through the literature (c.f., section 2.1.1.). Next, the papers were coded in SPSS by (1) identifying keywords and themes from Rhodes' (1961) 4P model, (2) coding the articles according to the themes, and (3) synthesizing the papers from their abstracts, theoretical frameworks, and conclusions. During this coding process, error correction for the coding occurred between each stage. Moreover, using Oh et al.'s (2006) Taxonomy of IS Research, the papers were coded according to their reference discipline depending on their scientific heritage from organizational, economic, behavioral, and computer science.

In conclusion, the review provides an overview of the creativity literature present within the IS field. Moreover, the review identifies unaddressed areas from the literature in the economic sciences, idea evaluation, quality assurance, and strategizing creativity in IS organizations. More specifically, the review identifies a clear lack of research in relation to creativity and economics. Next, idea evaluation only accounts for 6% of the combined research, providing only five papers over the last 15 years and limited guidance for evaluation in an IS context. Furthermore, guidance is similarly limited in ensuring quality in creative processes and for maturing the creative environment. Subsequently, this limited research also calls for better strategies for creativity in IS organizations that use creativity enhancing software and creativity management practices.

4.3. RA2: INFORMAL EVALUATION AND INSTITUTIONALIZATION OF NEOTERIC TECHNOLOGY IDEAS: THE CASE OF TWO DANISH ORGANIZATIONS

Ulrich, Frank; Mengiste, Shegaw Anagaw; Müller, Sune Dueholm. (2015). “Informal Evaluation and Institutionalization of Neoteric Technology Ideas: The Case of Two Danish Organizations," Communications of the Association for Information Systems, Accepted.

The second research article addresses RQ1 by exploring sensemaking and institutionalization processes, and their connection to creativity and evaluation of technology ideas. The article addresses dynamic idea evaluation (conceptualized as *informal idea evaluation in the article) by suggesting a theoretical framework for organizational creativity that uses state-of-the-art literature on Scandinavian institutionalism and contemporary IS theory on creativity. The framework exhibits that those technology ideas that are novel and previously unknown in the organization will be adopted, rejected, or multiplied when human actors informally evaluate them.*

The article addresses the following research question: “How does the development, informal evaluation, and adoption of neoteric ideas affect organizational creativity?” The presented framework answers this question by showing how neoteric ideas (ideas previously unknown to the organizational actors) embedded in new technologies travel to organizations and introduce chaotic flux that human actors must informally evaluate in order to identify their value. In this process, human actors create frames of reference related to previously institutionalized technology ideas, which are used to negotiate the outcome of neoteric ideas. Agreement between frames of reference results in ideas being rejected or adopted, which institutionalizes the ideas. However, conflict between competing frames of reference can result in multiplication when human actors translate, transform, consolidate, or redefine existing technology ideas into something considered valuable by others in the organization, and hence help them in further negotiations. To illustrate the theory in practice, data from two Danish organizations is interpreted to provide empirical insights into the framework.

The first case concerns a software developer of simulators for in the naval industry. This case demonstrates how human actors draw on experiences from previous projects when they create and informally evaluate neoteric ideas during requirement engineering. Hence, the creation of neoteric ideas becomes a result of past and new experiences, whereas negotiations between different groups of human actors result in their adoption or rejection. The second case considers a municipality that experiments with mobile technologies. The case extends the findings from the software development company, and exemplifies how human actors in the municipality reject technology ideas about PDA projects. However, these rejected ideas become institutionalized in the organization and later resurface as technology frames during an open-ended experiment with tablet computers. These technology frames guide negotiations between different groups of human actors when they informally evaluate the technology ideas connected to the tablet computers. The result is reoccurring iterations of multiplication, where the neoteric ideas are translated, transformed, consolidated, and radically redefined into something that the negotiating groups of human actors can accept for adoption.

In conclusion, the article provides a framework that shows the isomorphic relationship between creativity and informal evaluation practices. This framework demonstrates how neoteric ideas travel, are created, and later become institutionalized. Moreover, the presented framework and the empirical illustrative vignettes provide new insight for research and practice by establishing that negotiations between competing frames of reference during informal evaluation can result in the divergent production of neoteric technology ideas.

4.4. RA3: CHAOS AND CREATIVITY IN INFORMATION SYSTEM ARTIFACTS

Ulrich, Frank; Nielsen, Peter Axel. (2015). "Chaos and Creativity in Information System Artifacts," Information Technology & People, In Review.

The third research article addresses RQ1 by exploring idea evaluation as an IS artifact. The article draws on contemporary research on chaos theory, idea evaluation, and creativity to compare and contrast two opposing IS idea evaluation approaches (conceptualized as IS artifacts). In this article, chaos theory is used to break down the creative IS artifact of idea evaluation into smaller components. Using this unit of analysis, new insight is revealed about the system behavior for the components in the idea evaluation approaches and how they can be improved. Moreover, it is theorized that positive and negative feedback in idea evaluation approaches influence the outcome of creative thinking by determining whether ideas will bifurcate and cross the edge of chaos toward strange attractors.

The article addresses the following research question: "How can chaos theory be used to understand creative information system artifacts?" Because creativity is inherently governed by chaotic properties (Stacey 1996), chaos theory is used to answer the research question by comparing and contrasting static and dynamic idea evaluation. Idea evaluation can be divided into two opposing approaches. Static idea evaluation is strictly convergent using a rating mechanism to identify appropriate ideas outside the creative process. Its rationale is that ideas exist in abundance and only the best should be selected. Dynamic idea evaluation is convergent and divergent by focusing continuously on constructive criticism and creative thinking skills that modify and improve ideas during the creative process. Its rationale is based on identifying the value in existing ideas that leads to additional creativity. This dynamic approach creates portfolios of interconnected ideas for viable solutions. Chaos theory is concerned with a range of theoretical constructs to describe system behavior. First, *negative feedback* counters any changes in the system's initial conditions and maintain system equilibrium. Overwhelming *positive feedback* further amplifies any small changes to the initial conditions that cause *bifurcation* (a punctuation or sudden shift in system behavior). Second, system *sensitivity* explains how easily a system's initial conditions are affected by outside interference. Third, *iterations* between event and choices amplify even incremental changes to the initial conditions. Fourth, *point attractions* move the system behavior toward an equilibrium state, whereas *strange attractors* feed upon bifurcation and pull the system over the *edge of chaos* toward a chaotic state.

The analysis demonstrates that static idea evaluation approaches restrict the occurrence of positive feedback by imposing rigorous evaluation parameters. These parameters create negative feedback that counters idea sensitivity by motivating point attractors that keep the system in equilibrium. Moreover, static evaluation does not attempt to iterate ideas. Instead, ideas are eliminated if they are not the right answer to a selected problem. Hence, ideas never bifurcate and are pulled across the edge of chaos by strange attractors. However, the focus on divergent thinking in dynamic idea evaluation iteratively imposes massive positive feedback to ideas when actors revisit, recreate, and re-evaluate those ideas. This positive feedback amplifies sensitivity in the initial conditions of ideas, resulting in bifurcation that punctuates or shifts the system behavior of the ideas. This bifurcation causes strange attractors to pull the ideas over the edge of chaos toward new novelty.

In conclusion, the article is an illustration of chaos theory being used to understand the system behavior of creative artifacts. Moreover, theoretical constructions are created for future research to use in order to understand IS that supports creativity. These constructs include pushing for positive feedback to enhance creativity, the concept of idea bifurcation to understand how ideas change in system behavior, and strange attractors to understand how ideas are pulled in different directions.

4.5. RA4: ENCOURAGING DIVERGENT THINKING IN IDEA EVALUATION USING CREATIVITY ENHANCING SYSTEMS

Ulrich, Frank; Müller, Sune Dueholm. (2015). " Encouraging Divergent Thinking from Knowledge Generated during Idea Evaluation: A Design Experiment with Creativity Enhancing Systems," Journal of Management Information Systems, 1nd Revise and resubmit.

The fourth research article addresses RQ2 by empirically testing the effectiveness of idea evaluation with creative encouragement in comparison with other approaches for idea evaluation and creativity enhancement. The article reports from a controlled laboratory experiment using three CES prototypes and 305 subjects from Amazon Mechanical Turk divided into three groups in a 3 × 1 factorial design. The results from the experiment show that CES that combines idea evaluation with creative encouragement (the dynamic approach) is more effective at supporting divergent production than CES that does not combine idea evaluation with creative encouragement (the static approach) and CES that only includes creative encouragement (the control).

The article addresses the following research question: “To what extent do Creativity Enhancing Systems support divergent thinking when incorporating knowledge generated during idea evaluation?” Creative encouragement was used to describe facilitation of language and techniques in CES design that encourages the participants' creative thinking abilities. To answer the research question, data from the laboratory experiment were statically interpreted using a standardized measurement framework that tests divergent thinking (Lewis et al. 2011). The subjects that participated in the experiment were divided into three groups. The first group used knowledge from idea evaluation without creative encouragement. The second group used knowledge from idea evaluation with creative encouragement. The third group acted as control by not including knowledge from idea evaluation, but included creative encouragement. All groups were empirically tested for their effectiveness to support divergent thinking.

Each response was scored for fluency (number of unique ideas), elaboration (number of unique sentences), flexibility (number of unique themes), originality (top 2% of all responses), and total divergent thinking score (the combined score across the variables). Thereafter, variance between medians was measured using ANOVA tests and Fisher's LSD post-hoc test.

The laboratory experiment provided three key findings to the research on CES that supports idea evaluation and creativity management. First, it showed that idea evaluation can support divergent production if creativity is encouraged. Second, it demonstrated that idea evaluation with creative encouragement is an effective alternative over existing creative processes. Third, it exemplified that evaluation research in support of idea evaluation as a convergent-only process (e.g., Blohm and Riedl 2011; Elam and Mead 1990; Girotra et al. 2010; Kennel et al. 2013; Osborn 1953; Riedl et al. 2010) has become self-fulfilling by introducing structures that eliminate divergent production.

In conclusion, CES that combines knowledge from idea evaluation with creative encouragement completely outperforms CES that does not combine knowledge from idea evaluation with creative encouragement. Hence, CES that combines knowledge from idea evaluation with creative encouragement is more effective on all measurable variables for divergent thinking. Moreover, CES that combines knowledge from idea evaluation with creative encouragement provides ideas that are more elaborate over the group that only received creative encouragement. Contrasting the three groups, the results show that dynamic idea evaluation is a viable alternative to static approaches for idea evaluation and creativity enhancement by being equally or more effective.

4.6. RA5: A GROUP CREATIVITY SUPPORT SYSTEM FOR DYNAMIC IDEA EVALUATION

Ulrich, Frank. (2015). "A Group Creativity Support System for Dynamic Idea Evaluation," 6th Scandinavian Conference on Information Systems (SCIS 2015). Published Lecture Notes in Business Information Processing Vol. 223, p. 137-151.

The fifth research article addresses RQ1 and RQ2 by exploring dynamic idea evaluation in an empirical setting. The article reports from a field experiment conducted with a Group Creativity Support System (GCSS) prototype in a university setting. The GCSS prototype was designed to support dynamic idea evaluation. Results from the field experiment shows that knowledge plays an integrate role when encouraging divergent and convergent thinking abilities during the creative process.

The article addresses the following research question: “How can idea evaluation support creative thinking through GCSS?” To answer the research question, data from the field experiment were interpretively analyzed using Sternberg's (1999) classification of knowledge and creativity combined with theory on divergent and convergent production (Cropley 2006; Guilford 1967, 1977). Over the five iterations that the field experiment lasted, clear signs of divergent production were identified. As such, the subjects extended the borders of knowledge domain for existing ideas, shifted their context and branched them out, and crossed their boundaries. In addition, a high level of *fluency* (generation of multiple novel ideas) was identified, which indicates divergent production (c.f., Guilford 1967). However, subjects would also stay within the knowledge domain of an idea by suggesting incremental improvements. This finding suggested that subjects in the field experiment also applied convergent production.

The article contains two key contributions. First, the article challenges the previous research that argues that idea evaluation only supports convergent production. It shows how a GCSS prototype that supports dynamic idea evaluation can encourage the convergent and divergent production of ideas. Second, the article provides new insights to the interrelationship between convergent and divergent production in dynamic idea evaluation. The article demonstrates how dynamic idea evaluation helps participants in their convergent production to improve existing ideas. Moreover, the article shows how dynamic idea evaluation can encourage the participants’ divergent production when they relate existing ideas to their own practice, and then transfer and combine this knowledge to apply novel alternatives.

In conclusion, existing research and practice have argued that idea evaluation is strictly convergent and should only be conducted when all other divergent production activities are concluded (Elam and Mead 1990; Osborn 1953; Osterwalder and Pigneur 2010). In contrast, this article demonstrates that an IS that supports dynamic idea evaluation can indeed support convergent and divergent production simultaneously during the creative process. The presence of simultaneous divergent and convergent production also empirically illustrates Cropley's (2006) theory that novel and effective solutions originate from a healthy environment where divergent and convergent production co-exist.

CHAPTER 5. A DESIGN THEORY FOR CES THAT SUPPORTS DYNAMIC IDEA EVALUATION

This chapter addresses RQ1-RQ3 by synthesizing the five research articles into design theory. The first article forms the body-of-knowledge for the justificatory knowledge of the design theory. The additional four articles add supplementary theory and findings to the presented design requirements.

This chapter is first structured by an initial presentation of the purpose and scope of the design theory. Next, the design requirements are elaborated from the justificatory knowledge from existing research and the five research articles. Thereafter, a blueprint of the system is presented with its constructs and principles of form and function. The design theory is concluded with a description of the system's mutability and principles for its implementation.

5.1. PURPOSE AND SCOPE

Creativity can often be complex and chaotic in any organization (Stacey 1996). Focusing on structuring the complexity of the organization thus becomes imperative to developing ideas and discovering new novel possibilities in them (c.f., section 2.1.2. and RA3). As outlined earlier, idea evaluation is situated toward convergent production in the scientific literature. This research excludes idea evaluation from the creative process. The purpose of this design theory is to close this gap by providing explicit prescriptions for a new type of CES that supports dynamic idea evaluation. The proposed design theory demonstrates how idea evaluation can capture the complex nature of creativity in the organization, rather than inhibiting it.

The scope of this design theory is to create a new class of CES that supports dynamic idea evaluation. In this CES, individuals and groups can utilize ideas in a variety of different industries. As such, the aim is to create design theory for a dynamic idea evaluation system that helps creative people develop novel ideas. Systems derived from this design theory should be able to help creative people evaluate their novel work iteratively by providing new insights/changes for their original ideas and suggest new directions for spin-off ideas or even new ideas. Such systems can support IT-developers using waterfall development models by drastically improving the novelty of requirements specifications for new IT systems (e.g., Maiden and Gizikis 2001; Maiden et al. 2004a, 2004b, 2006). Similarly, in agile development, an iterative evaluation and creativity system can provide better knowledge about the IT artifact (e.g., Aaen 2008), thus reducing prototype development time. Moreover, increased novelty in the agile development of new IT systems can occur when developers evaluate their work as part of the creativity process. Other complex creative commences, such as the commercial and electronic industries, might find value in this class of CES because it helps them test, re-develop, and identify novel directions for campaigns and product ideas before they test them through costly trials and prototyping.

5.2. JUSTIFICATORY KNOWLEDGE FOR SUPPORTING DIVERGENT AND CONVERGENT PRODUCTION IN IDEA EVALUATION

Creativity is a mental process influenced by environment factors that allow individuals to communicate original concepts for novel, useful, and appropriate solutions (Rhodes 1961; Runco and Jaeger 2012). Furthermore, creativity is inherently chaotic (Stacey 1996) in that it produces novel outcomes for complex problems with a high level of uncertainty (Amabile 1996; Mich et al. 2004; Mueller et al. 2012; Seidel et al. 2010b). The evaluation of ideas is thus two-sided because it is (a) necessary for identifying those issues connected with novelty, usefulness, and appropriateness of the presented idea (Amabile 1996; Dean et al. 2006), and (b) necessary for identifying needed changes and discovering new paths toward additional novel outcomes (Couger 1996a; Isaksen and Treffinger 1985). The research articles add their individual findings to the design requirements. RA1 adds the body of knowledge for the design theory. This knowledge is supplemented with additional literature from the other research articles. RA2 adds insight to the design theory by viewing multiplication as the overall objective to achieve. RA3 adds kernel related to chaos theory and dynamics of idea evaluation. RC4 and RC5 supply empirical evidence from the laboratory and field.

5.2.1. REQUIREMENTS FOR A CES PROCESS TO SUPPORT DIVERGENT AND CONVERGENT PRODUCTION IN IDEA EVALUATION

In the following paragraphs, four design requirements are presented for a CES that supports divergent and convergent production in idea evaluation.

Use evaluation to acquire new knowledge about submitted ideas. Knowledge can spark creativity when participants view it in a new light, reconstruct or redirect it, transfer or extend it to a new domain or within an existing domain beyond its accepted borders, and finally, radically redefine the knowledge for a completely new domain (Cropley 2006; Sternberg 1999). Ideas are represented in *"textual, aural, or visual formats"* (Lindic et al. 2011;183), and the development of ideas is characterized by a duality between recombining knowledge in novel ways (Burt 2004; Weitzman 1998) and applying new knowledge to the idea created when new discoveries are made (Hesmer et al. 2011). Moreover, the starting point of a good idea is a well-defined problem (Couger 1996a). Hence, the development of novel ideas is dependent on the knowledge embedded in the participants' expertise and their ability to facilitate approaches to solving problems by developing solutions (Amabile 1998). Luckily, idea evaluation is a knowledge-generating entity that can engage participants in identifying key issues related to an idea, and then process the collected information into a useable form (Lindic et al. 2011; Weitzman 1998). Furthermore, discovering new information can lead to new insights by exploiting the resources originally established to address different problems (Clark 1996). The importance of identifying knowledge is exemplified in RA2, RA4, and RA5. RA2 illustrates how human actors can use explicit and tacit knowledge connected to ideas in order to multiply them. As such, human actors can multiply ideas by translating and transforming them during convergent production and by consolidating and redefining them through divergent production. The results from RA4 demonstrate that dynamic idea evaluation can trigger divergent production, and that human actors produce more elaborate ideas when introduced to knowledge from a pre-evaluated idea. The results from RA5 confirm these observations from RA2 and RA4 by showing how the knowledge embedded in ideas extended the existing knowledge domains, traveled between them, and helped create novel domains. Correspondingly,

> *Design Requirement 1. "Use evaluation to acquire new knowledge about submitted ideas." In CES that supports divergent and convergent production with idea evaluation, create evaluation mechanisms that collect the knowledge embedded in the participants' expertise. Such knowledge can be known problems, benefits, and other key issues connected to the evaluated idea.*

Deploy idea evaluation in the early stages of idea development to trigger idea bifurcation from the collected knowledge. Bifurcation is a well-known theoretical concept that facilitates understanding of organizational and human processes as non-linear dynamic systems (Dhillon and Fabian 2005; Fitzgerald 2002; Guo et al. 2009; Hung and Tu 2011; McBride 2005; Samoilenko 2008; Schuldberg 1999; Thietart and Forgues 1995). Moreover, idea bifurcation is explained in detail in RA3. Idea bifurcation explains what happens when a system experiences a sudden change in behavior as it receives an influx of unbalanced actions or information (McBride 2005). Bifurcation also explains the system's qualitative state that transforms into another: for example, from a state of stability to a state of chaos (Schuldberg 1999). Bifurcation is the tipping point at which positive feedback (new input to the system) spins the system out of control. When this positive feedback is not met by negative feedback (stabilizing mechanisms) that counter the changes made to the system (McBride 2005; Schuldberg 1999), the system is pulled toward a state of deterministic chaos by strange attractors (chaotic behavior). These attractors are triggered by bifurcation and pull the system toward a new qualitative state, thus creating a new system with different qualitative properties from its original form (McBride 2005).

Creative systems are very similar to chaotic systems as described here. They are considered unpredictable, but they also encompass *"stages of generativity and consolidation, incubation, and elaboration"* (Schuldberg 1999;186). As such, a creative system can settle into a state of predictability and repetition, thus reducing its ability to generate novelty (Schuldberg 1999). In a stable state, negative feedback counters positive feedback (Dhillon and Ward 2002; McBride 2005), for example, eliminating ideas through predetermined ranking mechanisms (Riedl et al. 2010). However, when fresh knowledge leads to new insights (Clark 1996), the positive feedback can be overwhelming (Dhillon and Ward 2002; McBride 2005), thus triggering bifurcation and divergent thought patterns. Idea bifurcation is, for example, when knowledge identified in one idea triggers divergent production of a range of novel ideas in different directions. Creativity techniques (Couger et al. 1993) and identified knowledge from the evaluation process (Candy and Edmonds 1996) can serve to bifurcate existing ideas, creating both incremental and radical ideas that increase the novelty of the idea originally reviewed. Moreover, You (1993) recommended mixing evaluation and the idea development process to influence the level of positive feedback on the system by obtaining new knowledge from the participants, triggering divergent production within the idea that brings it toward a state of chaos where novel outcomes can occur. RA3 follows this recommendation by suggesting that the dynamic evaluation artifact should combine critical thinking with creativity thinking skills from the very start in order to trigger idea bifurcation. Correspondingly,

> *Design Requirement 2. "Deploy idea evaluation in the early stages of idea development to trigger idea bifurcation from the collected knowledge." In CES that supports divergent and convergent production with idea evaluation, include evaluation in the early stages of idea development. Early access to idea evaluation may introduce instability from the positive feedback posed by the acquired knowledge, which may trigger early bifurcation of the submitted ideas. Such activities can lead to idea bifurcation and chaotic outcomes.*

Deploy creativity techniques to enhance the novelty of the creative output. Next, there is substantial literature on creativity management using creativity techniques (Couger 1996a; Couger et al. 1993; Maiden et al. 2004a; Osborn 1953) and on integrating those techniques into CES (Dennis et al. 1999; Hender et al. 2002; Malaga 2000; Yuan and Chen 2008). Modern creativity techniques go back to the development of brainstorming (Osborn 1953). Since then, researchers and practitioners have developed several hundred techniques (see mycoted.com). Couger et al. (1993) explained that creativity techniques are useful in both the initial phase of idea development, when participants must discover new pathways, and in later evaluative development, when the need to identify problems and benefits arises. In Couger's later work (1996), he lists several creativity techniques for idea evaluation, which include using progressive abstraction that serves the purpose of identifying new ideas by progressively abstracting a given problem into smaller units. Moreover, Couger (1996a) recommends force field analysis for idea evaluation to list idea problems and benefits side-by-side, thus providing a roadmap for breaking down known problems and reinforcing identified benefits.

Transferring traditional creativity techniques to a digitalized form is well known within the IS field (Lubart 2005), and so are the benefits of doing so. Several researchers have shown that even small changes in structuring or configuring creativity techniques within CES can have profound effects on the creative outcome (Dennis et al. 1999; Hender et al. 2002; Malaga 2000). Other researchers, such as Aiken et al. (1996) compared two electronic brainstorming techniques and found scant differences in the creative outcome between the two techniques. However, studies have shown that software-supported creativity techniques can improve the overall quality and novelty of generated ideas over traditional pen-and-paper techniques (MacCrimmon and Wagner 1994). In similar studies, transferring these techniques into a digitalized group setting has also been proven to reduce tensions within groups (Nunamaker 1987) and to provide greater participant productivity and satisfaction compared with groups that work with traditional pen-and-paper techniques (DeRosa et al. 2007; Elfvengren et al. 2009). Hence, adapting and deploying digitalized creativity techniques is a key requirement to motivate divergent and convergent production in idea generation and evaluation. These techniques can help participants identify and exploit new novel solutions from those problems or benefits they identify when evaluating existing ideas, thereby potentially generating new knowledge and/or radical or incremental solutions that expand or alter the idea originally evaluated. The laboratory experiment from RA4 and the field experiment from RA5 confirm that creativity techniques can successfully be inserted to support creativity in the evaluation process. However, the experiences from these two experiments also suggest that designers should alter existing creativity techniques to work with dynamic idea evaluation or use specialized creativity techniques for idea evaluation, such as force field analysis and progressive abstraction. Correspondingly,

> *Design Requirement 3. "Deploy creativity techniques to enhance the novelty of the creative output." In CES that supports divergent and convergent production with idea evaluation, include modified creativity techniques to motivate divergent and convergent production throughout the idea evaluation process.*

Make evaluation part of an iterative creative process. Amabile (1996) described the creative process as a mixture of compelling iterative components of task motivation, expert knowledge, and creativity-relevant skills, such as communication, risk taking, and understanding of complexities. Each component influences the others and the overall creative outcome. Working iteratively is widely recognized in agile software development for allowing the continuous improvement of software product (Rose 2011). More recently, Aaen (2008) criticized agile development methods for not including creativity. Aaen (2008) proposed a different alternative for software development called ESSENCE (essence.dk), where creativity is part of every aspect of software development and it is not constrained to the initial creation of product specifications. You (1993) raised similar critique by questioning the linearity of evaluation. Instead, he proposed an approach where creative and evaluative processes are mixed iteratively to increase the novel outcome and reduce the negative impact of evaluation on creative thinking. Evaluation can stabilize an idea through convergent production (Chen 1998; Elam and Mead 1990; You 1993), whereas the discovery of new information can trigger bifurcation and potentially chaotic situations where divergent production patterns based on the bifurcation pull the idea toward new novelty (Richards 2001; Schuldberg 1999; Stacey 1996; You 1993). RA2 and RA3 add new insight to this discussion. In RA2, multiplication occurs iteratively over time when human actors informally evaluate ideas, negotiate them, and act to find common ground. The theoretical analysis of dynamic idea evaluation in RA3 illustrates a similar perspective. In this perspective, ideas that are continuously iterated have the potential of changing their form, to be redefined into alternative forms, and to be clustered into portfolios for working solutions. RA5 confirms the observations from RA2 and RA3. First, the experiment produced multiplication of ideas over its five iterations. Second, ideas changed, produced alternative and novel configurations, and were clustered together under different challenges. Correspondingly,

> *Design Requirement 4. "Make evaluation part of an iterative creative process." In CES that supports divergent and convergent production with idea evaluation, include iterative mechanisms that trigger bifurcation by identifying idea quality changes and additional paths toward new problems or novel qualitative changes not previously discovered in the creative process.*

5.3. CONSTRUCTS AND PRINCIPLES OF FORM AND FUNCTION

This section focuses on *"the principles that define the structure, organization, and functioning"* for constructing the design artifact (Gregor and Jones 2007, p. 325). As such, the design requirements are translated into the constructs and principles of form and function that serve as those features that the IS product should contain, and the architecture within those features that should be constructed (Gregor and Jones 2007; Müller-Wienbergen et al. 2011). The end result is an IS artifact that facilitates participant engagement in divergent and convergent production by including creativity-enabling events in the design upon which participants can act. In the following paragraphs, an approach to the *"blueprint"* of the IS artifact (Gregor and

Jones 2007, p. 326) is explained. This blueprint involves a system that allows participants to create ideas for improvements and novel ideas when they evaluate existing ideas.

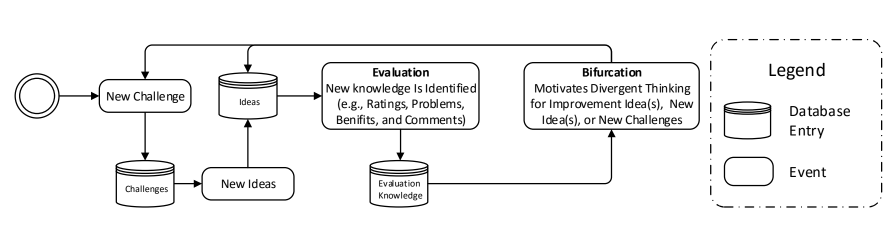

Figure 4: Proposed System Architecture

Figure 4 demonstrates the suggested architecture for an idea evaluation system that supports divergent and convergent production through an iterative process (requirement 4). In the proposed architecture, participants create overall challenges and novel ideas to solve those challenges. The participants then evaluate the ideas and create improvements and additional novel ideas from the knowledge obtained through the evaluation process. The arrows in the figure show the flow of events between the elements.

The proposed system architecture serves to facilitate the identification of overall challenges, and the creation of novel and improvement ideas. Novel ideas and their improvements are automatically stored in a database. Moreover, the system architecture can include digitalized creativity techniques that help bifurcate knowledge and facilitate creativity (requirement 3).

When a participant develops a novel idea, the proposed CES aids the evaluation process by collecting participant input, e.g., ratings, comments, and identified problems and benefits. Moreover, the participants can add new information to the existing knowledge by, for example, commenting on problems and benefits associated with a given idea (requirement 1).

The evaluation process is aimed toward creating a state of bifurcation using creativity techniques within the evaluation process (requirement 2). In the suggested architecture, the creativity techniques can help the participants' convergent production by, for example, solving problems or strengthening benefits in the initial idea (requirement 3). Similarly, the idea bifurcation created through this creative process can inspire divergent production, allowing them to identify non-related ideas or overall problems than the vision they initially evaluated.

5.3.1. DESIGN THEORY CONSTRUCTS

The constructs represent the basic units of interest in the design theory that can be either *"physical phenomena or abstract theoretical terms"* (Gregor and Jones 2007:325). The constructs of the proposed design theory are derived from the design requirements and are further inspired by existing research and practice. The constructs exist within a participant-generated ecology of ideas. The ecology is an area of influence within which other entities or constructs can act (McBride 2005). Within this ecology, knowledge items (Müller-Wienbergen et al. 2011) exist and are created. To evaluate ideas, the participants can provide additional knowledge items through comments that identify those issues related to the ideas or their problems and benefits. From evaluation, the participants can generate original ideas that are knowledge items with explicit novel properties. They can also create improvement ideas to existing ideas under evaluation. Through the digitalized idea evaluation, participants can assess these incoming ideas (Dean et al. 2006; Di Gangi and Wasko 2009). The generated knowledge serves the purpose of generating bifurcation (Dhillon and Fabian 2005; Fitzgerald 2002; Guo et al. 2009; Hung and Tu 2011; McBride 2005; Samoilenko 2008; Schuldberg 1999; Thietart and Forgues 1995), which motivates the participants to change their behavior to allow them to create novel ideas and further expand the ecology of ideas. Digitalized creativity techniques (Couger 1996a; Couger et al. 1993; Greene 2002) can support bifurcation by enhancing the novelty of the ideas created, for example, by being conjoined with evaluation techniques that use captured knowledge to motivate participants to generate more improvements and novel ideas (see Couger 1996a; Couger et al. 1993).

The constructs, purpose, and their source of inspiration from an existing theory or technology construct are summarized in Table 6.

Table 6. Design Theory Constructs

Construct	Purpose	Source(s) of inspiration
Knowledge items (Requirement 1)	Knowledge items that take the form of improvement and original ideas constructed through the evaluation process. Knowledge item can also be evaluation content, such as participant comments that address specific issues related to ideas under evaluation.	Existing literature: (Di Gangi and Wasko 2009; Müller-Wienbergen et al. 2011). Included research articles: RA2, RA4, RA5.
Conjoined evaluation and creativity (Requirement 2)	Digitalized constructs that gather information about existing ideas while encouraging creativity to create new ideas.	Existing literature: (Couger 1996a; Couger et al. 1993; Dean et al. 2006; Di Gangi and Wasko 2009; Greene 2002). Included research articles: RA3, RA4, RA5.

Table 6. Design Theory Constructs - Continued		
Construct	Purpose	Source(s) of inspiration
Idea bifurcation (Requirements 2, 3, and 4)	Build-in feature that creates a change in behavior, hence motivating participants to create ideas. Digitalized creativity techniques and iterative development processes can support bifurcation.	Existing literature: (Couger 1996a; Dhillon and Fabian 2005; Fitzgerald 2002; Greene 2002; Guo et al. 2009; Hung and Tu 2011; McBride 2005; Samoilenko 2008; Schuldberg 1999; Thietart and Forgues 1995). Included research articles: RA2, RA3, RA4, RA5.

5.3.2. DESIGN PRINCIPLES FOR A DYNAMIC SOFTWARE-DRIVEN PROCESS BETWEEN EVALUATION AND CREATIVITY

Design principles can be specific features of a system that are *"applicable to other systems yet to be constructed"* (Gregor and Jones 2007:331). To support a dynamic and iterative process that creates novelty from identified knowledge in the evaluation process, the set of design principles described in the following paragraphs is proposed.

Initially, idea evaluation serves to collect new knowledge from submitted ideas by, for example, identifying problems and benefits. This knowledge is collected from participant comments and by identifying problems and benefits (requirement 1). Participant comments and identifying problems and benefits allow the participant to collect previously unidentified knowledge on a submitted idea. Consequently, the following design features are proposed:

> *The participants should be able to add evaluation content for submitted ideas by, for example, proposing problems and benefits. They should also be able to comment on ideas and existing evaluation content. These features can encourage divergent and convergent production when the participants find inspiration in the collected knowledge.*

Second, idea evaluation serves the function of triggering bifurcation using the collected information to encourage divergent and convergent production. To achieve this objective, designers should implement idea evaluation early in the creative process by applying evaluation mechanisms directly to the foundation of the creative process. As such, designers can customize creativity techniques to identify problems and benefits from the proposed ideas while bifurcating the acquired knowledge toward alternative divergent and novel states (requirement 2). Alternatively, nudging or encouraging participants to perform specific tasks (Thaler and Sunstein 2009) can reinforce bifurcation by placing action buttons (Duyne et al. 2002) (e.g., Amazon's one-click buy button) in specific areas of the participant interface. Nudging can encourage participant engagement in the creative process. Consequently, the following design features are proposed:

> *Posted ideas should be displayed on the opening screen of the system. Clicking an idea to view details should transfer the participant directly to the evaluation process. This quick access to idea evaluation has the potential of engaging participants to contribute early and iteratively in the evaluative and creative process.*

> *When evaluating submitted ideas, the digitalized evaluation process should mimic a creativity technique that encourages participants to create novel ideas. Creativity techniques, such as brainstorming (intended for divergent production), could be modified for idea evaluation and could motivate the divergent production of novel ideas. Built-in action buttons in the participant interface could further advance this objective by creating nudges that encourage the participant to create knowledge for evaluation purposes and motivate divergent and convergent production.*

Designers should adapt other creativity techniques to enhance the creative process and transfer the knowledge created from the evaluation process into developing original ideas, solving problems, and/or exploiting benefits in proposed ideas (requirement 3). The participants could access such creativity techniques from the evaluation process through action buttons. Hence, the system can provide easy access to toolkits that can support participants experiencing a moment of inspiration from the knowledge creation process as they evaluate ideas. Consequently, the following design features are proposed:

> *From the participant interface in the idea evaluation process, the participants should have direct access to a toolkit of creativity techniques, for example, by building them into the participant interface. Quick access to creativity techniques could enhance divergent and convergent production from the bifurcation created in the idea evaluation process. Action buttons integrated in the participant interface of idea evaluation could further nudge participants to act creatively upon bifurcation.*

Last, the system should be iterative in the sense that it should constantly revisit previously submitted ideas, connect ideas together, and generate new content (evaluation content, new ideas, and connections between existing knowledge) for the ecology of ideas generated over time (requirement 5). Hence, a three-way iterative and creative process is deployed in the proposed CES, where evaluation content for submitted ideas are identified and then acted upon using convergent production to create improvement ideas that can fix problems or exploit benefits. Moreover, a CES is proposed where knowledge generated from the evaluation process allows participants to be immersed in divergent production and create original ideas that move in a completely new direction from the idea originally evaluated.

Table 7 summarizes the design requirements in relation to the presented construct and design principles of form and function.

Table 7. Relationship between Design Requirements and Constructs and Principles of Form and Function

Design requirement	Constructs and principles of form and function
1. Use evaluation to acquire new knowledge about submitted ideas.	Idea evaluation functions by providing new knowledge about problems and benefits for submitted ideas, which is achieved through participant-generated evaluation content, such as comments, ratings, and problems and benefits.
2. Deploy idea evaluation in the early stages of idea development to trigger idea bifurcation from the collected knowledge.	The idea evaluation process is a central part of the creative process. Knowledge acquired from ideas and the evaluation process is used to create bifurcation. This bifurcation encourages participants to generate ideas by improving identified problems and exploiting benefits. Moreover, bifurcation can encourage participants to create original ideas moving toward a completely different direction. Alternatively, nudging in the participant interface can reinforce bifurcation.
3. Deploy creativity techniques to enhance the novelty of the creative output.	When participants decide to create improvement and original ideas, the system has creativity techniques integrated in the participant interface that enhance divergent and convergent production.
4. Make evaluation part of an iterative creative process.	When changes occur in the evaluation process, participants can revisit submitted ideas. Evaluation thus becomes a three-way process: identifying and creating evaluation content, creating ideas that fix problems and exploit benefits, and creating ideas that move in a novel direction.

5.4. PRINCIPLES OF IMPLEMENTATION

The implementation principles outlined in this section explain the specific context of how the proposed design theory comes to life through a product or method (Gregor and Jones 2007). Hence, for bringing the theory to life, it is important to theorize on how the proposed design would translate into a real-world setting.

Mobilization of the contributors is key to the success of creativity-based systems (Bragge et al. 2005; Lindic et al. 2011). These contributors can be employees, customers, or external business partners (Lindic et al. 2011). Thus, initial and continuous mobilization of contributors is one of the key principles for the successful implementation of the proposed design. This design theory focuses on two principles of mobilization when implementing the proposed IS artifact.

The first principle of contributor mobilization requires a critical mass of participant-generated knowledge items to be used for creative thinking within the system (Müller-Wienbergen et al. 2011). Contributor mobilization can be obtained through crowd-based idea competitions (Blohm et al. 2011; Leimeister et al. 2009; Lindic et al. 2011). Recent research shows that the use of CES is very dependent on participant training and available resources in the organization (Ulrich and Mengiste 2014). The experiences from the evaluation of the design artifact showed a similar pattern, because subjects required some training to operate the artifact. Moreover, lack of resources (time) resulted in one subject ending her participation, whereas other subjects found it difficult to participate because of work-related duties. Hence, this first principle requires the initial engagement of managers and stakeholders to provide training, allocate resources, and provide time to participate in the process.

The second principle of contributor mobilization requires the manager to maintain generated knowledge items within the system by updating or removing those items that are outdated, which can be obtained through good usability and sociability between the contributors (Müller-Wienbergen et al. 2011). Deploying the design artifact as a working prototype in a real world setting found that large-scale implementation of a CES without any moderators could become chaotic very quickly. The 15 subjects in RA5 added 294 entries over only five iterations. In some cases, they also added benefits, problems, and ideas in comments while adding comments and ideas as benefits or problems. For example, 26 improvement ideas were extracted from the evaluation content. Thus, the second principle requires dedicated and trained moderators with the power of changing content and solving issues between participants.

5.5. ARTIFACT MUTABILITY

Artifact mutability describes how an IS artifact evolves and adapts over time (Gregor and Jones 2007). The proposed design theory has usage across multiple industries. The continued development and adaptability of the design theory and the internal consistency of its core constructs (ideas and evaluation content as knowledge items, digitalized evaluation process, and idea bifurcation) is highly dependent on the social norms, work practices, and structure where the design theory is implemented. The findings from RA5 show that the force field analysis technique proved valuable for adding perceived value to ideas. Such creativity techniques could be mutated to cover idea development in IT acquisitions, for example, by acting as a knowledge database for creating better business cases (e.g., Ward et al. 2008).

Furthermore, RC5 included idea generation for new requirements for a travel expense system. Using creativity in requirement engineering has been covered in the existing literature (Maiden and Gizikis 2001; Maiden et al. 2004a, 2004b, 2006). However, companies that use waterfall methods for software development could adapt the design artifact toward initial requirement engineering or adapt its use to gain a closer relationship with their customers (e.g., Di Gangi and Wasko 2009). For IS development teams that use an agile methodology to facilitate creativity (e.g., Aaen and Jensen 2014; Aaen 2008), the IS artifact could be mutated in a completely different direction. In such cases, idea and evaluation content could include prototypes, code snippets, or user cases.

CHAPTER 6. DISCUSSION

This chapter outlines the contributions, implications, and limitations of the conducted research. Moreover, future prospect for research is presented. The discussion is structured with a positioning of the PhD study in relation to the framework presented in chapter 2. Thereafter, the contributions from the PhD study are outlined followed by the implications for research and practice. Next, the limitations of the PhD study are summarized. Finally, the discussion is concluded with future possibilities for research.

6.1. POSITIONING OF FINDINGS

The research framework of this PhD study includes a 2 × 2 matrix of operational creativity research (Section 2.1.1.). This framework is based on Rhodes' (1961) 4P framework of Press, Person, Product, and Process used by RA1 to analyze the creativity literature in the IS research field. In this PhD study, the 2 × 2 matrix is extended with Ackoff & Vergara's (1981) view of origin and processor-orientation. The findings of the PhD study are positioned with this combined framework. For origin, there is strong emphasis on using existing interpersonal skills and building a virtual environment where creativity can thrive. For processor, emphasis is placed on continuous learning and enhancing existing creative abilities. Moreover, the research findings of this PhD study are situated in this understanding of operational creativity by being entrenched in all the Ps of this refined 4P model (Figure 5).

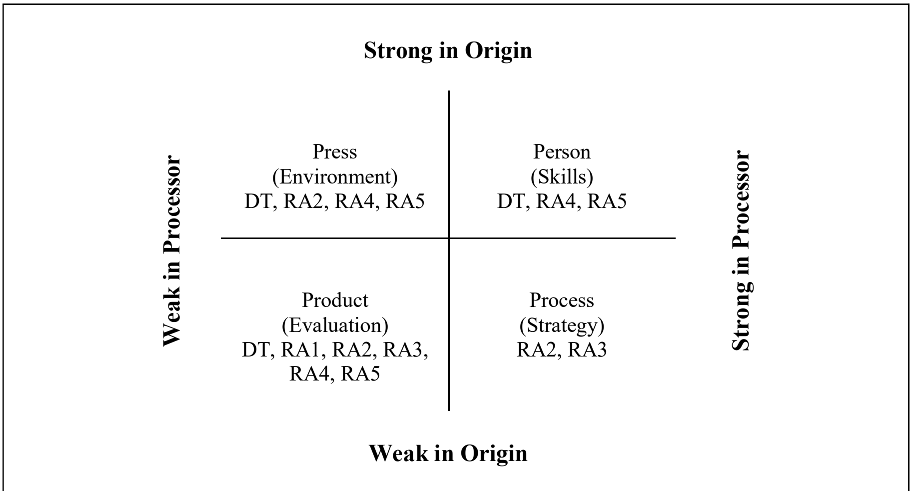

Figure 5: Model for Organizational Creativity

Situated in *Press*, the design theory (listed as DT in Figure 5) details design requirements, constructs, and principles for form and function for a digital environment (CES) that uses dynamic idea evaluation to encourage divergent and convergent thinking. The design theory also includes principles for artifact implementation and mutability for this digital environment. Moreover, RA5 empirically explores the knowledge production of CES, whereas RA4 empirically tests the effectiveness of similar systems. RA4 and RA5 are co-constructed with the design theory and provide clear prescriptions on how to build a digital environment that supports dynamic idea evaluation. Finally, RA2 adds new knowledge to Press by exploring the social dynamics of creativity in the organizational environment. Situated in *Person*, the PhD study combines idea evaluation with the enhancement of creative thinking abilities. In the enclosed design theory, such creativity techniques are included as a design requirement (Section 5.2.1 – Requirement 3). Moreover, in RA4 and RA5, both standardized and specialized creativity techniques are integrated into the design artifacts. Situated in *Product*, the PhD study provides a new framework constituted as dynamic idea evaluation. The disproportion of idea evaluation literature in the IS research field is identified in RA1, whereas RA2, RA3, RA4, and RA5 are concerned with the development and empirical testing of dynamic idea evaluation. Moreover, the dynamic idea evaluation approach is synthesized into the design theory. Situated in *Process*, the PhD study challenges some fundamental issues connected to strategizing idea evaluation in organizations. In RA2, formal and informal strategies are presented. Formal strategies involve fixed parameters based on previous practices and learning. Informal strategies, however, involve continuous learning and emergence of new practices. In RA3, these two strategies are further compared and contrasted by examining the creative artifacts into which they are embedded.

6.2. FINDINGS AND THEIR CONTRIBUTIONS

Three research questions are approached in this PhD study. The first two ask how idea evaluation can support divergent thinking (RQ1) and whether such an approach will be effective (RQ2). The third question inquires how to design Creativity Enhancing Systems (CES) when using idea evaluation to support divergent thinking (RQ3). The first two research questions are addressed by the five research articles by providing an overview of the literature (RA1) and by understanding the social and structural dynamics of idea evaluation (RA2 and RA3). Furthermore, these two research questions lead to empirically examining effectiveness in the laboratory using CES that supports static and dynamic idea evaluation (RA4) and exploring the knowledge practices in the field associated with dynamic idea evaluation (RA5). The third research question is addressed by the included design theory that provides clear prescriptions on how to build a CES that supports dynamic idea evaluation. Moreover, the research articles add to RQ3 by including testable propositions (RA4) and a prototypical instantiation for the design theory (RA5).

6.2.1. RESPONSE TO RQ1

In response to RQ1 (How can idea evaluation support divergent thinking?), multiple theoretical constructs were identified. These constructs were used to theorize an idea evaluation approach that can support divergent and convergent thinking. The following paragraphs expand the findings and contributions of the developed theoretical constructs for organizational creativity and idea evaluation.

Multiplication. RA2 presents a new theoretical framework for organizational creativity that predicts the outcome for neoteric ideas. Neoteric ideas are those unknown to the human actors by containing flux that they need in order to make sense of, to consider, the ideas' novelty and usefulness. The theoretical framework predicts that human actors negotiate on the outcome of neoteric ideas. In this sensemaking process, they adopt those ideas of which they can make sense, reject those ideas of which they cannot make sense, and multiply ideas when conflict arises during negotiations. Multiplication occurs when human actors translate, transform, consolidate, and radically redefine knowledge into something that provides meaning and helps them during negotiations. However, multiplication can also produce something that other human actors consider neoteric when governed by competing frames of reference.

As the following discussion shows, multiplication is an important contribution to our understanding of organizational creativity. The discussion also shows that multiplication offers operational advantage over creativity by being a new conceptualization of creativity that incorporates human action and cognition, the travel of ideas, generativity, formative and informal evaluation, and time. Unlike creativity, multiplication is not affected by ambiguous definitions. Instead, multiplication is a straightforward conceptualization that can help researchers understand how ideas spread over time, and build better systems that support such practices.

Operational frameworks of organizational creativity include Rhodes' (1961) 4P model and Amabile's (1983b) view on interpersonal skills, task-related skills, and task motivation (see section 2.1.1.). The research framework in chapter 2 includes a temporary conceptualization of creativity that defines it cognitively as a product of divergent or convergent thinking (Guilford 1967, 1977), operationally as an activity in the organization (Rhodes 1961), and as something that is measurable through its product and task-sensitivity (Amabile 1983b). Creativity was also defined as being evolutionally from enactments of existing knowledge, which defined its ability to be disruptive over time and space (Czarniawska and Joerges 1995; Ford and Sullivan 2004; Stacey 1996; Weick 1993). However, this definition also exemplifies that creativity, as an operational terminology, is fragmented and ambiguous. This is supported by existing research, thus showing that creativity, as an operational terminology, suffers from multiple and often conflicting definitions (Couger 1996a).

Moreover, evaluating its outcome (ideas) struggles with the negative effects connected to task motivation (Amabile 1998), and idea evaluation has become disconnected from innovation (Govindarajan and Trimble 2010). Finally, creativity as an operational concept struggles with explaining how ideas travel between organizations and different contexts. For the same reason, creativity is rarely used as an operational terminology in the literature associated with the travel of ideas (e.g., Nielsen et al. 2014; Røvik 2011; Valikangas and Sevon 2010).

Multiplication does not suffer from this ambiguity. *First*, multiplication explains how human actors translate, transform, consolidate, or radically redefine ideas into something that helps them during negotiations and that others might consider neoteric. As such, multiplication is strongly connected to contemporary views on the travel of ideas from Scandinavian traditions on institutionalism (Czarniawska and Joerges 1995; Røvik 2011). *Second*, multiplication captures generativity whether based on divergent or convergent production. *Third*, multiplication captures formative and informal evaluation and task-sensitivity when suggesting that sensemaking and negotiations between conflicting frames of reference are key to generating new ideas. For the same reason, multiplication captures conflict and decision-making that makes it operational for understanding how organizations adopt or reject ideas. Finally, multiplication connects creativity to innovation by explaining how human actions over time evaluate, negotiate, and multiply neoteric ideas embedded in technologies.

Using Gregor's (2006) terminology of IS theory, multiplication can be understood as a theory for explaining and predicting, which can be applied to building a theory for design and action. As such, the theory of multiplication explains what happens when human actors encounter neoteric ideas, and predicts the outcome of conflicts between competing frames. For researchers and practitioners, multiplication offers operational advantages over creativity by providing a terminology where the value of ideas is measured through their ability to spread, become adopted, and ultimately spread and travel to other organizations or contexts. Multiplication is easy to measure and thus operationalize. Multiplication can be measured through the ideas being produced. Identification of embedded self-similar knowledge in ideas can also map their relationship to other ideas, and the technological innovations into which those ideas become embedded. Moreover, multiplication includes how ideas travel over time and space. However, multiplication also introduces the processes and thinking patterns associated to creativity neglected by the body of literature within the travel of ideas. For designers of CES, multiplication offers an important terminology over creativity by providing a desired effect that is measurable through the system’s ability to demonstrate interconnectivity between submitted ideas. For example, multiplication is instrumental in creating design requirements for the CES design theory that encourages divergent thinking through dynamic idea evaluation (Chapter 5).

Feedback and idea bifurcation. This PhD study contains an in-depth understanding of the system's dynamics of static and dynamic idea evaluation artifacts (RA3). Multiple system dynamics of idea evaluation were identified using chaos theory (Dhillon and Fabian 2005; Dhillon and Ward 2002; McBride 2005) to compare and contrast two opposing IS artifacts. Hence, system dynamics, such as feedback, bifurcation, and attractors, were shown to control the convergent and divergent properties of these evaluation artifacts.

First, positive and negative feedback showed to be important when designing creative IS artifacts with evaluation support (RA3). Through the theoretical lens of chaos theory, feedback can be understood as a classification of knowledge that the IS artifacts are designed to process. Hence, understanding these feedback mechanisms are important in designing IS artifacts, such as CES that supports idea evaluation. As the analysis from RA3 showed, understanding feedback is an important factor for encouraging divergent production during idea evaluation. An overflow of negative feedback could keep ideas within equilibrium, whereas positive feedback might potentially bifurcate ideas.

Second, idea bifurcation is a theoretical construct introduced in RA3. Idea bifurcation explains how ideas move or split from their original state to multiple states with potential novelty. RA5 indirectly demonstrates this theoretical observation. Based on Sternberg's (1999) theory of how knowledge in ideas shift domains, the interpretive analysis of the empirical data in RA5 showed that ideas contain knowledge that human actors can combine with other knowledge, thus transferring it to other domains where this knowledge can help form additional novel ideas. As such, those ideas bifurcate from their original state to multiple novel states. Idea bifurcation is similar to feedback mechanisms that are important for designing CES by providing a mechanism that leads to ideas evolving and spreading. For example, idea bifurcation was used to construct formal design requirements for the proposed CES design theory (Section 5.2.1 – Requirements 3 and 4). Moreover, idea bifurcation explains how ideas change when pulled toward strange attractors that can be materialized as creative metaphors (RA3).

Feedback adds an important contribution to the design of IS artifacts dependent on processing knowledge to encourage creativity. Knowledge has previously been examined in various CES research scenarios (e.g., Candy and Edmonds 1996; Cheung et al. 2008; Elfvengren et al. 2009; Hesmer et al. 2011; Müller-Wienbergen et al. 2011). As shown through this PhD study, idea evaluation generates knowledge that materializes as feedback. Hence, when deploying appropriate mechanisms that generate different feedback, designers can shift between states of convergent and divergent production. However, these feedback mechanisms are also important for designing other IS artifacts within Computer Supported Cooperative Work (CSCW), which includes groupware systems such as Group Support Systems (GSS). These types of IS artifacts are strongly influenced by knowledge and expertise sharing, and collaboration between human actors (e.g., Ackerman et al. 2013). As such, designing for the flow of different feedback in knowledge sharing and collaboration could prove important for these classes of IS artifacts. Feedback is also important for other types of IS artifacts. For example, maintaining equilibrium is important for making lean processes effective (e.g., Shah and Ward 2003). Feedback adds new knowledge to this literature by demonstrating that maintaining equilibrium is dependent on controlling the feedback flow.

Idea bifurcation is an important contribution for the design of IS artifacts that support creative processes. As noted earlier in this section, idea bifurcation explains how ideas change characteristics and materialize as creative metaphors for novel ideas. In other words, idea bifurcation helps understand when ideas break or split into something new. In the enclosed design theory (chapter 5), the understanding of idea bifurcation helps construct a requirement that moves idea evaluation into the creative process, rather than being a separate and external process, as noted by Elam and Mead (1990). Thus, for CES design research (e.g., Müller-Wienbergen et al. 2011; Voigt et al. 2012, 2013), idea bifurcation can be used by researchers to construct design requirements for other IS artifacts that involve creative processes. Such requirements could use idea bifurcation to rethink established practices using the same design approach exemplified in this PhD study. Moreover, within the literature of the travel of ideas (e.g., Czarniawska and Joerges 1995), idea bifurcation adds an important system perspective by explaining the chaotic system properties of creativity. The travel of ideas attempts to understand how ideas tend to act similar to viruses by mutating, adapting, and spreading between organizations (Røvik 2011). This chaos theory perspective may prove important to understanding the intricate nature of the mechanisms associated to how ideas mutate.

Idea evaluation. This section provides an overview of the findings related to idea evaluation. In the research framework (section 2.3.), two different approaches for idea evaluation were presented. The PhD study contains individual findings for these approaches, because they both have been analyzed and compared in RA2, RA3, RA4, and RA5. As such, the findings related to static and dynamic idea evaluation are found by examining the body of knowledge within the IS literature (RA1) and the management literature outside the IS research field. Moreover, the findings are situated within the theoretical and empirical work of the PhD study. To understand their differences, the findings related to static and dynamic idea evaluation are compared, contrasted, and summarized in Table 8. Thereafter, the combined contribution is discussed in relation to existing research.

Table 8: Findings related to Idea Evaluation		
	Static idea evaluation	Dynamic idea evaluation
Approach	Summative when creative activities have ended. Iterations rarely occur because only the best ideas are developed further.	Formative and iterative during ongoing creative activities.
Focus	Improve and develop only selected ideas.	View all ideas as potentially valuable and iteratively multiplying them into novel alternatives.
Purpose	To identify value in order to allow selecting the best ideas from all the alternatives.	To identify the best solution over time.
Strategy	Formal and prearranged.	Informal and ad hoc.
Value	Fixed and identified when all creative activities are concluded.	Identified iteratively and changes over time when human actors multiply ideas according to their own practice.
Evaluation parameters	Become quantitative when value is based on fixed parameters.	Become qualitative when human actors discuss and negotiate ideas over time.
System dynamics	Designed to process only negative feedback, which activates point attractors that keep ideas within equilibrium.	Designed to process positive and negative feedback that results in idea bifurcation that activates strange attractors, and pulls the ideas across the edge of chaos.
Creativity	Limited use of convergent thinking to narrow a pool of ideas down to few viable alternatives.	Active use of convergent and divergent production to improve existing ideas and form novel alternatives.
IS Manifestation	Manifested in IS artifacts that use rating mechanisms to evaluate and identify appropriate ideas when divergent activities are concluded.	Manifested in IS artifacts that enhance creativity and iteratively evaluate ideas.

Using the summative and formative evaluation classification by Moeran and Christensen (2013), the *approach* of static idea evaluation is summative. The reason for this is that static idea evaluation is conducted when all creative activities have ended (e.g., Elam and Mead 1990). This approach leaves no room for iterations. Instead, *focus* is placed on improving and further developing only the selected ideas (Girotra et al. 2010). The *purpose* of static idea evaluation is to identify the best ideas from all the alternatives (Girotra et al. 2010). In order to support this purpose, static idea evaluation is built upon a *strategy* that is formal and prearranged to occur when a large pool of ideas are developed using, for example, brainstorming (e.g., Elam and Mead 1990; Osterwalder and Pigneur 2010). To identify the *value* in such a pool of ideas, static idea evaluation primarily uses quantitative *evaluation parameters* (Reinig et al. 2007; Riedl et al. 2010). These qualitative parameters are based on fixed definitions of quality, such as novelty, usefulness, relevance, elaboration, etc. (Blohm et al. 2010; Dean et al. 2006). The results from the system analysis in RA3 demonstrate that when using such quantitative evaluation to select certain ideas while eliminating others, they act as negative feedback and have devastating effects on the ability of static idea evaluation to encourage divergent and convergent production. When static idea evaluation is only able to process negative feedback, point attractors keep ideas within equilibrium and prevent them from bifurcating. As such, the active use of *creativity* is limited in static idea evaluation. The empirical evidence from RA4 supports this observation by showing that static idea evaluation is unable to encourage divergent production. Moreover, the body of knowledge from the literature (Elam and Mead 1990; Guilford 1967; van der Lugt 2000; Sakamoto and Bao 2011) and the system analysis from RA3 exemplifies that it only uses convergent production to narrow ideas down to a few viable alternatives. Because of these system properties, the IS manifestation of static idea evaluation is artifacts that use rating mechanisms to identify appropriate ideas when all divergent activities are concluded.

Using Moeran and Christensen's (2013) classification, the findings from RA3 and RA5 demonstrate that the *approach* for dynamic idea evaluation is formative by being part of the creative process and by leaving plenty room for continuous iterations (see also RA2, RA3, and RA5). *Focus* is thus placed on viewing all ideas as being potentially valuable if they receive time and consideration (Couger 1996a). As a result of this view, ideas continuously iterate between evaluation that identifies potential value and multiplication that translates, transforms, consolidates, or radically redefines the ideas into novel alternatives (RA2, RA5). Such novel alternatives can be convergent production of improvements for existing ideas or divergent production of ideas for different knowledge domains (RA5). The purpose of dynamic idea evaluation consequently becomes into the identification of the best solution over time from inter-related ideas over the identification of one *"killer idea."* For the same reason, the *strategy* is informal and ad hoc when the adopted ideas are those that make sense for the human actors (RA2). This informal strategy is also important for the perceived *value* of ideas. As shown in RA2, the value of ideas is not fixed in time. Instead, value changes and is iteratively identified over time when human actors have new experiences and multiply the ideas according to such learning practices. The *evaluation parameters* thus become qualitative when human actors discuss and negotiate ideas (RA3, RA5). The results from the system analysis in RA3 show that this interaction might result in positive feedback, which makes ideas bifurcate and draws them toward strange attractors that pull the ideas across the edge of chaos toward new novelty. This observation is confirmed in RA5 where the discussion between participants resulted in multiple novel ideas. The same study also shows that inserting creativity techniques into the creative process allowed the participants' continuous convergent and divergent production. Convergent production occurred when the participants improved ideas within its accepted borders, whereas divergent production occurred when they formed novel alternatives (new ideas) beyond such borders. Because of these properties of dynamic idea evaluation, the manifestation of such IS artifacts should be designed to use creativity techniques in the evaluation process and/or iteratively evaluate ideas to enhance creativity. Prototypical instantiations of such design manifestations are demonstrated in RA4 and RA5.

The first research question is concerned with how idea evaluation can support divergent thinking. Throughout the PhD study, this central question has guided the research. The findings from RA2, RA3, RA4, and RA5 identified and combined existing research on idea evaluation and conceptualized a new approach that supports divergent and convergent thinking. Previous research has kept idea evaluation external to divergent production (Elam and Mead 1990), and uses idea evaluation to search for one *"killer idea"* by eliminating less valuable alternatives (Girotra et al. 2010). This new and dynamic approach is an important contribution to this existing body of knowledge by viewing all idea as valuable because they can lead to important knowledge that can be multiplied into novel ideas. Hence, the PhD study provides a change in focus to the idea evaluation literature from identifying the most appropriate idea toward creating the most appropriate solution using both convergent and divergent thinking skills.

The research presented through the PhD study can be criticized for using static idea evaluation as a "straw man argument" for promoting another alternative. The assumption has some merit when viewing an exercise where static idea evaluation practices are joined with creative processes, for example, in crowdsourced platforms (e.g., ideastorm.com and nos.co). However, in order to understand their dynamics and individual entities, the two evaluation approaches had to be theoretically separated. Hence, the assumption of the "straw man" is misguided. However, the research demonstrated as being centered around static idea evaluation (e.g., Cropley 2006; Elam and Mead 1990; Guilford 1967; van der Lugt 2000; Osterwalder and Pigneur 2010; Sakamoto and Bao 2011) is misguided in its conceptualization of idea evaluation being a convergent-only activity. This PhD study adds new insights to this body of research by challenging this assumption of idea evaluation being a convergent-only activity. Instead, this PhD study empirically exemplifies that CES can be designed to use knowledge generated from idea evaluation to encourage both divergent and convergent production (RA4, RA5).

Earlier research has connected sensemaking to idea evaluation and creativity (Briggs and Reinig 2010) and has used idea evaluation during brainstorming (Connolly et al. 1990). The results from RA2 contribute to this research by showing that idea evaluation is not necessarily a formal process with measurable parameters. Instead, idea evaluation is often an informal sensemaking activity that occurs during creative activities. However, this PhD study goes beyond Briggs and Reinig (2010) and Connolly et al. (1990) when showing that idea evaluation is affected by institutionalized practices that influence whether ideas become adopted, rejected, or multiplied.

6.2.2. RESPONSE TO RQ2

In response to RQ2 (Will CES that supports idea evaluation be effective in encouraging divergent thinking?), RA4 showed that dynamic idea evaluation outperforms static idea evaluation in the ability of supporting divergent production. Moreover, four of the five parameters that measure divergent production, dynamic idea evaluation proved equally as effective as the control group that refrained from idea evaluation, but used standardized creativity techniques. However, on elaboration, dynamic idea evaluation proved more effective over the control group.

Placing together the findings from the system's dynamics of static and dynamic idea evaluation (RA3) and the assessment of their effectiveness (RA4), an important finding appears about their design. The ability of idea evaluation to encourage divergent and convergent production is fundamentally affected through its design. As the findings from RA3 and RA4 show, static idea evaluation is not designed with the intention of supporting divergent production. Consequently, static idea evaluation is completely incapable of encouraging divergent production. However, support of divergent production is a design feature in dynamic idea evaluation, which makes it capable of encouraging divergent production. This PhD study exemplifies observation through the empirical testing of two alternative prototypes that support dynamic idea evaluation (see RA4 and RA5). The findings show that designers can create CES that uses the knowledge obtained during idea evaluation to encourage divergent and convergent production. Moreover, the findings from RA4 show that the selected dynamic approach is effective in supporting divergent production.

Previous research has argued for placing idea evaluation as a separate process after creative problem solving activities because idea evaluation is strictly convergent (Chen 1998; Elam and Mead 1990; Herman and Reiter-Palmon 2011; Osborn 1953; Osterwalder and Pigneur 2010). The empirical contribution from RA4 challenges this view. Instead, it becomes clear that static idea evaluation has become self-fulfilling in supporting the argument for being convergent only. The convergent-only argument supports the design of static approaches when they remove divergent production from the idea evaluation process. In return, static approaches support the argument that idea evaluation does not support divergent production by creating artifacts that only support convergent production. Moreover, the empirical findings from RA4 and RA5 contribute to the body of knowledge by identifying flaws in the existing idea evaluation approaches, thus challenging the design criteria of such approaches that were previously presumed. Combined, these findings contribute with an IS perspective to a beginning body of knowledge within the organizational and social psychology of creativity that does not view idea evaluation as an convergent-only activity (Moeran and Christensen 2013; Runco 2002).

However, RA4 can be criticized for not showing whether dynamic idea evaluation can produce better ideas. For example, Girotra et al. (2010) exemplified that brainstorming based on other ideas could be counterproductive because the buildup of ideas can have a negative effect on the quality of those ideas. However, Girotra et al. (2010) did not consider the buildup of explicit knowledge (e.g., business cases and project plans) and tacit knowledge (personal experiences generated over time). Nor did their study consider the role of informal evaluation practices in the creative process. The interpretive study from RA3 indicates that such explicit and tacit knowledge generated over time are important factors in changing the quality of ideas. For example, the municipality in the study framed ideas according to tacit and explicit knowledge. These frames guided their decision-making and allowed the human actors to multiply the ideas over time to a point where they could adopt them. Moreover, the field experiment in RA5 showed that knowledge from evaluation content (e.g., idea comments, problems, and benefits) triggered the participants' ability to discover novel ideas.

6.2.3. RESPONSE TO RQ3

In response to RQ3 (What are the characteristics of a CES design theory that uses idea evaluation to support divergent thinking?), the PhD study includes design theory that provides distinct prescriptions on how to build a CES that supports dynamic idea evaluation. The design theory includes all eight components of design theory as suggested by Gregor and Jones (2007). The components of purpose and scope, justificatory knowledge, constructs, principles of form and function, principles of implementation, and artifact mutability are included in the design theory. The testable propositions are included in RA4, whereas the expository instantiation is communicated through RA5.

The design theory includes two key contributions. The first is the approach for making the design theory. This approach illustrates Peffers et al.'s (2008) DSRM process model in practice. As such, the design theory approach used a problem-centered initiation where the results between the different phases were iterated back to improve the design theory. Peffers et al. (2008;54) argued that *"it may be useful to atomize the problem conceptually so that the solution can capture its complexity."* The three first research articles served this goal of atomizing the problem conceptually. They did so by identifying the appropriate gap in the literature (RA1), theorizing about the interconnectivity between creativity and evaluation in an organizational context (RA2), and comparing and contrasting the system dynamics of the two opposing idea evaluation artifacts. During this conceptual process, the literature review from RA1 and initial theory development in RA2 and RA3 added theoretical insight to identifying the problem. In addition to identifying the problem, these articles added justificatory knowledge, and hence guided the creation of the design requirements. For example, the overall objective of the design theory was to support the multiplication of ideas using dynamic evaluation practices, whereas idea bifurcation was inserted as a design requirement to ensure chaotic outcomes. The selected approach of joining the individual research articles into design theory could inspire prospect researchers in their PhD studies. This PhD study exemplifies in detail how researchers can synthesize individual research contributions into one unit. In this PhD study, the synthesized unit results in design theory. This design theory ensures the internal validity of the PhD study by bringing the individual contributions together. Moreover, the design theory provides external validity to the theory developed in the research publications. This external validity is achieved by synthesizing kernel abstractions from the research publication into a design theory that guides the production of artifacts for future studies. In the same line of thinking, the design theory contributes to design science in general. Design theories are normally constructed from external kernel theories (e.g., Markus et al. 2002; Müller-Wienbergen et al. 2011; Voigt et al. 2013; Walls et al. 1992). However, in this PhD study, the initiation of the design theory started with extensive theoretical development to understand and atomize the initial problem conceptually. This theoretical development also helped build a body of knowledge that later would form the design theory.

The second contribution is the design theory itself. As shown in the extended literature review in section 2.2, only a minority of the combined CES design literature is concerned with using design science to create CES artifacts (e.g., Müller-Wienbergen et al. 2011; Voigt et al. 2013). This PhD study extends this limited body of knowledge within a beginning research tradition of design science and CES. In addition, the design contribution in this PhD study focuses on using idea evaluation to stimulate creative thinking. Consequently, the contribution differs from existing design theories within CES that are primarily focused on organizing knowledge for creative problem solving (Müller-Wienbergen et al. 2011) and organizing structures for creative processes (Voigt et al. 2013). Finally, the PhD study contributes to the overall CES research field through its practical use of design science. In addition to providing dynamic idea evaluation as a unique creative artifact that challenges previous presumptions about creativity, the PhD study also contains a method for design that can help future CES research. As such, the PhD study demonstrates how to conceptualize a novel problem identified in the literature and theory development, embed this theory into a new design theory for a CES artifact, and empirically test the artifact and iterate the results back to improve the design theory.

6.3. IMPLICATIONS

This PhD study includes several implications for research and practice. For research, the PhD study confirms previous observations that show that organizational creativity is immensely complex (Ulrich and Mengiste 2014) and is governed by chaotic system properties (Stacey 1996). To embrace this complexity, this PhD study presents new a theoretical construct that provides some operational mechanisms to what we have come to know as creativity. These constructs include multiplication and idea bifurcation. Multiplication are an operational construct that connects creativity with evaluation and critical decision making that translate, transform, consolidate, and redefine ideas and makes them travel. As such, multiplication is a unified theoretical construct that explains how ideas evolve in organizations. In research concerned with the travel of ideas, multiplication operationalizes creativity and allows its use where it has previously been avoided (Nielsen et al. 2014; Røvik 2011; Valikangas and Sevon 2010). Multiplication can be applied to explain how ideas mutate over time (e.g., Røvik 2011) and how creativity is influenced by inter-related organizational factors and challenges (e.g., Ulrich and Mengiste 2014). In addition, multiplication includes Avital and Te'eni's (2009) view on generative fit and capacity. Hence, multiplication may prove useful for understanding how technology-based fashion waves emerge in literature and practice (e.g., Baskerville and Myers 2009). Multiplication can also help researchers create assessment models that measure the effectiveness of creative strategies or identify constraints for creativity in the organizational environment (e.g., Amabile 1989). Moreover, studies can use multiplication to measure the spread of ideas in CES. For example, multiplication can prove useful for research in crowdsourced CES (e.g., Di Gangi and Wasko 2009; Leimeister et al. 2009) in order to measure how similar knowledge concepts spread across different ideas.

Idea bifurcation and its associated feedback mechanisms can prove useful for developing new creative techniques (e.g., Couger 1996a; Couger et al. 1993) and designing CES (e.g., Müller-Wienbergen et al. 2011; Voigt et al. 2013). Idea bifurcation can make creativity techniques more effective by measuring the type of feedback accepted by the techniques and their ability to bifurcate ideas and pull them toward alternative novel states, for example, using metaphorical thinking (Blackwell 2006; Lanzara 1983; Madsen 1994; Schön 1993). Understanding the system dynamics of creativity (including idea bifurcation) is also important for designing CES. These complex and chaotic properties are exemplified in the presented creative IS artifacts. As Elam and Mead's (1990) study showed, even small changes in the design of creative artifacts can impact their performance. As such, this PhD study demonstrates two different idea evaluation artifacts with the similar purpose of identifying the value of ideas. However, the static and dynamic idea evaluation artifact performs quite differently in supporting divergent thinking, and hence confirms these early observations. Consequently, the demonstrated design theory for dynamic idea evaluation artifacts involves an underlying understanding of the system dynamics of creativity. Rather than designing blindly, design thinking based on understanding the system dynamics of creativity results in small structural changes, such as using creativity techniques during idea evaluation and iterating ideas over time. The result is a dynamic idea evaluation IS artifact with the capability of supporting divergent thinking and outperforming its static counterpart.

Finally, the PhD study provides theoretical contributions and supporting empirical evidence that contradicts previous assumptions on idea evaluation. As such, this PhD study demonstrates in detail how idea evaluation can be designed to be effective at supporting divergent production. These results raise a much needed critique on the assumption that critical evaluation does not belong in the creative process (e.g., Osborn 1953), and that idea evaluation should be considered as strictly convergent (e.g., Chen 1998; Elam and Mead 1990). In fact, the contributions of the PhD study underpins the assumption that previous static idea evaluation approaches were unintentionally designed to become self-fulfilling in not supporting divergent production.

In addition to the listed contributions to research, this PhD study provides several contributions that are deployable for improving creative management practices.

- An organizational creativity framework that industry leaders can use to strategize creativity and technology innovation.
- A framework for dynamic idea evaluation that can be adapted for use in creative industries.
- An illustration of how knowledge identified during evaluative processes can be used to encourage divergent and convergent production.
- A design theory for dynamic idea evaluation from which practitioners can draw inspiration when developing CES with evaluation support.

6.4. LIMITATIONS

This PhD study contains some limitations associated to idea selection and convergent thinking. Moreover, the PhD study contains limitations related to artifact effectiveness over time and the measurement of idea quality.

One limitation is the narrow focus on idea selection. The management objectives of idea evaluation are to identify idea values, whereas selection is the identification of valuable and appropriate ideas that can solve specific problems. The organizational dynamics of idea selection is covered in RA2, which provides an in-depth analysis on how ideas become rejected, adopted, or multiplied. However, the focus of this PhD study is primarily centered on creating additional value during evaluative processes, and idea selection is not extended in the presented framework/artifacts that constitute dynamic idea evaluation. As such, there is a further need to understand the dynamic properties of idea selection in connection to creativity, which remains unexplored in this PhD study.

A second limitation is connected to convergent production. Convergent production improves existing ideas by adding critical thinking to the creative process (Cropley 2006). Hence, convergent production provides valuable input in the creative process that is equally important to divergent production. However, the research topic of this PhD study is centered on enhancing divergent production in idea evaluation. As such, convergent production is not given much attention because its role in relation to idea evaluation is covered by existing research (e.g., Chen 1998; Cropley 2006; Elam and Mead 1990; Guilford 1967, 1977). However, the analysis of static idea evaluation also indicates its use in convergent production to eliminate ideas over improving them (see Table 8). However, this result is based on the literature and overall observations during experimentation with static and dynamic idea evaluation. Hence, this observation should be extended through further studies, because the PhD study is unable to produce significant results that verify the limited use of convergent production in static idea evaluation.

A final limitation is measurement of divergent thinking over time and the effectiveness associated with idea quality. RA4 provides results that show that dynamic idea evaluation is more effective at supporting divergent thinking over static idea evaluation and standardized creativity techniques. To have similar conditions for all treatments, the experiment in RA4 was conducted over a single iteration. However, dynamic idea evaluation supports multiple iterations. The empirical elaboration of iterations was only considered to a limited extent in RA2 and RA5 by not being connected to the effectiveness of dynamic idea evaluation. Moreover, because of the focus on divergent thinking, idea quality (e.g., novelty and usefulness) was not considered when collecting and analyzing the data in the three empirical studies in RA2, RA4, and RA5. Hence, a further understanding of the influence of time is still needed to measure the divergent effectiveness of dynamic idea evaluation. Moreover, the issue of idea quality needs to be further investigated.

6.5. FUTURE RESEARCH

This PhD study explored a neglected area of research concerning the enhancement of creativity during evaluative processes. The PhD study answered important questions concerning the dynamics of creativity and idea evaluation, design of IS artifacts that account for such dynamics, and effects of the designed artifacts on users and organizations. Although the PhD study is a significant step forward that challenges old myths through novel views on organizational creativity and idea evaluation, the area of dynamic idea evaluation is still in its early infancy and should be continuously explored in future research.

The PhD study still raises multiple questions that future research can answer from this perspective of infancy and its relation to IS research. For example, future studies might answer how to integrate dynamic idea evaluation in agile development practices (Aaen and Jensen 2014; Aaen 2008). Moreover, future studies could help identify novel theoretical and empirical discoveries connected to designing CES for dynamic idea evaluation, for example, using design science to create new creative IS artifacts (Müller-Wienbergen et al. 2011; Voigt et al. 2013). Researchers could also encounter organizational challenges connected to implementing such IS artifacts (Dennis and Reinicke 2004; Di Gangi and Wasko 2009). For example, it would be interesting to identify whether dynamic idea evaluation refrains human actors from being overcritical, given that previous studies show overcritical idea evaluation having a negative effect on task motivation (Amabile 1996, 1998; Amabile et al. 2005). Such studies could include a more extensive use of Action Design Research (DSR), where the development and use of the IS artifact in the organizational context shapes its design (Sein et al. 2011). If using such research strategy, these studies might, in all likelihood, extend the PhD study findings and provide new knowledge on this emerging subject in IS research.

Based directly on the contributions, implications, and limitations of the PhD study, the following research endeavors are relevant to pursue:

- Studies that explore multiplication from a management perspective based on economic parameters. Multiplication could prove important for theorizing creativity in an economic perspective, for example, when exploring how technology ideas spread through open platforms or crowdsourcing.

- Studies that use the system dynamic implication from this study, such as feedback and idea bifurcation, to understand the dynamics of other creative IS artifacts. Such research could include studies within electronic brainstorming or Human Computer Interaction (HCI) studies related to the user interfaces of creative IS artifacts.

- Studies that empirically investigate dynamic idea evaluation. This PhD study includes three empirical studies. However, further empirical studies on the subject of dynamic idea evaluation can add knowledge to the subject. As suggested earlier, such research could include studies on agile development, implementation, and task motivation. Further empirical studies could also include the proposed design theory. Such studies could provide new insights and further improve the design theory.

- Studies that examine how to motivate creative thinking during idea selection. Similar to dynamic idea evaluation, the idea selection process could be improved using creativity and evaluation techniques that connect self-similar ideas. Such techniques and iterative thinking could help human actors improve existing ideas and discover neoteric ideas that are missing when they attempt to consolidate a viable solution.

- Studies that explore convergent thinking and idea evaluation. Future studies could further examine the interconnectivity of convergent and divergent production in the idea evaluation process. Moreover, future studies could explore how to support such practices when designing CES.

- Studies that improve quality identification during dynamic idea evaluation. The proposed dynamic idea evaluation artifact is a novel alternative for supporting divergent production. However, the issue of idea quality needs to be explored further. Such research could include further theory development, design studies, and empirical studies that examine how to dynamically identify idea quality and use this knowledge creatively.

CHAPTER 7. CONCLUSION

The purpose of this PhD study was to answer three research questions: (1) How can idea evaluation support divergent thinking? (2) Will CES that supports idea evaluation be effective in encouraging divergent thinking? (3) What are the characteristics of a CES design theory that uses idea evaluation to support divergent thinking? The research is based on two literature reviews, theoretical development, multiple case studies, laboratory and field experiments, and design theory. First, the literature reviews organized the body of knowledge within creativity and CES in the IS research field. Second, the theoretical development provided new constructs for organizational creativity and the design of CES. Third, the multiple case studies illustrated how human actors adopt, reject, or multiply technology ideas when they negotiate from different frames of reference. Fourth, the laboratory experiment demonstrated that combining the knowledge generated during idea evaluation with creativity techniques is effective in encouraging divergent thinking. Fifth, the field experiment showed that CES can support convergent and divergent thinking. Finally, the results from the research were synthesized into design theory for CES that supports dynamic idea evaluation. Combined, the research presented in this thesis provided a fresh view on idea evaluation and demonstrated how this approach is deployable in practice. The most important findings and their contributions are summarized in Table 9.

Table 9: Summary of Key Findings and Contributions

Research questions	Important findings	Contributions
RQ1: How can idea evaluation support divergent thinking?	Ideas can multiply when human actors evaluate and negotiate them (RA2).	A new theory on organizational creativity that incorporates human action and cognition, the travel of ideas, generativity, formative and informal evaluation, and time.
		Multiplication provides a unified operationalization of creativity that is free from ambiguity, easy to measure, and tracks over time.
	Ideas can bifurcate and move toward strange attractors (e.g., metaphors) when they receive overwhelming positive feedback (e.g., new knowledge). Negative feedback (e.g., rating mechanisms) keeps ideas within equilibrium (RA3).	Feedback and bifurcation can help designers construct better CES by helping them understand when ideas break or split into something new.

Table 9: Summary of Key Findings and Contributions – Continued		
Research questions	Important findings	Contributions
RQ1: How can idea evaluation support divergent thinking?	A framework for dynamic idea evaluation that supports convergent and divergent production (Table 8).	A dynamic alternative to existing static evaluation approaches. This dynamic evaluation approach differs from existing static approaches that encourage convergent production using knowledge from idea evaluation in order to encourage divergent and convergent production.
RQ2: Will CES that supports idea evaluation be effective in encouraging divergent thinking?	CES that uses knowledge from idea evaluation is more effective in encouraging divergent production over CES that supports idea evaluation that does not encourage divergent production, and CES that only encourages divergent production (RA4).	Challenges existing research that states that idea evaluation only supports convergent production.
	CES that supports idea evaluation must be designed specifically to enhance divergent production (RA4).	Might contribute to the future development of CES that supports idea evaluation by empirically demonstrating that static approaches are specifically designed not to support divergent production.
	CES that uses dynamic idea evaluation can support both dynamic and convergent production (RA5).	Might contribute to the future development of CES that supports idea evaluation by providing an alternative approach for such CES.
RQ3: What are the characteristics of a CES design theory that uses idea evaluation to support divergent thinking?	A design theory for CES that supports dynamic idea evaluation (Chapter 6).	Might provide inspiration to future PhD studies. The PhD thesis shows how researchers can use design science to synthesize individual research findings into a design theory, thus strengthening the internal and external validity of the PhD study.
		Adds new knowledge to design science by demonstrating that an in-depth conceptualization of the initial problem could result in new kernel abstraction that can help construct a unique design theory.

Table 9: Summary of Key Findings and Contributions – Continued		
Research questions	Important findings	Contributions
RQ3: What are the characteristics of a CES design theory that uses idea evaluation to support divergent thinking?	A design theory for CES that supports dynamic idea evaluation (Chapter 6).	Adds an idea evaluation design theory to the limited body of knowledge of CES design theories.

CHAPTER 8. REFERENCES

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APPENDICES

Appendix A (Research article 1): Müller, Sune Dueholm and Ulrich, Frank. (2013). "Creativity and Information Systems in a Hypercompetitive Environment: A Literature Review," Communications of the Association for Information Systems: Vol. 32, Article 7.

Appendix B (Research Article 2): Ulrich, Frank; Mengiste, Shegaw Anagaw; Müller, Sune Dueholm. (2015). "Informal Evaluation and Institutionalization of Neoteric Technology Ideas: The Case of Two Danish Organizations," Communications of the Association for Information Systems, Accepted.

Appendix C (Research Article 3): Ulrich, Frank; Nielsen, Peter Axel. (2015). "Chaos and Creativity in Information System Artifacts," Information Technology & People, In Review.

Appendix D (Research Article 4): Ulrich, Frank and Müller, Sune Dueholm. (2015). " Encouraging Divergent Thinking from Knowledge Generated during Idea Evaluation: A Design Experiment with Creativity Enhancing Systems," Journal of Management Information Systems, First revision and resubmit.

Appendix E (Research Article 5): Ulrich, Frank. (2015). "A Group Creativity Support System for Dynamic Idea Evaluation," 6th Scandinavian Conference on Information Systems (SCIS 2015). Published in Lecture Notes in Business Information Processing Vol. 223, p. 137-151.

Appendix A. Creativity and Information Systems in a Hypercompetitive Environment: A Literature Review

Communications of the Association for Information Systems: Vol. 32, Article 7.

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Abstract

In today's hypercompetitive environment in which markets change rapidly and competitive advantages are difficult to sustain, companies are forced to innovate and identify new business opportunities. However, innovation requires ingenuity and creativity. Product and service development depends on the creativity of employees, but harvesting and bringing novel ideas to fruition is often a chaotic process, which underscores the importance of creativity management within organizations. In this article, we review the literature on creativity in an effort to summarize state-of-the-art knowledge on how to stimulate creativity and spur innovation in modern organizations. For that purpose, we use Rhodes' 4-Ps model (1961) distinguishing between creative environments (called press), people, products, and processes. Through a review of 110 journals on the AIS journal list, this article offers insights—based on eighty-eight articles—into how creativity can be stimulated and supported by attending to each of these components. The literature teaches us how to utilize, evaluate, and strategize about creativity in organizational settings. Managers are advised to advance creativity and ideation processes, for example by building virtual environments that strengthen collaboration and creativity across organizational boundaries. Researchers are encouraged to investigate the relationship between strategy and information systems (IS) usage in fostering creativity.

Keywords: creativity, information systems, creativity support systems, and innovation management

I. INTRODUCTION

In a globalized business environment, the role of IT is changing and information systems become strategic assets driving business transactions, organizational processes, and knowledge sharing [Applegate, Austin, and Soule, 2009]. Therefore, companies increasingly use IT strategically in pursuit of business opportunities [Pearlson and Saunders, 2007]. Bill Gates described the changing role of IT over the last three decades in this way: "… if the 1980s were about quality and the 1990s were about reengineering, then the 2000s will be about velocity" [Attaran,2004, p. 586]. In a similar vein, Pearlson and Saunders [2007] argue that the current business environment is characterized by hypercompetition, meaning that markets change rapidly and competitive advantages are shortlived. Consequently, companies must innovate constantly in order to stay competitive. According to Tidd and Bessant [2009], "… innovation is consistently found to be the most important characteristic associated with success" [Tidd and Bessant, 2009, p. 9]. Innovation furthers business growth, enables companies to capture larger marketshares, and is a means to increase overall profitability [Tidd and Bessant, 2009]. However, whether or not companies succeed in their innovation efforts largely depends on their creativity.

Creativity has attracted the attention of researchers and practitioners since the ancient Greeks. According to Couger [1996a], there are over 100 definitions of creativity in the literature―from the philosophy of Plato, to the mathematics of Poincaré, to the psychology of Freud. Creativity is often seen as complex constructions [Shalley, Gilson, and Blum, 2000] involving the production, conceptualization, or development of novel and useful ideas, processes, or procedures by an individual or group of collaborating individuals [Amabile, 1988]. Creative endeavors must be novel and have value that exceeds existing ideas [Couger, 1996a]. This makes creativity a critical factor in any innovation process by providing new ideas for product and service development [Govindarajan and Trimble, 2010], management of information systems, and training of IS personnel [Couger, 1996a]. However, creativity may also stifle innovation efforts in organizations if not properly managed, because massive flows of ideas potentially overwhelm decision makers [Levitt, 2002]. Creativity often gives managers a headache, due to its highly chaotic nature, defying traditional management practices. Creative people are notoriously difficult to manage, as they are intelligent, organizational savvy, and prone to ignoring corporate hierarchy by challenging decisions and questioning their surroundings [Florida and Goodnight, 2005; Goffee and Jones, 2007]. Yet innovative companies such as Google are able to harness the chaos and nurture novel ideas in a corporate culture of social creativity and a disregard of the possibility of failure [Iyer and Davenport, 2008]. Lego is another company that has reaped the benefits of including customers in the creative and collaborative development of their products, using online communities where users co-design new products through specialized software [Piller, Schubert, Koch, and Möslein, 2005]. In 2010 FLSmidth launched their "FLSmidth Idea Portal" to encourage everyone across the organization to participate in sharing innovative ideas and improving the company's product offerings. The portal receives 1500 daily visits and has generated more than 1000 novel ideas over the last two years.[5] Pixar fostered a strong creative culture through the use of technology, empowerment, and an open-minded community [Catmull, 2008]. Last, but not least, the "IBM 2010 Global CEO Study" of 1500 CEOs across thirty-three industries point to creativity as the most crucial factor for future success.[6]

Despite the importance of creativity in innovation in general and IS development in particular, no attempt has been made to establish an overview of our state-of-the-art knowledge of creativity within the IS field, with the exception of a minor review by J. Couger [1996c]. This article fills that knowledge gap. We have reviewed the IS literature on creativity by searching the 110 journals on the AIS list of MIS journal rankings.[7] Through an exhaustive and systematic search, we identified eighty-eight articles on the subject of creativity. These articles were then categorized based on a creativity framework for IS development [Couger, Higgins, and McIntyre, 1993] adapted from Rhodes' 4-Ps model of creativity [Rhodes, 1961]. Compared to the innovation literature, our literature review reveals a need for more research on creativity within the IS field.[8]

A Definition of Creativity Management within IS

Creativity is the creation of novel ideas by individuals or groups [Couger, 1996a]. Innovation is the adaptation and commercialization of these ideas [Smeltz and Cross, 1984; Levitt, 2002; Govindarajan and Trimble, 2010] in an organizational context [Amabile, 1996]. Innovation happens when ideas are plentiful and employees are motivated to do something about them [Govindarajan and Trimble, 2010]. This is a process of reusing ideas from existing innovations or combining new and existing ideas [Majchrzak, Cooper, and Neece, 2004]. However, researchers and practitioners have often merged creativity and innovation into one concept [Govindarajan and Trimble, 2010; Ginn, 1986]. This mix-up often occurs when researchers try to unfold the innovation process [Gorschek, Fricker, Palm, and Kunsman, 2010; Rigby, Gruver, and Allen, 2009] or describe the process of radical innovation [Malhotra, Majchrzak, Carman, and Lott, 2001]. This study concerns the development and management of ideas using IS or using these ideas for IS development purposes. Creativity in an IS context can manifest itself in the early stages of developing

[5] See http://www.ipendo.com/Newsletter/Pages/FLSmidth-Profile.aspx.

[6] See http://www-03.ibm.com/press/us/en/pressrelease/31670.wss#contact.

[7] See http://ais.affiniscape.com/displaycommon.cfm?an=1&subarticlenbr=432.

[8] Topic searches in Web of Science yield more than ten times as many IS related references to innovation than creativity literature (4879 versus 443 hits).

innovative information systems or services. During that process, creativity is managed by means of organizational strategies, best practices, skill enhancement, evaluation schemes, structures, and processes. Creativity is also about ideation supported by IS, for example, by creating virtual environments or by implementing other forms of computerized creativity support, such as brainstorming for the purpose of allowing employees and groups to explore new ideas together.

II. THEORETICAL FRAMING

Modern creativity research is rooted in the field of psychology where numerous studies have been conducted since the beginning of the early twentieth century [Couger et al., 1993]. The IS literature has adopted key concepts from the psychology and management literature in which there is a firm belief that individual and group creativity is motivated and enhanced through organizational incentives, such as work climate, training, and reward systems [Couger, 1996a; Couger et al., 1993]. In addition, various techniques and tools for skill enhancement can be used to foster greater creativity among individuals and groups in IS organizations [Cooper, 2000; Couger, 1996a].

Cooper [2000] identifies three research streams within creativity and IS development. The first stream involves techniques and software tools for skill enhancement [Rao and Dennis, 2000; Couger, 1996a]. The second focuses on strategies and conditions for implementing these techniques and tools within IS organizations [Kohashi and Kurokawa, 2005; Warr and O'Neill, 2005]. The third centers on Creativity Support Systems (CSSs) and IS supported creativity management, i.e., combining creativity management techniques with computer technology [Massetti, 1996; Shneiderman, 2002] However, in this article we identify a fourth stream with a focus on evaluation of creative activities, products, and services of IS organizations [Couger et al., 1993]. Our literature review is based on Rhodes' [1961] 4-Ps model and takes these research streams as a starting point.

The 4-Ps Model and IS

Couger et al. [1993] developed an IS-specific framework based on Rhodes' 4-Ps model of creativity [1961]. In the 4-Ps model, creativity is thematically divided into four highly interactive components: Person, process, product, and press.

The component of the creative *person* shows that some individuals are more creative than others [Rhodes, 1961] by genetic endowment [Guilford, 1977]. In an IS development context, the person component can be enhanced through the use of techniques and software tools for skill and creativity enhancement [Cooper, 2000]. In addition, management can stimulate creativity among employees through encouragement and by relying on proven techniques [Couger et al., 1993].

The component of the creative *process* deals with motivation, perception, learning, thinking, and communication. Creativity is seen as something than can be taught and learned [Rhodes, 1961]. Individuals can enhance their creative abilities by means of training programs and methods [Couger,et al., 1993]. In the IS literature, the process component takes center stage through the use of strategies and conditions for implementing skill-enhancing techniques and software tools within the IS organization [Cooper, 2000].

The component of the creative *product* is rooted in the evaluation and benchmarking literature. Products are artifact of thoughts that can be tested, evaluated, and analyzed in terms of creativity [Rhodes, 1961]. As Couger et al. [1993]) argue: "… it is helpful for employees to have ways to measure their creativity results" (p. 379). Prajogo and Sohal [2001] argue that management philosophies like Total Quality Management (TQM) ensure quality of current and future product and service innovations through an increased focus on customers, continuous improvement, and employee empowerment. However, TQM can also negatively impact the creation of novel solutions leading to unproductive "me too" competition when organizations focus on continuous, incremental customer-driven improvements rather than innovative solutions for new markets [Prajogo and Sohal, 2001]. Still, expectations of performance measurements or evaluations have a positive effect on creativity [Shalley, 1995]. From a management perspective, creativity is about identifying, strategizing, and utilizing ideas from individuals and groups to accomplish organizational goals in new and originals ways [Couger et al., 1993; Shalley et al., 2000]. Thus, innovation is defined as the novel and useful application of a creative output (product or service) in an organizational setting [Couger et al., 1993; Oldham and Cummings, 1996; Shalley, 1991]. For the same reason, organizations evaluate or benchmark the quality of new creative products and services [Dean, Hender, Rodgers, and Santanen, 2006], for example, by examining the rarity [Eisenberger and Selbst, 1994] and originality [Redmond, Mumford, and Teach, 1993] of the idea or product.

The component of the creative *press* is about the work environment and its support for creativity in the organization [Rhodes, 1961]. The creative output of IS organizations is influenced by organizational values and norms that promote and chart a course for creative activities in the organization [Couger, Higgins, and McIntyre, 1993]. The creative environment can be supported by creativity-enhancing software that combines creativity management techniques with information technology [Cooper, 2000].

The 4-Ps Creativity Model

Couger [1996a] has used the 4-Ps creativity model in an early study of creativity [Couger, 1996c]. In this review, we extend the work of Couger by categorizing the IS literature based on the same model. The 4-Ps model is shown in Figure 1. For each

"P", we provide a short description followed by an IS specific perspective on the component.

The creative press (environment)	**The creative person**
The creative environment in an organization affects individuals' and groups' creative output [Rhodes, 1961]. Organizational climate and culture enhances creativity by removing organizational barriers, rewarding ingenuity, and encouraging risk-taking behavior [Couger et al., 1993]. <u>IS perspective</u> IS supports the creativity of individuals and groups through a combination of creativity management, techniques and computer technology [Cooper, 2000].	Some individuals tend to have more creative abilities than others [Rhodes, 1961] by genetic endowment [Guilford, 1977]. <u>IS perspective</u> Management nurtures employees' creativity through encouragement, by using well-proven tools and techniques [Couger et al., 1993], and by enhancing the IS development skills of individuals and groups [Cooper, 2000].
The creative product Products are the artifact of thoughts that can be tested, evaluated, and analyzed in terms of creativity [Rhodes, 1961]. The creative element of products and services can be evaluated and benchmarked in terms of novelty, relevance, performance, workability, and thoroughness [Dean et al., 2006], and the quality of current and future product and service innovations can be ensured through TQM and similar management philosophies [Prajogo and Sohal, 2001]. <u>IS perspective</u> When managing strategic goals in an IS organization, evaluation and measurement of creative IS product and service value is paramount [Couger et al., 1993].	**The creative process** The process perspective is based on the notion that creativity can be taught and learned, and it involves motivation, training, creative thinking, and communication [Rhodes, 1961]. <u>IS perspective</u> Creativity improvement programs and methods in IS organizations enhance overall creativity, quality, and productivity of employees [Couger et al., 1993]. This component focuses on strategies and conditions (requirements) for implementing skill-enhancing techniques and software tools within the IS organization [Cooper, 2000].

Figure 1. The 4-Ps Creativity Model

In the review methodology section, we describe our selection of keywords from the 4-Ps model for the purpose of analyzing and categorizing the literature.

III. REVIEW METHODOLOGY

Overall, our approach is based on Webster and Watson [2002] who offer guidance on how to carry out a literature review. From their perspective, synthesizing and reflecting on previous research provides a solid foundation for future advancements within the IS field [Webster and Watson, 2002]. According to Okoli and Schabram [2010], documenting choices is important when conducting a literature review in order to convince others of the reliability and quality of the result. We follow their advice by documenting our literature selection and analysis process. The details are provided below.

Searching the Literature

In terms of selection criteria, we focused on peer reviewed publications dealing with creativity within the IS field. To that end, we performed exhaustive searches in the 110 journals on the AIS list of journal rankings (see Appendix A), thereby excluding books and conference proceedings, with one notable exception. We decided to include papers from the premier creativity conference, the ACM Conference on Creativity and Cognition, because conference papers often contain more playful perspectives and provide a window into new trends and themes. Figure 2 gives an overview of the literature search and selection process.

As illustrated by Figure 2, we first conducted a pilot study by searching the top twenty journals on the AIS list of MIS journal rankings. The purpose of this pilot study was to test the search parameters. This step (Step 1 in Figure 2) resulted in 714 articles.[9]

Second, we reduced the initial pool of articles to twenty-five through manual selection. To that end, we used a threestep checklist for article screening [Okoli and Schabram, 2010] which encapsulates the research topic and contains predefined parameters for selection (see Appendix B). Subsequently, the relevance of each article was determined independently by each author and results were compared [Fink, 2009]. Through this process of "check coding," the number of articles was cut to eighteen. At this stage (Step 2 in Figure 2), the intercoder reliability was estimated at 80 percent—above the average 70 percent mentioned by Miles and Huberman [1994].

Third, we analyzed the results and redefined the search parameters in light of the pilot study (Step 3 in Figure 2).

[9] We used the following databases and search engines: Web of Science, Proquest, Scopus, and Google Scholar. We used a combination of search facilities because not all journals are accessible through one database/search engine.

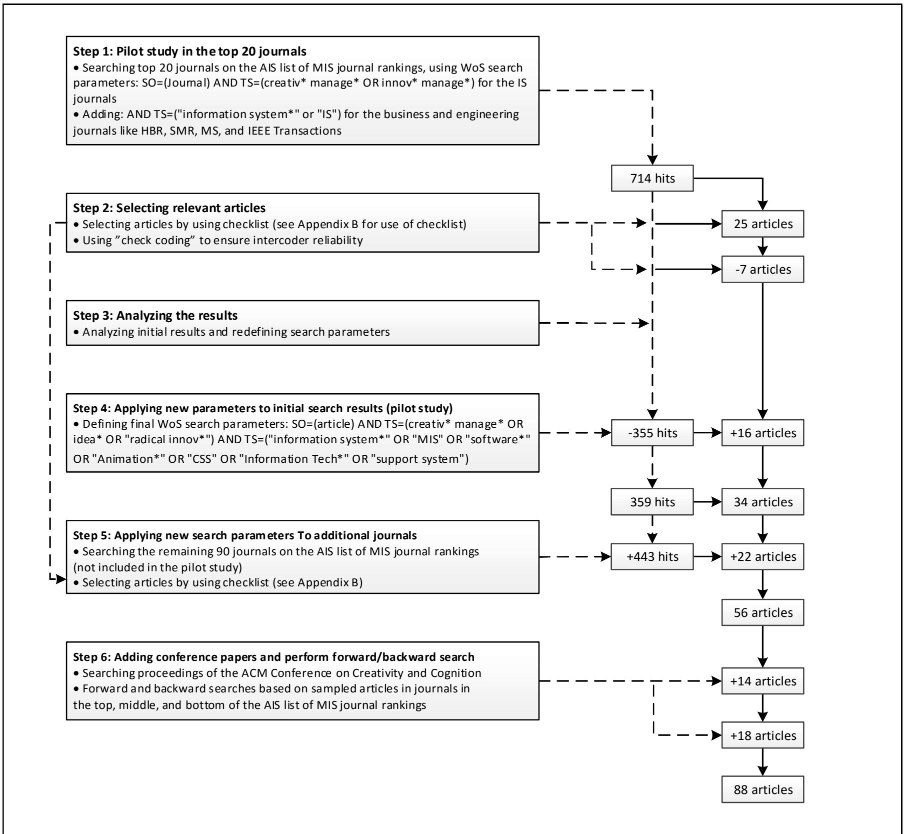

Figure 2. Literature Search and Selection Process

Fourth, we applied the new search parameters to the same twenty journals used in the pilot study. This (Step 4 in Figure 2) resulted in a reduction in the number of potentially relevant articles from 714 to 359, out of which an additional sixteen relevant articles were identified.

Fifth, we searched the remaining ninety journals on the AIS list of MIS journal rankings that were not included in the pilot study (Step 5 in Figure 2), yielding 761 potentially relevant articles. Out of this pool of articles, we selected fiftysix, using the checklist for article screening (see Appendix B).

Sixth, we searched the proceedings of the ACM Conference on Creativity and Cognition and found fourteen papers. In addition, we conducted forward and backward searches based on sampled articles in journals in the top (ranked 1–5), middle (ranked 45–60), and bottom (ranked 100–110) of the AIS list of MIS journal rankings.6 At the end of the literature search and selection process (Step 6 in Figure 2), we identified eighty-eight relevant articles across the 110 journals.

Analyzing the Literature

For the purpose of analyzing the articles, we first identified keywords and themes for each component of the 4-Ps creativity model. These keywords and themes encapsulate each of the four Ps of the model. For each component there are three groups of keywords and themes mirroring Couger's descriptions of the four Ps in the creativity model [Couger et al., 1993]. This grouping reduces complexity and increases transparency of the model. Some keywords appear under more than one component because they carry different meanings in different contexts. One example is the word quality which appears in both product and press. In the component of the creative product, the keyword relates to product and service quality as opposed to worker performance quality in press.

Second, we coded the articles in a three-stage qualitative process (see Appendix B). In stage one, we coded the articles in SPSS according to component (press, product, person, or process), using the keywords and themes (derived from the 4-Ps creativity model) listed in Table 1 as a guideline. In stage two, we coded the articles according to theme using Table 1 as a guideline while correcting any errors from stage one. The result is shown in Table 2 in which the eighty-eight articles are categorized by component and theme. In stage three, we synthesized the articles, using a bottom-up approach in which the abstract, theoretical framework and conclusion of each article provided deeper insight into the research field. This approach also corrected any errors made during stage two. The combined process allowed us to code the same literature three times, strengthening the reliability of the coding effort.

Third, we coded the articles according to their reference discipline depending on their scientific heritage. The IS field is multidisciplinary, by nature drawing on other research traditions [Oh, Choi, and Kim, 2005]. The IS field is traditionally divided into two major camps, one drawing on design science and the other on natural or behavioral science [Hevner, March, Park, and Ram, 2004; March and Smith, 1995]. Benbasat and Weber [1996] have elaborated on this argument by distinguishing among four major reference disciplines [Benbasat and Weber, 1996], specifically, organizational science [Cooper, 2000], economic science [Hunton and Beeler, 1997; Zhu, Kraemer, Gurbaxani, and Xu, 2006], behavioral science [Massetti, 1996], and computer science [Andreichicov and Andreichicova, 2001]. Several other researchers have contributed to this debate [Oh et al., 2005; Swanson and Ramiller, 1993; Vessey, Ramesh, and Glass, 2002]. We have identified the reference disciplines of all articles based on Oh et al.'s Taxonomy of IS Research [Oh et al., 2005]. This type of coding enables us to locate each article in the IS landscape, position the articles in relation to one another, and identify needs for additional research.

Table 1: Keywords and Themes for Each Component of the 4-Ps Creativity Model

Component	Group	Keyword	Theme
Press	1	Environment(s), climate(s), culture(s)	Factors that influence the environment in creative IS organizations Software-based environment for creativity support, e.g., Creativity Support Systems (CSSs) or Group Support Systems (GSSs)
	2	Barrier(s), reward(s), risk(s)	Breakdown of barriers in IS organizations Use of reward systems to stimulate creativity Risk-taking in creative IS organizations
	3	Enhance(ment), support	Enhancement of creative employees' skills through IS support or training
Product	1	Evaluation, benchmarking, measure(ment), goal(s), performance, novel(ty), relevant/relevance, workability, thoroughness	Evaluation, measurement, or benchmarking of novel and creative IS products and services Impact of evaluation on performance of creative employees and groups Evaluation, measurement, or benchmarking of creativity performance and goals in IS organizations
	2	Product(s), service(s)	Evaluation of creative designs for products and services in IS organizations
	3	Value(s), quality, assurance(s)	Quality of creative products and services Quality assurance of processes for developing creative products and services, e.g., through TQM or SPI
Person	1	Ability/abilities, endowment	Genetic endowment or creative employees' abilities
	2	Individual(s), person(s), employee(s), group(s)	Impact of individuals and groups on creativity in IS projects Recruitment or job profiles of creative employees in IS organizations Leadership of creative individuals and teams
	3	Technique(s), skill(s), tool(s), Encouragement(s)	Techniques and software tools for skill enhancement of creative employees and groups in IS organizations Encouragement of creative employees in IS organizations
Process	1	Strategy/strategies, program(s), diffusion, requirement(s)	Strategies for improvement of creativity in IS organizations Creativity improvement programs in IS organizations Strategies and conditions for implementing creativity improvement programs in IS organizations
	2	Software tool(s), technique(s)	Strategies and conditions for implementing creativity techniques and software tools in IS organizations Organizational diffusion and adoption of software tools for supporting creative employees
	3	Improve(ment), quality, training, motivation, learning, creative thinking, communicate/ communication	Improvement of the quality and productivity of creative employees' performance in IS organizations Training strategies for creative employees in IS organizations

IV. ANALYSIS RESULTS

Our literature search revealed eighty-eight articles published between 1998 and 2011 across 110 IS journals. Figure 3 shows the distribution of articles across the components of the 4-Ps creativity model, and Appendix C lists the articles by journal (ranking). The majority—47 percent (41)—of articles fall within the component of the creative press. This is due to the high number of articles on Creativity Support Systems (CSSs) and Group Support Systems (GSSs). In all, 27 percent (24) of the articles relate to the component of the creative person, whereas process and product account for 20 percent (18) and 6 percent (5) respectively. The distribution of articles across reference disciplines also shows some interesting results. 43 percent (38) of the articles draw on organizational science, 41 percent (36) on behavioral science, 16 percent (14) on computer science, whereas no articles have a basis in economic science. Not only is the distribution lopsided, but there is an entire area ripe for research.

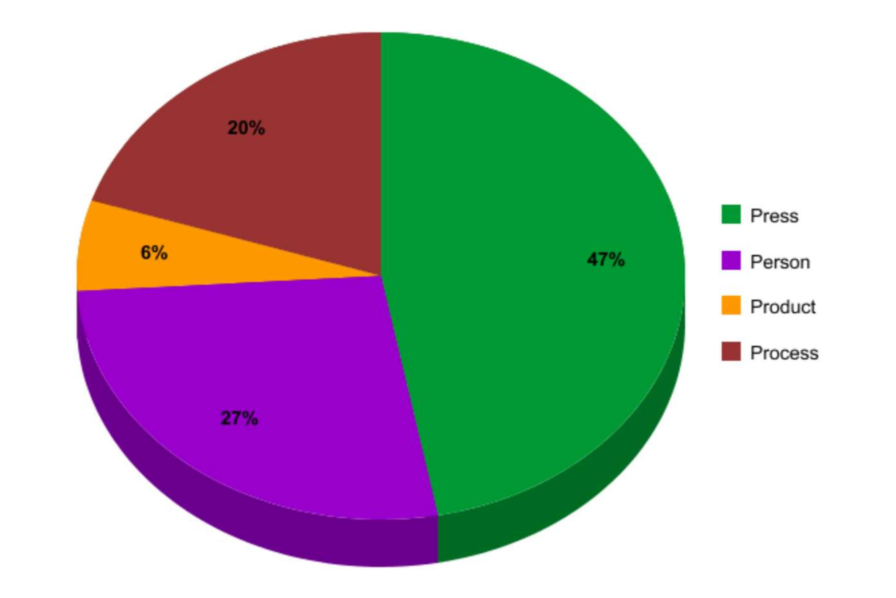

Figure 3. Distribution of Articles Across Components

Synthesis

We have identified key themes in the literature using a bottom-up approach. The result is shown in Table 2 in which references are sorted by component and underlying theme.

Press

The component of the creative *press* has been researched from various perspectives. Research on the use of Creativity Support Systems (CSSs), Group Support Systems (GSSs), and similar systems that provide virtual environments for creative personnel is dominant, judging by the number of publications (21). The research shows that information systems like CSSs and GSSs provide environments that lead to more novel and useful ideas compared to those fostered by paper-and-pencil approaches to ideation [Doll and Deng, 2011]. Creativity involves highly chaotic and complex processes which information systems render more manageable. Specifically, information systems help define problems and provoke opportunities, compile relevant information, generate new ideas or concepts, as well as evaluate and prioritize ideas for implementation [Abrams et al., 2002; Aiken and Carlisle, 1992; Hailpern et al., 2007; Hori, 1994; Kerne et al., 2008; Kletke et al., 2001; MacCrimmon and Wagner, 1994; Massetti, 1996; Nakakoji et al., 1999; Shneiderman, 2002; Doll and Deng, 2011]. GSSs give employees easy access to social groups and enhance communication between individuals and groups, which in turn provides a stimulating environment that allows them to share novel ideas and collaboratively explore their creativity [Elfvengren et al., 2009; Munemori and Nagasawa, 1991; Munemori and Nagasawa, 1996; Hesmer et al., 2011]. In contrast, other studies indicate that support systems do not always have a positive effect on creativity. Cheung, Chau, and Au's [2008] study shows how an intranet-based knowledge repository inhibits creative thinking among individuals and groups, because managers did not take employees' personal characteristics into account when implementing it. Other research points to the decline of creativity when support systems are used for analytical tasks [Durand and VanHuss, 1992]. AI-aided creativity has been among the research topics with regard to CSSs [Andreichicov and Andreichicova, 2001]. In relation to both CSSs and GSSs, such information systems have been shown to negate gender-based differences in groups with both males and females when developing novel and useful ideas.

Consequently, organizations using CSSs and GSSs in their creative endeavors will be able to get input from women and men alike [Klein and Dologite, 2000]. Moreover, when Executive Information Systems (EISs) are combined with information retrieval (e.g., browsing of data, searching for answers to specific problems, etc.) and decision support, they foster creativity in leaders [Vandenbosch and Huff, 1997; Wierenga and van Bruggen, 1998].

Another part of the research revolving around the component of the creative press focuses on factors that influence the creative environment in IS organizations. Elam and Mead [1987], Marakas and Elam [1997], Bonnardel [1999], and Kohler et al. [2011] identify design principles and guidelines for virtual co-creation systems as a form of creativity-based systems. Thatcher and Brown [2010] show that creativity is positively influenced by demographic differences, such as work experience and education, with regard to information access. Meanwhile, social differences, for example, in terms of race/ethnic background, nationality, sex, and age, can impact negatively on creativity. Fagan [2004] and Jacucci and Wagner [2007] classify factors that influence the creative style and work climate of individuals and teams in IT departments. These are closely related to the factors influencing communication in the creative work environment [Tuikka and Kuutti, 2000; Zaman et al., 2010], e.g., how social differences, for example, in terms of race/ethnic background, nationality, sex, and age, can impact negatively on creativity. Fagan [2004] and Jacucci and Wagner [2007] classify factors that influence the creative style and work climate of individuals and teams in IT departments. These are closely related to the factors influencing communication in the creative work environment [Tuikka and Kuutti, 2000; Zaman et al., 2010], e.g., how social structures in the organization affect creative thinking [Sosa, 2011] and how social-technical factors in the environment influence stakeholders in creative development and ideation processes [Bruns, 2007; Fischer, 1999; Wakkary and Maestri, 2007].

It is important to break down cultural barriers when accessing cross-department knowledge for ideation [Faniel and Majchrzak, 2007], sharing new technology ideas [Leonardi, 2011], collaborating in cross-cultural environments, and working creatively across spatial, temporal, and technological boundaries [Fischer, 2005]. Empowering employees to solve problems by themselves has proven useful when it comes to breaking down organizational barriers in creative cultures [Catmull, 2008].

Risk-taking is a factor that impacts creativity management in IS organizations. Eaglestone, Lin, Nunes, and Annansingh [2003] argue that while risk management may have a positive effect on an IS project, the constraints that risk management imply can also inhibit creativity.

Yet another strand of research focuses on empowering creative employees through IS support and training in the creative environment. Individuals' human–computer interaction influence training, learning, and creative abilities, such as spontaneity, exploration, and motivation [Shaw et al., 1993]. TaxÉn et al.'s [2001] findings demonstrate the positive effect on creativity by using cooperative inquiry methods when collaborating with young school children in designing an advanced storytelling technology.

Product

The component of the creative *product* is fairly unexplored by researchers. Only 6 percent (5) of the articles are written with this perspective on creativity in mind. Research findings demonstrate the necessity of evaluating the creative output in order to raise the quality of ideas produced [Reinig et al., 2007]. Evaluation has a positive effect on the performance of creative employees and teams when used properly [Connolly et al., 1990].

Dean et al. [2006] have examined the literature on idea evaluation and argue that the creativity evaluation literature is based on novelty-centric and multi-attribute definitions. From the novelty-centric perspective, evaluation focuses on the rarity and originality of the idea, product, or service. The multi-attribute definition is—as the name suggests—concerned with several attributes, including novelty (the novelty-centric perspective). In addition, the relevance (Does it solve a problem?), the workability (Is it implementable?), and thoroughness (Is it worked out in detail?) of the idea, product, or service is of interest. The creative performance, goals, or results of the IS organization can be assessed based on these attributes [Dean et al., 2006].

Other IS researchers have focused on design evaluation of new products or services, e.g., evaluation of the usefulness and novelty of creative software designs [Gomes et al., 2006] and product screening by assessing idea success rate, idea performance, and customer lifetime value [Chan et al., 2011].

Person

Research on the component of the creative *person* explores how techniques and software tools foster and enhance individual or group creativity. Such techniques and software tools include groupware-based creativity techniques [Garfield et al., 2001], brainstorming techniques [Aiken et al., 1996; Couger, McIntyre, Higgins, and Snow, 1991; DeRosa et al., 2007; Santanen et al., 2004; Valacich et al., 1994], picture- and word-stimuli techniques [Couger et al., 1991; Malaga, 2000], imagination techniques [Couger et al., 1991; Resnick, 2007], concept mapping and critical reflection methods [Couger et al., 1991; McLaren et al., 2007], concept-classification methods [Noguchi, 1997], environment-based techniques [Couger et al., 1991], and tools that provide memory aid, platforms for development, or help in sharing ideas [Coughlan and Johnson, 2008].

Research also focuses on the merging of these techniques and software tools with IS. Kuutti, Iacucci, and Iacucci [2002] study creativity enhancement in the design of mobile units, while other researchers explore different creativity-enhancement techniques incorporated into the design of information systems like CSSs and GSSs.

This includes electronic brainstorming techniques [Hender et al., 2002; Olson et al., 1993; Rao and Dennis, 2000; Yuan and Chen, 2008] and management approaches to business intelligence [Bond and Otterson, 1998; Chen, 1998]. In addition, managers may stimulate creativity and ideation by supporting the underlying mechanisms of idea-generation techniques (e.g., analogical thinking, consequence thinking, and adaptive use of existing knowledge) through IS [Knoll and Horton, 2011].

In addition, individual and team creativity has been shown to influence the outcome of IS projects; individuals' expertise influences overall team creativity [Tiwana and McLean, 2005]. Social influence and acts by individuals and groups also have proven to affect project creativity and design outcomes [Gero, 2002]. Consequently, leadership by creative individuals and teams is required. The literature explores the challenges associated with the leadership of interorganizational and virtual creative teams [Malhotra et al., 2001] and the principles of managing creative employees [Florida and Goodnight, 2005]. It has been demonstrated that various encouragements can motivate creative employees in IS organizations by establishing incentives for people to contribute with ideas and allowing ideas to compete [Leimeister et al., 2009].

Process

Within the component of the creative *process*, researchers have investigated various strategic factors influencing the enhancement of individual and group creativity. Creative activities are often associated with managerial challenges and organizational uncertainty because of the high level of risk involved. Therefore, in IS organizations, strategies for improving creativity through the use of information technologies are often needed to conceptualize how creativity can go hand in hand with business processes [Seidel et al., 2010] or to deploy IS in support of ideation processes [Lindič et al., 2011]. Among these are strategies for gaining competitive advantages through the creation of internal knowledge rather than reliance on external knowledge for the development of new competitive information systems [Nambisan et al., 1999] and strategies for getting user feedback on development ideas [Bragge et al., 2005]. Strategies are also needed for encouraging and managing creative requirements in IS development [Cooper, 2000; Maiden et al., 2004]. Furthermore, strategies are required for integrating new knowledge in the organization without inhibiting creative processes [Brown and Duguid, 2000], which is accomplished by balancing creativity and discipline [Herbold, 2002]. Yet, sometimes strategies for detaching creative ideas are necessary, because ideas have a tendency to take hold of managers and organizations which, in turn, may impact decision-making processes and outcomes negatively [Välikangas and Sevón, 2010].

Research on strategies and requirements for the development of creative techniques and software tools in IS organizations underscores the importance of creativity management practices that are compatible with market needs and IS development activities [Kohashi and Kurokawa, 2005]. In addition, modern user interfaces do not always support users' creative practices. Therefore, design guidelines are needed for developing support systems for creative people [Terry and Mynatt, 2002] and for mitigating the social influences on design teams when developing creativity software [Warr and O'Neill, 2005].

Table 2: Themes in the IS Literature on Creativity

		Theme	Reference
Component	Press	Factors that influence the environment in creative IS organizations	Bonnardel, 1999; Bruns, 2007; Elam and Mead, 1987; Fagan, 2004; Fischer, 1999; Jacucci and Wagner, 2007; Kohler, Fueller, Matzler, and Stieger, 2011; Marakas and Elam, 1997; Thatcher and Brown, 2010; Tuikka and Kuutti, 2000; Wakkary and Maestri, 2007; Zaman, Anandarajan, and Dai, 2010; Sosa, 2011
		Software-based environment for creativity support, e.g., Creativity Support Systems (CSSs) or Group Support Systems (GSSs)	Wierenga and van Bruggen, 1998; Vandenbosch and Huff, 1997; Shneiderman, 2002; Nakakoji, Yamamoto, and Ohira, 1999; Munemori and Nagasawa, 1996; Munemori and Nagasawa, 1991; Massetti, 1996; MacCrimmon and Wagner, 1994; Kletke, Mackay, Barr, and Jones, 2001; Klein and Dologite, 2000; Kerne, Koh, Smith, Webb, and Dworaczyk, 2008; Hori, 1994; Hailpern, Hinterbichler, Leppert, Cook, and Bailey, 2007; Elfvengren, Kortelainen, and Tuominen, 2009; Durand and VanHuss, 1992; Cheung, Chau, and Au, 2008; Andreichicov and Andreichicova, 2001; Aiken and Carlisle, 1992; Abrams, Bellofatto, Fuhrer, Oppenheim, Wright, Boulanger, et al., 2002; Hesmer, Hribernik, Baalsrud Hauge, and Thoben, 2011; Doll and Deng, 2011
		Breakdown of barriers in IS organizations	Leonardi, 2011; Fischer, 2005; Faniel and Majchrzak, 2007; Catmull, 2008
		Risk taking in creative IS organizations	Eaglestone, Lin, Nunes, and Annansingh, 2003
		Enhancement of creative employees' skills through IS support or training	Webster and Martocchio, 1992; TaxÉn, Druin, Fast, and Kjellin, 2001
	Product	Evaluation, measurement, or benchmarking of novel and creative IS products and services	Reinig, Briggs, and Nunamaker, 2007
		Impact of evaluation on performance of creative employees and groups	Connolly, Jessup, and Valacich, 1990
		Evaluation, measurement, or benchmarking of creativity performance and goals in IS organizations	Dean et al., 2006
		Evaluation of creative designs for products and services in IS organizations	Gomes et al., 2006; Chan, Ip, and Kwong, 2011

Table 2: Themes in the IS Literature on Creativity – Continued			
Component	Person	Impact of individuals and groups on creativity in IS projects	Tiwana and McLean, 2005; Gero, 2002
		Leadership of creative individuals and teams	Malhotra et al., 2001; Florida and Goodnight, 2005
		Techniques and software tools for skill enhancement of creative employees and groups in IS organizations	Yuan and Chen, 2008; Valacich, Dennis, and Connolly, 1994; Shaw, Arnason, and Belardo, 1993; Santanen, Briggs, and de Vreede, 2004; Resnick, 2007; Rao and Dennis, 2000; Olson, Olson, Storrøsten, and Carter, 1993; Noguchi, 1997; McLaren, Vuong, and Grant, 2007; Malaga, 2000; Kuutti, Iacucci, and Iacucci, 2002; Knoll and Horton, 2011; Hender, Dean, Rodgers, and Nunamaker, 2002; Garfield, Taylor, Dennis, and Satzinger, 2001; DeRosa, Smith, and Hantula, 2007; Coughlan and Johnson, 2008; Couger et al., 1991; Chen, 1998; Bond and Otterson, 1998; Aiken, Vanjani, and Paolillo, 1996
		Encouragement of creative employees in IS organizations	Leimeister, Huber, Bretschneider, and Krcmar, 2009
	Process	Strategies for improvement of creativity in IS organizations	Seidel, Müller-Wienbergen, and Rosemann, 2010; Nambisan, Agarwal, and Tanniru, 1999; Maiden, Gizikis, and Robertson, 2004; Lindič, Baloh, Ribière, and Desouza, 2011; Herbold, 2002; Cooper, 2000; Brown and Duguid, 2000; Bragge, Merisalo- antanen, and Hallikainen, 2005; Välikangas and Sevón, 2010
		Strategies and conditions for implementing creativity techniques and software tools in IS organizations	Warr and O'Neill, 2005; Terry and Mynatt, 2002; Kohashi and Kurokawa, 2005
		Organizational diffusion and adoption of software tools for supporting creative employees	Kappel and Rubenstein, 1999; Gallivan, 2003
		Improvement of the quality and productivity of creative employees' performance in IS organizations	Song and Adams, 1994; Briggs and Reinig, 2010
		Training strategies for creative employees in IS organizations	Couger, 1996b

Process also involves research on organizational diffusion and adoption of software tools by creative employees in IS organizations, demonstrating that managers must consider creative employees' attitudes toward technological innovations that alter existing work practices in the creative process [Gallivan, 2003]. Developers of information systems for creativity enhancement must themselves consider how design issues, such as problem structure, engineering knowledge, expert systems, ideation, and the social context of technologies affect the adaptation and use of systems [Kappel and Rubenstein, 1999].

In order to improve the productivity of creative employees in IS organizations, managers must envision the possibilities for new products and services and help employees align product-development efforts with organizational needs and business strategies [Song and Adams, 1994]. This is accomplished by improving the ideation quality of individuals' creativity, e.g., by examining the relationship between the number of good ideas and the number of ideas contributed [Briggs and Reinig, 2010] and by having training strategies for creative employees. Couger [1996a] argues that IS curricula should allow students to conceptualize and develop creative approaches to problem solving in systems development [Couger, 1996b].

V. DISCUSSION

The purpose of this review is to get an overview of state-of-the-art knowledge on creativity within the IS research field. Having searched the 110 journals on the AIS list of MIS journal rankings, as well as the ACM Conference on Creativity and Cognition, we identified eighty-eight articles on the topic published between 1988 and 2011. As argued below, our analyses suggest that the research field lacks maturity compared to the literature on innovation in IS. Thus, there are many unexplored areas of research that await exploration. We discuss the implications of our literature review for both researchers and practitioners below, and we provide advice that enables practitioners to better meet the challenges of today’s hypercompetitive environment.

Implications

Our existing knowledge suggests important implications for both managers and researchers. This is evident in managing creative employees and groups as well as managing creative processes in different organizational settings, which, in turn, has implications for the design of creativity-enabling software.

Implications for Research

In terms of the 4-Ps creativity model, it is surprising that the main body of research, i.e., 47 percent (41), focuses on the component of the creative press. This is probably due to the long tradition within IS research of exploring the social aspects of information systems [Hedberg and Jönsson, 1978; Kiesler, Siegel and McGuire, 1984; Lamb and Kling, 2003].

Research on the creative environment (the component of the creative press) has focused on optimal work conditions for creative employees and groups through software support (see Table 2). Studies show the positive effect of CSSs and GSSs on creativity by providing employees and managers in IS organizations with creative environments for developing novel and useful ideas for future innovations. Additional research is needed to investigate exactly how CSSs and GSSs affect creativity in IS supported environments [Eaglestone et al., 2003; Fischer, 2005]. In addition, research indicates that reward systems may have a positive effect on the creative environment [Couger, 1996a]. However, we found no dedicated research on the subject matter.

This article demonstrates that previous research has placed great emphasis on utilizing the creative potential in employees and groups. This is evident by the majority of the literature being placed within four large groups within the components of the creative press, person, and process (see Table 2). Research within these groups have focused on understanding human interaction with creativity facilitating systems, virtual environments, software tools, techniques, and strategies from behavioral, organizational, and computer science perspectives (see Table 2).

It is surprising that 16 percent (14) of the articles draw on computer science which suggests a positive relationship between understanding creativity and transforming this knowledge into useable software designs that creative people may utilize during ideation processes. The future use of AI-aided creativity [Andreichicov and Andreichicova, 2001] especially offers great prospects and new possibilities for both researchers and practitioners in terms of exploring and utilizing the benefits of human–computer interaction for creative purposes. However, additional research within this area is needed.

Even more surprising is the lack of research grounded in economic science, which leaves the field wide open for researchers to explore. The literature review reveals several interesting research topics, including the design and evaluation of economic systems for creative use. For example, Vandenbosch and Huff's study of executives' creative use of decision support systems could be related to the financial sector focusing on bankers, investors, and other financial decision makers [Vandenbosch and Huff, 1997]. Research could also investigate how employees within the financial sector might be able to break down creative and organizational barriers by using creativity software in their work environment [Faniel and Majchrzak, 2007]. In fact, most of the literature categorized under press, product, and process should inspire researchers to explore how support tools, virtual environments, and IS strategies might enable creative thinking among managers and employees in the financial sector. Research should also include implementation studies of creativity software in financial institutions.

Avenues for future research also exist for researchers interested in the component of the creative process, for example, by investigating the creative capability maturity of IS organizations, similar to studies within the software process improvement field [Herbsleb, Zubrow, Goldenson, Hayes, and Paulk, 1997], where creativity research is also lacking [Müller, Mathiassen, and Balshøj, 2010]. Moreover, additional research on quality-assurance systems and evaluation methods in an IS context would be useful to organizations struggling in their creative endeavors.

Implications for Practice

Managers may strengthen the creative environment by providing actors with new information, tools, and computerized ideation processes [Kerne et al., 2008; Massetti, 1996; Shneiderman, 2002] and by creating virtual environments across sites in IS organizations, which eases communication and breaks down organizational barriers [Catmull, 2008; Faniel and Majchrzak, 2007; Leonardi, 2011]. However, there are design challenges with regard to unlocking creativity when creating these environments, including challenges associated with human–computer interaction [Durand and VanHuss, 1992], organizational risk-taking [Eaglestone et al., 2003], and implementation of creativity-enabling IS [Cheung, Chau, and Au, 2008]. Meanwhile, research indicates that despite these challenges, creative environments created by IS have a positive impact on the creative output.

Managers are well-advised to recognize the positive effects of GSSs, CSSs, and similar systems in terms of enhancing employees' creative capabilities [Massetti, 1996]. However, managers need to be aware of the mitigating effects of organizational structures and actions on creativity, such as social power distribution, risk taking, and organizational governance [Fischer, 1999; Sosa, 2011; Thatcher and Brown, 2010].

Innovation of existing work practices implies that radical changes are achievable, for example, through business process reengineering [Hammer, 1990]. Innovation, in turn, requires creativity [Kettinger, Teng, and Guha, 1997]. Therefore, managers need to monitor and evaluate the flow of alternative creative ideas to develop effective strategies and make quality decisions [MacCrimmon and Wagner, 1994]. The literature offers little guidance, however, on how to evaluate creative and novel ideas in IS organizations. Only 6 percent (5) of the articles relate to the component of the creative product. These articles describe how evaluation improves idea quality [Reinig et al., 2007] and worker performance [Connolly et al., 1990], and how multiple creativity evaluation methods can be used [Chan et al., 2011; Dean et al., 2006; Gomes et al., 2006]. IS managers face different strategic options when deciding how to enhance and assess the quality of ideas. They may encourage employees to think in product-development terms based on organizational needs and business strategies [Song and Adams, 1994], use evaluation schemes to assess the quality of ideas, or provide training in creative thinking [Couger, 1996b].

The importance of strategies becomes evident when managers attempt to incorporate creativity into the organization or improve business processes [Seidel et al., 2010]. Research shows that strategies positively affect the design, use, and adaptation of creativity-enhancing software when managers know the underlying mental models behind creativity [Terry and Mynatt, 2002]. In addition, the social context and employees' needs and attitudes have also been identified as important factors impacting the development and implementation of creativity software [Gallivan, 2003; Kappel and Rubenstein, 1999]. Such contributions provide managers with new insights into the organizational mechanics of creativity. However, they also emphasize the need for research on creativity improvement programs in IS organizations and more knowledge about the strategies and conditions for the diffusion of creativity techniques and software tools.

Limitations

Even though we adopted a rigorous approach, our study has limitations. First, we selected articles from journals on the AIS list of MIS journal rankings and the ACM Conference on Creativity and Cognition. We have not covered articles published in other journals and conferences or research reported in books. Our reason for primarily relying on the AIS list is that it is inclusive, based on eight other ranking lists of software engineering and IS journals [Hardgrave and Walstrom, 1997; Lowry, Romans, and Curtis, 2004; Mylonopoulos and Theoharakis, 2001; Peffers and Tang, 2003; Rainer and Miller, 2005; Walstrom, Hardgrave, and Wilson, 1995; Whitman, Hendrickson, and Townsend, 1999; Katerattanakul, Han, and Hong, 2003]. We further complemented the basis for selection by including proceedings of the ACM Conference on Creativity and Cognition, because it is one of the premier outlets for research on creativity within the IS field. Our focus on journals and conferences proceedings known for their quality publications (due to peer reviews and similar measures) strengthens the validity of the analyses. However, by excluding books, journals not on the AIS list, and numerous conferences, there is a risk of overlooking important contributions to our knowledge of creativity published in other media.

Another limitation is our use of Rhodes' 4-Ps model of creativity [1961]. We have used the 4-Ps model for categorizing the articles, but in reality most articles deal with more than one component of the model. In his small-scale review, Couger categorizes articles within multiple components [Couger, 1996c]. However, whereas Couger looked at only a handful of articles, our review includes eighty-eight articles, which makes the same approach unfeasible in our case. To reduce the level of complexity and maintain the readability of the article, we decided to categorize each article by its main focus only. Instead, we identified central themes across the four components.

VI. CONCLUSION

In a hypercompetitive environment, companies' competitiveness depends on their ability to innovate, which in turn requires creativity. Creativity involves multiple perspectives with regard to the organizational environment and structures, behavioral engagement of employees and groups, design paradigms in software development, and evaluation and benchmarking of IS products and services.

We have conducted a comprehensive review of the literature on creativity within the IS field by searching the 110 journals on the AIS list of MIS journal rankings and identifying eighty-eight relevant articles published between 1988 and 2011. We categorized these articles based on Rhodes' 4-Ps model of creativity [1961], distinguishing among the creative press, person, product, and process components. We have also looked at the underlying reference disciplines behind the articles.

The review provides an overview of the literature and offers insights into the field of creativity and IS by describing the potential for and use of creativity in IS organizations. For researchers, the results highlight avenues for future research, for example, by emphasizing the need for additional research within the component of the creative product, which accounts for only 6 percent (5) of the articles published. The review also reveals a lack of research from an economic science standpoint, which suggests that the research field is not yet mature. Furthermore, avenues for future research also exist within the component of the creative process, e.g., the creative capability maturity of IS organizations and quality assurance of creative processes. Last, but not least, additional research into the relationship between strategy and information systems usage in fostering creativity is needed. For practitioners, our findings demonstrate that managers can utilize strategies, software tools, techniques, evaluation schemes, reward systems, organizational awareness, and information systems to advance the creative potential of employees and groups in their pursuit of innovation—being a prerequisite for survival in today's hypercompetitive environment. Managers may strengthen the creative environment through IS supported ideation [Kerne et al., 2008; Massetti, 1996; Shneiderman, 2002] and virtual environments [Catmull, 2008; Faniel and Majchrzak, 2007; Leonardi, 2011]. In particular, GSSs, CSSs, and similar systems support employees in their creative endeavors [Massetti, 1996], and AI allows practitioners to explore and utilize the benefits of human–computer interaction for creative purposes [Andreichicov and Andreichicova, 2001].

VII. REFERENCES

Editor's Note: The following reference list contains hyperlinks to World Wide Web pages. Readers who have the ability to access the Web directly from their word processor or are reading the article on the Web can gain direct access to these linked references. Readers are warned, however, that:

1. These links existed as of the date of publication but are not guaranteed to be working thereafter.
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APPENDIX A: AIS LIST OF MIS JOURNAL RANKINGS

The table below shows the journals on the AIS list of MIS journal rankings by ranking.

Table A–1: The AIS List of MIS Journal Rankings by Ranking

Rank	Journal	Rank	Journal
1	MIS Quarterly	59	Computer Decisions
2	Information Systems Research	60	Information Technology and Management
3	Communications of the ACM	61	Wirtschaftsinformatik
4	Management Science	62	Information and Organization (formerly Accounting, Management, and IT)
5	Journal of Management Information Systems	63	ACM Special Interest Group Publications
6	Artificial Intelligence	64	Expert Systems with Applications
7	Decision Sciences	65	Information Systems Management
8	Harvard Business Review	66	Interfaces (INFORMS)
9	IEEE Transactions	67	Omega
10	AI Magazine	68	International Journal of Human–Computer Studies
11	European Journal of Information Systems	69	Database
12	Decision Support Systems	70	Journal of Systems and Software
13	IEEE Software	71	Data Management
14	Information and Management	72	International Journal of Man–Machine Studies
15	ACM Transactions on Database Systems	73	Journal of Information Systems (accounting)
16	IEEE Transactions on Software Engineering	74	Journal of Information Systems Management
17	ACM Transactions	75	Journal of Information Technology
18	Journal of Computer and System Sciences	76	Journal of Operations Research
19	Sloan Management Review	77	Journal of Organizational Computing and Electronic Commerce

Table A–1: The AIS List of MIS Journal Rankings by Ranking – Continued			
Rank	Journal	Rank	Journal
20	Communications of the Association for Information Systems	78	Information Resources Management Journal
21	IEEE Transactions on Systems, Man, and Cybernetics	79	Journal of Information Technology Case and Application Research
22	ACM Computing Surveys	80	Journal of Information Systems Education
23	INFORMS Journal on Computing	81	Journal of Systems Management
24	Academy of Management Journal	82	Journal of the American Society for Information Science
25	International Journal of Electronic Commerce	83	Organizational Behavior and Human Decision Processes
26	Journal of the AIS	84	Electronic Markets
27	IEEE Transactions on Computers	85	Australian Journal of Information Systems
28	Information Systems Frontiers	86	Journal of Organizational and End User Computing
29	Journal of Management Systems	87	Computer Supported Cooperative Work
30	Organization Science	88	Journal of Information Science
31	IEEE Computer	89	Datamation
32	Information Systems Journal	90	INFOR
33	Administrative Science Quarterly	91	International Journal of Information Management
34	Journal of Global Information Management	92	Journal of Information Technology Management
35	DATABASE for Advances in Information Systems	93	Behaviour and Information Technology
36	Journal of Database Management	94	Expert Systems Review
37	Information Systems	95	Journal of Education for Management Information Systems
38	MISQ Discovery	96	Computer Journal
39	Academy of Management Review	97	Information Processing and Management
40	Journal of the ACM	98	Electronic Commerce Research and Application
41	Computers and Operations Research	99	International Journal of Technology Management
42	Human–Computer Interaction	100	Journal of Information Systems (education)
43	California Management Review	101	Computers in Human Behavior
44	Information Technology and People	102	European Journal of Operations Research
45	Journal of Strategic Information Systems	103	The Information Society
46	Journal of Global Information Technology Management	104	Communication Research
47	ACM Transactions on Information Systems	105	Information Research
48	Informing Science	106	Journal of International Information Management
49	Journal of Information Management	107	E-Service Journal
50	Operations Research	108	Information and Software Technology
51	Journal of Computer Information Systems	109	Simulation
52	Business Horizons	110	Database Programming and Design

Table A–1: The AIS List of MIS Journal Rankings by Ranking – Continued			
Rank	Journal	Rank	Journal
53	IEEE Transactions on Knowledge and Data Engineering		
54	Journal of Database Administration		
55	IBM Systems Journal		
56	Infosystems		
57	Journal of Information Technology Theory and Application		
58	Knowledge Based Systems		

APPENDIX B: CHECKLIST FOR ARTICLE SCREENING

1. Does the article concern information systems or information technology research?

IF	**Action**
YES	Keep
NO	Remove

2. Does the article concern creativity or innovation?

IF	**Action**
Innovation as creativity = Innovation defined as creativity, ideation, or the creative process leading to innovation, e.g., the creative process in IS product or service development.	Keep
Innovation as Innovation = Diffusion of innovation, use of innovations, implementation, product development after ideation or creative process, etc.	Remove

3. Is the article's primary focus on creativity?

IF	**Action**
Yes. Main emphasis is on creativity, ideation, or the creative process leading to innovation.	Keep
No. Main emphasis is not on creativity, but on another subject like knowledge management or the innovation process.	Remove

APPENDIX C: REVIEWED ARTICLES

The table below contains the articles reviewed in this article sorted by journal (ranking).

Table C–1: Articles Reviewed Sorted by Journal (Ranking)			
Journal (Rank)	Reference	Title	Component
MIS Quarterly (1)	Webster and Martocchio, 1992	Microcomputer Playfulness: Development of a Measure with Workplace Implications	Press
	Couger, Higgins, and McIntyre, 1993	(Un)Structured Creativity in Information Systems Organizations	Framework
	Massetti, 1996	An Empirical Examination of the Value of Creativity Support Systems on Idea Generation	Press
	Vandenbosch and Huff, 1997	Searching and Scanning: How Executives Obtain Information from Executive Information Systems	Press
	Wierenga and van Bruggen, 1998	The Dependent Variable in Research into the Effects of Creativity Support Systems: Quality and Quantity of Ideas	Press
	Nambisan, Agarwal, and Tanniru, 1999	Organizational Mechanisms for Enhancing User Innovation in Information Technology	Process
	Cooper, 2000	Information Technology Development Creativity: A Case Study of Attempted Radical Change	Process
	Malhotra, Majchrzak, Carman, and Lott, 2001	Radical Innovation Without Collocation: A Case Study at Boeing–Rocketdyne	Person
	Kohler, Fueller, Matzler, and Stieger, 2011	Co-creation in Virtual Worlds: The Design of the User Experience	Press
Information Systems Research (2)	Garfield, Taylor, Dennis, and Satzinger, 2001	Research Report: Modifying Paradigms - Individual Differences, Creativity Techniques, and Exposure to Ideas in Group Idea Generation	Person
Communications of the ACM (3)	Shneiderman, 2002	Creativity Support Tools	Process
Management Science (4)	Connolly, Jessup, and Valacich, 1990	Effects of Anonymity and Evaluative Tone on Idea Generation in Computer-Mediated Groups	Product
	MacCrimmon and Wagner, 1994	Stimulating Ideas Through Creativity Software	Press
	Marakas and Elam, 1997	Creativity Enhancement in Problem Solving: Through Software or Process?	Press

Table C–1: Articles Reviewed Sorted by Journal (Ranking) – Continued			
Journal (Rank)	Reference	Title	Component
Journal of Management Information Systems (5)	Hender, Dean, Rodgers, and Nunamaker, 2002	An Examination of the Impact of Stimuli Type and GSS Structure on Creativity: Brainstorming versus Non-brainstorming Techniques in a GSS Environment	Person
	Santanen, Briggs, and de Vreede, 2004	Causal Relationships in Creative Problem Solving: Comparing Facilitation Interventions for Ideation	Person
	Tiwana and McLean, 2005	Expertise Integration and Creativity In Information Systems Development	Person
	Reinig, Briggs, and Nunamaker, 2007	On the Measurement of Ideation Quality	Product
	Leimeister, Huber, Bretschneider and Krcmar, 2009	Leveraging Crowdsourcing: Activation-Supporting Components for IT-Based Ideas Competition	Person
	Briggs and Reinig, 2010	Bounded Ideation Theory	Process
	Knoll and Horton, 2011	Changing the Perspective: Using a Cognitive Model to Improve Thinklets for Ideation	Person
Harvard Business Review (8)	Brown and Duguid, 2000	Balancing Act: How to Capture Knowledge without Killing It	Process
	Herbold, 2002	Inside Microsoft - Balancing Creativity and Discipline	Process
	Florida and Goodnight, 2005	Managing for Creativity	Person
	Catmull, 2008	How Pixar Fosters Collective Creativity	Press
IEEE Transactions (9)	Kappel and Rubenstein, 1999	Creativity in Design: The Contribution of Information Technology	Process
	Bragge, Merisalo-Rantanen, and Hallikainen, 2005	Gathering Innovative End-User Feedback for Continuous Development of Information Systems: A Repeatable and Transferable E-Collaboration Process	Process
Decision Support Systems (12)	Malaga, 2000	The Effect of Stimulus Modes And Associative Distance in Individual Creativity Support Systems	Person
	Faniel and Majchrzak, 2007	Innovating by Accessing Knowledge Across Departments	Press
	Cheung, Chau, and Au, 2008	Does Knowledge Reuse make a Creative Person more Creative?	Press
	Thatcher and Brown, 2010	Individual Creativity in Teams: The Importance of Communication Media Mix	Press

Table C–1: Articles Reviewed Sorted by Journal (Ranking) – Continued			
Journal (Rank)	Reference	Title	Component
IEEE Software (13)	Maiden, Gizikis, and Robertson, 2004	Provoking Creativity: Imagine What Your Requirements Could Be Like	Process
Information & Management (14)	Elam and Mead, 1987	Designing for Creativity - Considerations for DSS Development	Press
	Aiken and Carlisle, 1992	An Automated Idea Consolidation Tool for Computer Supported Cooperative Work	Press
	Durand and VanHuss, 1992	Creativity Software and DSS - Cautionary Findings	Press
	Song and Adams, 1994	A Morphological Approach to Generating Information Technology Product Ideas	Process
	Aiken, Vanjani, and Paolillo, 1996	A Comparison of Two Electronic Idea Generation Techniques	Person
	Gallivan, 2003	The Influence of Software Developers' Creative Style on Their Attitudes to and Assimilation of a Software Process Innovation	Process
Communications of the Association for Information Systems (20)	McLaren, Vuong, and Grant, 2007	Do You Know What You Don't Know? Critical Reflection and Concept Mapping in an Information Systems Strategy Course	Person
	Seidel, Müller-Wienbergen, and Rosemann, 2010	Pockets of Creativity in Business Processes	Process
IEEE Transactions on Systems, Man, and Cybernetics (21)	Shaw, Arnason, and Belardo, 1993	The Effects of Computer Mediated Interactivity on Idea Generation: An Experimental Investigation	Press
	Hori, 1994	A System for Aiding Creative Concept Formation	Press
Journal of the Association for Information Systems (26)	Dean, Hender, Rodgers, and Santanen, 2006	Identifying Quality, Novel, and Creative Ideas: Constructs and Scales for Idea Evaluation	Product
Organization Science (30)	Leonardi, 2011	Innovation Blindness: Culture, Frames and Crossboundary Problem Construction in the Development of New Technology Concepts	Press
	Sosa, 2011	Where Do Creative Interactions Come From? The Role of Tie Content and Social Networks	Press
Journal of Strategic Information Systems (45)	Välikangas and Sevón, 2010	Of Managers, Ideas and Jesters, and the Role of Information Technology	Process
ACM Transactions on Information Systems (47)	Olson, Olson, Storrøsten, and Carter, 1993	Groupwork Close Up: A Comparison of the Group Design Process with and Without a Simple Group Editor	Person

Table C–1: Articles Reviewed Sorted by Journal (Ranking) – Continued			
Journal (Rank)	Reference	Title	Component
ACM Transactions on Information Systems (47)	Kerne, Koh, Smith, Webb, and Dworaczyk, 2008	combinFormation: Mixed-initiative Composition of Image and Text Surrogates Promotes Information Discovery	Press
Journal of Computer Information Systems (51)	Couger, 1996b	Creativity: Important Addition to National Joint Undergraduate I.S. Curriculum	Process
	Fagan, 2004	The Influence of Creative Style and Climate on Software Development Team Creativity: An Exploratory Study	Press
IEEE Transactions on Knowledge and Data Engineering (53)	Yuan and Chen, 2008	Semantic Ideation Learning for Agent-based e-Brainstorming	Person
Knowledge Based Systems (58)	Noguchi, 1997	An Idea Generation Support System for Industrial Designers (Idea Sketch Processor)	Person
	Tuikka and Kuutti, 2000	Making New Design Ideas More Concrete	Press
	Gomes, Seco, Pereira, Paiva, Carreiro, Ferreira, and Bento., 2006	The Importance of Retrieval in Creative Design Analogies	Product
ACM Special Interest Group Publications (63)	Coughlan and Johnson, 2008	Idea Management in Creative Lives	Person
Expert Systems with Applications (64)	Chan, Ip, and Kwong, 2011	Closing the Loop Between Design and Market for New Product Idea Screening Decisions	Product
International Journal of Human-Computer Studies (68)	Kletke, Mackay, Barr, and Jones, 2001	Creativity in the Organization: The Role of Individual Creative Problem Solving and Computer Support	Press
Journal of Systems Management (81)	Couger, McIntyre, Higgins, and Snow, 1991	Using a Bottom-up Approach to Creativity Improvement in IS Development	Person
Organizational Behavior and Human Decision Processes (83)	Valacich, Dennis, and Connolly, 1994	Idea Generation in Computer-based Groups: A New Ending to an Old Story	Person
Journal of Organizational and End User Computing (86)	Doll and Deng, 2011	Antecedents of Improvisation in IT-enabled Engineering Work	Press
Journal of Information Science (88)	Eaglestone, Lin, Nunes, and Annansingh, 2003	Intention and Effect of IS Solutions: Does Risk Management Stifle Creativity?	Process
International Journal of Information Management (91)	Lindič, Baloh, Ribière, and Desouza, 2011	Deploying Information Technologies for Organizational Innovation: Lessons from Case Studies	Process
Journal of Information Technology Management (92)	Rao and Dennis, 2000	Equality of Reticence in Groups and Idea Generation: An Empirical Study	Person

Table C–1: Articles Reviewed Sorted by Journal (Ranking) – Continued			
Journal (Rank)	Reference	Title	Component
Behavior & Information Technology (93)	TaxÉn, Druin, Fast, and Kjellin, 2001	Kidstory: A Technology Design Partnership with Children	Press
International Journal of Technology Management (99)	Bond and Otterson, 1998	Creativity Enhancement Software: A Systemic Approach	Person
	Andreichicov and Andreichicova, 2001	Software for Inventive Problem-solving	Press
	Kohashi and Kurokawa, 2005	New Product Development and Creativity Management in Japanese Video Gaming Software Firms	Process
	Elfvengren, Kortelainen, and Tuominen, 2009	A GSS Process to Generate New Product Ideas and Business Concepts	Press
	Hesmer, Hribernik, Baalsrud Hauge, and Thoben, 2011	Supporting the Ideation Processes by a Collaborative Online-based Toolset	Press
Computers in Human Behavior (101)	Klein and Dologite, 2000	The Role of Computer Support Tools and Gender Composition in Innovative Information System Idea Generation by Small Groups	Press
	DeRosa, Smith, and Hantula, 2007	The Medium Matters: Mining the Long-Promised Merit of Group Interaction in Creative Idea Generation Tasks in a Meta-analysis of the Electronic Group Brainstorming Literature	Person
	Zaman, Anandarajan and Dai, 2010	Experiencing Flow with Instant Messaging and Its Facilitating Role on Creative Behaviors	Press
Information and Software Technology (108)	Munemori and Nagasawa, 1991	Development and Trial of Groupware for Organizational Design and Management: Distributed and Cooperative KJ Method Support System	Press
	Munemori and Nagasawa, 1996	GUNGEN: Groupware for a New Idea Generation Support System	Press
	Chen, 1998	Toward a Better Understanding of Idea Processors	Person
ACM conference on Creativity and Cognition (63)	Bonnardel, 1999	Creativity in Design Activities: The Role of Analogies in a Constrained Cognitive Environment	Press
	Fischer, 1999	Symmetry of Ignorance, Social Creativity, and Meta-design	Press
	Nakakoji, Yamamoto, and Ohira, 1999	A Framework That Supports Collective Creativity in Design Using Visual Images	Press
	Abrams et al., 2002	Qsketcher: An Environment for Composing Music for Film	Press
	Gero, 2002	Computational Models of Creative Designing Based on Situated Cognition	Person

Table C–1: Articles Reviewed Sorted by Journal (Ranking) – Continued			
Journal (Rank)	Reference	Title	Component
ACM conference on Creativity and Cognition (63)	Kuutti, Iacucci, and Iacucci, 2002	Acting to Know: Improving Creativity in the Design of Mobile Services by Using Performances	Person
	Terry and Mynatt, 2002	Recognizing Creative Needs in User Interface Design	Process
	Fischer, 2005	Distances and Diversity: Sources for Social Creativity	Press
	Warr and O'Neill, 2005	Understanding Design as a Social Creative Process	Process
	Bruns, 2007	Produsage	Press
	Hailpern, Hinterbichler, Leppert, Cook, and Bailey, 2007	TEAM STORM: Demonstrating an Interaction Model for Working with Multiple Ideas During Creative Group Work	Press
	Jacucci and Wagner, 2007	Performative Roles of Materiality for Collective Creativity	Press
	Resnick, 2007	All I Really Need to Know (About Creative Thinking) I Learned (By Studying How Children Learn) jn Kindergarten	Person
	Wakkary and Maestri, 2007	The Resourcefulness of Everyday Design	Press

ABOUT THE AUTHORS

Sune D. Müller is an assistant professor at the Center for IS Management, Aalborg University. He received his PhD in business process innovation from Aarhus School of Business (Aarhus University), Denmark, in 2009. His research interests are within information systems and software engineering, with a particular emphasis on IS/IT-enabled innovation.

Frank Ulrich is a MSc student in IT Management at Aalborg University. His research interests include creative collaboration through the use of creativity support systems. He has recently been accepted into the Ph.D. program at The Department of Computer Science at Aalborg University.

Appendix B. Informal Evaluation and Institutionalization of Neoteric Technology Ideas: The Case of Two Danish Organizations

Communications of the Association for Information Systems (Accepted).

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Abstract

This article explores the complex process of how ideas evolve in organizations that are engaged in developing and using information technology (IT) based systems. We put forward a framework emphasizing the interconnection between creativity and institutionalization. We argue that ideas are embedded in existing institutionalized technologies within the organization and that emerging technologies introduce neoteric ideas to the organization. Furthermore, we argue that when attempting to introduce technology-based ideas, human actors will focus their attention on ideas embedded in existing institutionalized technologies during their informal evaluation and sensemaking of these ideas. Moreover, we suggest that conflicts between competing frames of reference during this evaluation may result in the rejection, adoption, or multiplication of new technology ideas. Drawing on Information Systems (IS) based theories of creativity, Scandinavian institutionalism, and empirical data from two Danish organizations, this article investigates the interplay between creativity, technology, and human sensemaking in the process of translating and transforming technology ideas into full-fledged technological innovations.

I. INTRODUCTION

In the current hypercompetitive environment of businesses, modern organizations are under constant innovation pressure, forcing them to reinvent their business models [Johnson and Christensen, 2010; Onetti, Zucchella, Jones, and McDougall-Covin, 2010; Teo, Ranganathan, Srivastava, and Loo, 2007] and come up with novel ideas for products and services, relying on information technology and creativity management [Müller and Ulrich, 2013]. To achieve and sustain competitive advantage, organizations must invest in enhancing the creativity of their employees through various means. Such means may include technology supported creativity techniques for employee collaboration in developing novel ideas [Shneiderman, 2000, 2002, 2007]. Knowledge management and organizational learning are also central aspects of creating ideas from existing knowledge [Barrett, 1998; Leonardi, 2011; Nambisan, Agarwal, and Tanniru, 1999]. Furthermore, workforce management is key to fostering individual and group creativity and ensuring employee motivation [Amabile, 1989, 1998; Couger, 1996].

Managing creativity is a daunting task due to its somewhat rebellious and chaotic nature, involving high levels of abstract thinking [Ackoff and Vergara, 1981; Schuldberg, 1999]. As [Borghini, 2005:29] argues: "Creativity implies the braking of equilibrium and order." Consequently, organizations often struggle with supporting creativity and selecting which ideas to adopt [Couger, 1996]. Ideas can come from multiple sources. As Valikangas and Sevon [2010] argue, ideas socialize, escape, and organize. Ideas socialize with other ideas, technologies, and human actors as they travel across organizational boundaries. Organizations socialize with ideas, for example, during trade shows or adoption of new technologies. Ideas escape when they are too powerful for human actors to control. In their escape, they travel from person to person and from organization to organization. Finally, ideas organize by shaping related ideas, by leading to new ideas, and by creating contexts for other ideas. Ideas also organize people and organizational activity, for example when dominant management principles (ideas) are created that control innovation strategies and organizational behavior.

Ideas are creative products [Amabile, 1983]. For the sake of clarity, we define organizational creativity as human actors' ability to generate ideas that are considered novel and useful by others [Amabile, 1996; Couger, 1996; Couger, Higgins, and McIntyre, 1993]. Furthermore, creativity requires that the activity be heuristic and not algorithmic. Hence, if a human actor is simply following a guideline or recipe, the ensuing idea is not creative. In this light, ideas are knowledge products generated through human creativity [Ward, 2004]. Moreover, we follow Avital and Te'eni [2009] in acknowledging that ideas have generative properties that influence human action. From this perspective on creativity, ideas are knowledge products that inspire human actors to do something. As such, ideas can be redesigned, translated, and ultimately changed.

From an IT perspective, institutionalized technologies that are used by human actors in their daily practices are embedded with ideas [e.g. Valikangas and Sevon 2010]. Ideas are like cooking recipes. Cooking recipes are algorithms of which ingredients to use and meta-representations of the making, nutritional value, and serving of the food. Similarly, ideas are algorithms [Amabile, 1883] of purpose and meta-representations of form, function, and use that human actors may decide to implement into technologies or practices surrounding those technologies. Technologies are thus products of creative thinking [Couger and Dengate, 1992] in the sense that ideas become part and parcel of the technology and accompanying practices when implemented. Like cooking recipes, ideas may change over time. Properties of ideas may be added, removed, or changed, and existing ideas may inspire human actors to create new configurations of existing ideas or completely new ideas. In summary, we view technology ideas as generative knowledge-based algorithms and meta-representations about a given technological artifact that define its purpose, form, function, and use.

In order to determine their business value technology ideas must be evaluated before adopting them in the form of innovative IT-based products, services, or business models [Couger and Dengate, 1992; Dean, Hender, Rodgers, and Santanen, 2006; Osterwalder and Pigneur, 2010]. Yet, researchers have placed little emphasis on understanding the relationship between ideas, technology, and evaluation.

This article focuses on the relationship between organizational creativity and technology ideas. We examine the influence on organizational creativity of human actors' attempts to make sense of and frame technology ideas during informal evaluation processes. We use the term "human actors" to describe one or more people performing creative actions individually or collectively as a group. Thus, it is important to understand how human actors make sense of technology ideas during evaluation, for example, when trying to adapt ideas and use them in support of business needs. This is important, because human actors' (re-)actions are influenced by their ability to make sense of the incoming and chaotic flux of input [Weick, Sutcliffe, and Obstfeld, 2005; Weick, 1993] represented by new technology ideas. By new we mean “neoteric”, i.e. ideas that are new, modern, and different from what has previously been known to members of the organization. These neoteric technology ideas differ from institutionalized technology ideas that are implemented through existing technologies, are known by the human actors, and are accepted by members of the organization. Unless specifically referring to other definitions, we treat neoteric and institutionalized ideas as being technology-based knowledge products.

Throughout this article, we argue that human actors' sensemaking and framing of neoteric ideas during informal evaluation influence their future development and adoption. To understand the interwoven process of creativity and institutionalization, we draw on contemporary Information Systems (IS) based creativity research [Müller and Ulrich, 2013] and Scandinavian institutionalism [Nielsen, Mathiassen, and Newell, 2014]. We rely on their theories when investigating how human action is influenced by institutionalized ideas, and how human actors' frames of reference are shaped by particular ideas. In essence, we attempt to understand how institutionalized ideas shape neoteric ideas and how informal evaluation influences this process.

We organize the article by first describing the research perspective shaping our research question. Second, we present a framework grounded in IS-based creativity research and Scandinavian institutionalism. Third, we combine the various constructs in a theoretical framework, demonstrating the duality between creativity and institutionalization. Finally, we discuss the implications of the framework for both researchers and practitioners through two empirical case studies.

II. RESEARCH PERSPECTIVE

The following section draws on IS research to provide a comprehensive view on Scandinavian institutionalism and a state-of-the-art perspective on creativity research.

Neoteric ideas can travel between organizations through what Tiwana [2014] calls emerging technologies that generate business value. In line with Tiwana [2014], we view emerging technologies as technological artifacts imbued with neoteric ideas. Ideas travel when human actors embed them in internally developed artifacts, for example by following technology trends that introduce neoteric ideas to the organization. They may, however, also enter an organization through implementation of external technologies [Czarniawska and Joerges, 1995]. While we focus on ideas embedded in technological artifacts, ideas also manifest themselves in processes and services [e.g. Rose, 2010]. When it comes to evaluating ideas, we distinguish between formal and informal evaluation. Formal evaluation focuses on assessing quality through predefined parameters like novelty and usefulness [e.g. Dean et al., 2006]. Informal evaluation is often *ad hoc* and based on human actors' ability to make sense of the idea by placing value on it based on knowledge and cognitive abilities [e.g. Guilford 1977]. Because informal evaluation has largely been ignored in the IS-based creativity literature [see Müller and Ulrich 2013], we focus on this evaluation approach in our research.

Our research perspective is grounded in contemporary Scandinavian institutionalism according to which ideas and technologies are viewed as unstable institutional entities [Nielsen et al., 2014]. They travel across organizational boundaries [Czarniawska and

Joerges, 1995], are translated and transformed with reference to everyday practices [Orlikowski, 2000], and are subject to negotiation between human actors [Modell, 2006]. Historically, institutional theory within IS has focused on adaptation, interplay between technology and the institution, dynamic institutionalization processes, and technology fashions and trends [Nielsen et al., 2014]. However, institutional theory has paid little attention to the interplay between organizational creativity and evaluation.

Sensemaking theory has been used by researchers in several studies of organizational change [Weick et al., 2005; Weick, 1995, 2004] as well as in studies of technology use in organizations [Griffith, 1999; Orlikowski and Gash, 1994]. Within organizational research, Ford [1996] relies on sensemaking to investigate interpretive processes in organizational creativity, and Mumford, Scott, and Gaddis [2002] draw on the notion of sensemaking to study how practitioners may improve management of creative people. Other researchers focus on organizational creativity and change, and use sensemaking to understand and address associated problems [Borghini, 2005; Drazin, Glynn, and Kazanjian, 1999; Ford, 2002; Weick, 1993]. Weick [1993] argues from a sensemaking perspective that creativity serves as a driver for creating order out of chaotic situations, and Ford [2002] examines the differences in creative sensemaking processes between thinking ahead versus thinking about previous experiences. Moreover, Drazin et al. [1999] use sensemaking to understand how human actors engage in creative actions during organizational crises. In a similar study, Borghini [2005] investigates from a sensemaking perspective how managers may break existing equilibriums or order in an organization to influence the level of creativity. Leonardi [2011] shows a different side of sensemaking where human actors are blinded by culturally based interpretive schemes and interpretive schemes associated with the technology, which in turn guide their view of how to solve technological and organizational problems. As human actors interpret technology based on these schemes, they are blind to the fact that other interpretations may exist. Though IS researchers have explored creativity against the backdrop of sensemaking [Doll and Deng, 2011; Eaglestone, Lin, Nunes, and Annansingh, 2003; Leonardi, 2011], their work is limited to understanding the impact of risk management on creativity in organizations [Eaglestone et al., 2003] and understanding creative improvisation by IT engineers [Doll and Deng, 2011]. Besides the work of Leonardi [2011], IS and organizational researchers have generally made little effort to understand how sensemaking influences the outcome of informal evaluation when human actors attempt to frame neoteric ideas that, for example, are introduced to the organization through emerging technologies.

Creativity is not a new topic in IS research. However, IS creativity research has primarily focused on information systems supporting creativity [Maccrimmon and Wagner, 1994; Massetti, 1996; Shneiderman, 2000, 2002, 2007] and fostering creative environments for group-based collaboration [Hailpern, Hinterbichler, Leppert, Cook, and Bailey, 2007; Kohler, Fueller, Matzler, and Stieger, 2011].

Examples include group support systems that enhance both divergent and convergent thinking [Müller-Wienbergen, Müller, Seidel, and Becker, 2011], collaborative brainstorming tools [Nunamaker, 1987], and large-scale idea management portals in technology-oriented companies [Di Gangi and Wasko, 2009]. Equal emphasis is placed on the physical and social work environment in organizations, such as management styles and practices encouraging creativity [Florida and Goodnight, 2005; Malhotra, Majchrzak, Carman, and Lott, 2001], and workforce incentives stimulating creativity [Couger et al., 1993; Couger, 1996]. Moreover, creativity has been linked to management practices through the different options it affords managers as bases for their decision making [Maccrimmon and Wagner, 1994]. Research has also dealt with creativity techniques in software development [Couger et al., 1993; Couger, 1996]. Recently, research interest has shifted toward agile development methods nurturing creative and innovative thinking [Aaen, 2008; Rose, 2010]. In their study of creative and technological artifacts, Avital and Te'eni [2009] introduce the concept of generativity in IS design. They argue that any technology has the capacity to spawn novel configurations of itself (called generative fit) through its functionality and ability to support organizational processes. This generative fit may influence employees' creative work (called generative capacity), enabling them to explore new opportunities by creating something novel—thereby challenging the status quo. In this process, employees develop and redevelop knowledge from existing technologies into novel solutions and design alternatives, generating new possibilities. Moreover, Avital and Te'eni [2009] argue that a technological artifact should not be evaluated in terms of task-related performance alone, but also in terms of its generative fit and stimulation of employees' generative capacity. Later in this article, we elaborate on the idea of generative fit and generative capacity. In addition, we will demonstrate how creativity and institutionalization relate, and how sensemaking during informal evaluation of ideas plays an important role in the creative process.

There is a lack of research into the influence of idea evaluation on creativity and institutionalization. The literature is limited to understanding idea rating based on standardized parameters. These parameters include novelty (originality, newness, and radicalness of ideas), workability (acceptance or willingness to implement ideas), relevance (ability to perform efficient problem solving), and specificity (detail level, impact, and clarity of outcomes) [Dean et al., 2006]. Current formal idea evaluation practices are disconnected from creative processes [Elam and Mead, 1990] and only serve to eliminate unfruitful ideas [Blohm and Riedl, 2011; Osterwalder and Pigneur, 2010; Riedl, Blohm, Leimeister, and Krcmar, 2010]. Such practices have been criticized for destroying incentives to being creative by installing management cultures that kill novel ideas by striving to reduce risks and uncertainties, and implementing reward schemes that are harmful to employees' intrinsic motivation [Amabile, Barsade, Mueller, and Staw, 2005; Amabile, 1996, 1998; Mueller, Melwani, and Goncalo, 2012]. Creativity research has not sufficiently investigated the influence of informal evaluation on creative processes, although early researchers like Guilford [1967, 1977] have shown that informal evaluation enables human actors to draw on previous practices and experiences in stimulating creative thinking. By trying to understand creativity and informal evaluation from an institutional perspective, this study increases our knowledge of the interplay between ideas and technology, and helps us understand how creativity drives institutionalization forward. Equally important, an institutional perspective also helps us understand the human aspects of evaluation by focusing on actors' behaviors during informal evaluation rather than the effectiveness or efficiency of formal evaluation as in previous studies [Blohm and Riedl, 2011; Dean et al., 2006; Osterwalder and Pigneur, 2010; Riedl et al., 2010].

In this theory-driven article, we move beyond previous work by creating a framework that shows human sensemaking playing an integral part in the development of neoteric ideas when human actors evaluate other actors' ideas embedded in emerging technologies. With this framework, we highlight the close relationship between human actors and the organization in which creativity and informal evaluation of ideas take place. In doing so, we set out to bridge the knowledge gap between informal evaluation, the development of ideas, and technological innovation by honing in on the following research question: "How does the development, informal evaluation, and adoption of neoteric ideas affect organizational creativity?"

In the following section, we provide a theory-based elaboration of our initial research question that combines the institutional perspective with creativity research.

III. INFORMAL EVALUATION OF IDEAS AS NEGOTIATED ORDER

Innovation is the implementation of creative ideas through organizational or technological artifacts [Govindarajan and Trimble, 2010]. However, creativity is a chaotic enterprise [Schuldberg, 1999]. Through the creation of ideas, which may be implemented as innovations, creativity has the potential to disrupt established activity patterns and cause bursts of transformation within an organization [Ford and Sullivan, 2004; Romanelli and Tushman, 1994; Weick, 1993]. Having said that, creative processes are known to be hypersensitive to the surrounding environment [Amabile, 1996, 1998], and organizational creativity is influenced by the diversity of organizational knowledge [Sosa, 2011] and management practices [Amabile, 1998; Barrett, 1998; Couger, 1996; Eaglestone et al., 2003].

In the following, we explain the interplay between sensemaking and creativity during informal evaluation. In doing so, we theorize the influence of sensemaking on the development of neoteric ideas through informal evaluation (section 3.1), institutionalization (section 3.2), and multiplication (section 3.3). We combine our theoretical arguments in the framework presented in section 3.4.

Creativity, Sensemaking, and Informal Evaluation of Neoteric Ideas

Creativity and sensemaking share a common starting point—chaos [Weick et al., 2005; Weick, 1993]. Sensemaking is an important element in the interaction between neoteric ideas and existing equilibriums (i.e. the existing order within the organization), as human actors try to understand what other actors are doing in their attempts to create order out of the apparent chaos [Weick et al., 2005]. Sensemaking organizes the chaotic flux of input in order for human actors to comprehend "the almost infinite stream of events and inputs that surround any organizational actor" [Weick et al., 2005: 411]. Neoteric ideas contribute to such flux in the sense that they provide a stream of inputs unfamiliar to the human actors. Drazin et al. [1999] emphasize that human actors' ability to make sense of others' creative actions determine their level of engagement in creative activities. In this endeavor, human actors socially construct cultures to collectively make sense of their surroundings [Trice, 1993]. Different occupational cultures within the same organization may have different perspectives on creativity that clash during decision-making processes, forcing people to resolve their issues through negotiation and adaptation [Drazin et al., 1999; Trice, 1993]. For example, Dougherty [1992] describes how "interpretive schemes" from different "thoughts worlds" can become collaboration barriers when human actors are unable to make sense of how others see and interpret the world.

Moreover, sensemaking relates to technological frames. Frames are mental models of tacit and explicit knowledge that human actors use to organize meaning, motivation, involvement, and actions. They facilitate understanding of incomprehensible or confusing events and information [Drazin et al., 1999; Leonardi, 2011; Orlikowski and Gash, 1994]. Framing occurs by sensemaking being retrospective through reflections of the past and presumptive through expectations regarding the future [Weick et al., 2005]. Hence, when human actors attempt to make sense of new input, they reflect retrospectively on past experiences and think ahead presumptively about the future, relying on hunches and expectations regarding future events [Weick et al., 2005].

Retrospective reflections of the past and presumptive expectations regarding the future influence organizational processes, including creativity [Ford, 2002]. This happens by human actors attempting to interpret and label neoteric ideas according to their own frames of reference by applying knowledge from training, previous work experiences, and life events [Drazin et al., 1999; Orlikowski and Gash, 1994; Weick et al., 2005; Weick, 1995]. Consequently, human actors may apply radically different frames [Davidson, 2002; Edmondson, 2001] when informally evaluating neoteric ideas. Likewise, frames are subject to change and renewal through human action [Drazin et al., 1999]. As a case in point, Davidson [2002] explains how shifting frames during requirements development of an emerging technology disrupted an R&D process.

Ideas must undergo evaluation by human actors to be considered novel and useful [Drazin et al., 1999; Runco and Jaeger, 2012]. As such, the creative outcome (ideas) becomes a product of sensemaking when human actors apply their interpretations based on, among other things, their individuals roles in the organization [Drazin et al., 1999]. In this light, informal evaluation depends on sensemaking. Sensemaking organizes the chaos associated with neoteric ideas and enables human actors to attach value to the ideas, which in turn determines whether they are simply implemented, further developed, or outright discarded.

In some situations technological frames provide meaning in complex and ambiguous situations while they are constraining in other situations by reinforcing established patterns of thinking, which inhibits creativity [Orlikowski and Gash, 1994]. For example, formal idea evaluation uses predefined evaluation parameters (e.g. novelty and usefulness) to select only the best ideas for implementation [Dean et al., 2006; Osterwalder and Pigneur, 2010]. Such predefined evaluation parameters may provide formalized brackets that discourage human actors from creating their own brackets as part of new technological frames, resulting in preferences for unoriginal ideas and technologies. Blair and Mumford [2007] demonstrate that removing such stringent evaluation parameters results in the selection of more original ideas. As Guilford [1977] argues, the ability to evaluate is central to human cognition and creativity. Informal evaluation allows people to tap into previous practices and experiences (what Guildford describes as memory storage) when engaging in creative activities. Informal idea evaluation grounded in human actors' own sensemaking capability allows them to create their own technological frames and brackets according to personal experiences and practices. It relies on human sensemaking to discover and frame the perceived value of ideas based on individual brackets. From a sensemaking perspective, human actors recognize value in ideas they engage with, and such value is subjective by nature. The value of ideas is recognized at the level of individual human actors as they tab into personal memories and at an organization level when individuals establish common ground in terms of perceptions through shared frames. Hence, informal evaluation becomes part of the creative process as value is continually recognized both individually and organizationally, which in turn provides basis for developing new ideas.

Institutionalization of Ideas

Institutionalization is about the production and reproduction of taken-for-granted behavior over time [Jepperson, 1991], while ideas are knowledge products generated through human creativity [Ward, 2004]. Ideas materialize at some point in time [Czarniawska, 2009], and once they are transformed into artifacts, documentation, and practices [Czarniawska and Joerges, 1995], they are said to be institutionalized, possibly surviving for generations as the accepted way of doing things [Tolbert and Zucker, 1996]. In other words, institutionalized ideas are human knowledge products materializing over time as social artifacts that are communally adopted and taken for granted.

However, Drazin et al. [1999] emphasize that creativity is shaped by human interaction in which human actors draw on the interpretations of others to make sense of ideas and derive meaning. As technological frames are shaped by human actors' unique combinations of prior experiences and cultural backgrounds [Orlikowski and Gash, 1994], differences and conflicts between frames are inevitable. Addressing such conflicts requires an ongoing process of negotiation and compromise to facilitate collaboration, build partnerships, and ensure mutual learning among diverse groups of human actors with different backgrounds, knowledge, expertise, and interests. Therefore, establishing a shared frame among a group of human actors is a continuous process of interaction and negotiation. As Modell [2006] notes, what we perceive as institutionalized norms at any point in time are products of past negotiations and may be renegotiated if the context is amenable to change. It is through this ongoing negotiation and renegotiation process that new organizational practices, standards, and ideas emerge. These interactions and negotiations between human actors influence the creative output, resulting in both positive and negative outcomes. As Orlikowski [1992] points out, technologies are interpretively flexible with meaning being ascribed to them as opposed to existing independent of them. Human actors are indeed able to construct distinct frames that guide their interpretation of, e.g., an emerging technology [Drazin et al., 1999]. In such situations, disagreement about the functionality of the technology may have various consequences. At times, disagreement fosters new ideas for additional functionality [Amabile, 1996], but it may also delay adoption or result in outright rejection of the technology [Di Gangi and Wasko, 2009].

Consequently, technology is "not external or independent of human action" [Orlikowski, 2000:407]. Technology emerges from continuous interaction between human actors and therefore never fully reaches an equilibrium or stable state, as it is constantly being re-enacted through human action when used [Orlikowski, 2000]. In other words, human actors enact technology through ongoing, situated interactions with it. Such enactment impacts the rules of appropriate behavior, social interaction among colleagues at the workplace, and the resources needed to realize work-related goals [Orlikowski, 2000]. According to Orlikowski [2000:402], "there can be no single, invariant, or final technology-in-practice, just multiple, recurrent, and situated enactments." Hence, recurrent use of technology changes the practices surrounding it. A technology only temporarily reaches an equilibrium state. Technologies reach temporary "black box" states between interactions with human actors only to be re-enacted and changed at a later stage based on new knowledge (from, e.g., training) and experiences (from, e.g., other job situations) with the technology [Orlikowski, 2000].

In essence, institutionalization of ideas through technology is subject to human sensemaking. When human actors generate or informally evaluate neoteric ideas and act in accordance with their individual interpretations and frames, sensemaking provides diversity in the creative output of organizations. In this process, informal evaluation of ideas includes negotiation between conflicting frames of reference. The ideas may be adopted by some human actors in the organization, while others may reject them. In such situations of conflict, human actors rely on prior experiences and cultural backgrounds to renegotiate a new order. Such a new order may lead to a shared perception of the idea in question, leading to a decision regarding adoption or rejection.

Independent of their adoption or rejection, ideas may become institutionalized as part of an organization's tacit knowledge through the experiences, identities, and training of employees or as evolving professional norms in the organization. Informal evaluation may result in the creation of explicit knowledge, e.g. in the form of documentation such as business cases and project plans. Generally speaking, adopted ideas may become institutionalized and implemented through technologies, and they manifest themselves in any documentation, practices, and norms related to the technology. Rejected ideas may become institutionalized in a similar fashion. Hence, neither formal decision-making processes nor individual human actors determine whether a specific idea is institutionalized or not. Both rejected and adopted ideas become ingrained in the tacit as well as explicit knowledge of human actors. As [Trice, 1993] notes, culture allows human actors to interpret meaning collectively. In this process, rejected and adopted ideas help shape the cultural mindset of the organization, practices, and appropriate ways of acting that over time are taken for granted. As such, the culture of organizations may change during periods of continuous flux of neoteric ideas, breaking down existing equilibriums and challenging the stability of institutionalized ideas. Nonetheless, when ideas are institutionalized they help human actors by providing frames of reference when informally evaluating neoteric ideas through changes in their shared cultural knowledge.

Multiplication and Emergence of Neoteric Ideas

Human actors may frame neoteric ideas in ways that are conducive to adoption or rejection. Moreover, the flexibility of ideas makes them sensitive to changes and reframing [Czarniawska and Joerges, 1995]. Like technologies, ideas tend to change over time, as they are unstable entities sensitive to fluctuations in the environment that may be amplified exponentially over time [You, 1993]. In situations where human actors are blind to the perspectives of others [Leonardi, 2011], creative thinking may reframe existing ideas or create neoteric ideas in an ongoing negotiation process. In the words of Weick et al. [2005:410]: “people organize to make sense of equivocal inputs and enact this sense back into the world to make that world more orderly.” Consequently, one positive aspect of human actors having different frames of reference is the resulting multiplication of neoteric ideas arising from existing ideas. In the following, we suggest that multiplication is the translation, transformation, redefinition, and consolidation of existing ideas or knowledge into something that may be considered valuable by others. Multiplication happens when human actors try to make sense of neoteric ideas and create additional ideas to make them fit with their own technological frames. For example, Avital and Te'eni [2009] argue that all ideas and technological artifacts contain a level of generative fit that provokes novel ways of thinking and challenges existing equilibriums. This generative fit then enables human actors to utilize their generative capacity to spawn usable "new configurations or possibilities" through neoteric ideas [Avital and Te'eni, 2009:354]. A clear example of this phenomenon is apps development for mobile devices. Only a few years after the mainstream introduction of smartphones, apps were being developed at an unprecedented rate [Ngai and Gunasekaran, 2007] with consumers being able to download apps for any need [Butler, 2011]. Hence, smartphones have a high generative fit due to open platforms and development tools, which in turn influences the generative capacity of third party developers. Similar to private consumers, both private companies and public organizations have developed and implemented specialized apps for mobile technologies, complementing their existing IT portfolios to take advantage of new business opportunities or to facilitate communication between employees. Avital and Te'eni [2009] point to the Apple iPod as an example of such business opportunities. The iPod revolutionized the music industry. However, it did not allow users to generate alternative use cases and therefore had a low generative fit that negatively influenced the generative capacity of its users. In some instances, the generative capacity of users can overrule the intended generative fit of the technology. Flowers [2008] and Schulz and Wagner [2008] explain how hackers bypassed the software protection schemes of gaming consoles to install new firmware enabling users to modify their functionality. By removing the software protection schemes, hackers increased the generative fit of the technology.

When human actors attempt to make sense of ideas during informal idea evaluation, their interactions may display similar patterns to those of hackers. Weick describes the dynamics of ideas by stating: "Ideas shape ideas, they lead on to other ideas, they enact their own contexts" [Weick, 2004:657]. In a similar vein, Nagasundaram and Dennis [1993] suggest that human actors may be animated to engage in creative activities when exposed to existing ideas. In two empirical studies of brainstorming by Kohn, Paulus, and Choi [2011] and Kohn and Smith [2011], the authors show that human actors are able to build on each other's ideas during creative processes. Røvik [2011] argues that ideas mutate when human actors translate and transform them according to their own practices, for example by modifying the ideas to make them fit with problems in the organizational context. When ideas are translated and transformed, they multiply. Multiplication takes place when ideas are generated that support the translation or transformation. Multiplication also involves creative processes in which similar ideas and knowledge are consolidated into a new entity [e.g. Aiken and Carlisle, 1992]. Finally, multiplication involves breaking existing patterns of thinking as human actors interact with and informally evaluate ideas, for example by consolidating pieces of semantically unrelated knowledge or by radically redefining the knowledge into something new [e.g. Sternberg, 1999]. As such, multiplication is best described as a mixture of convergent and divergent production [c.f. Guilford, 1967, 1977]. Convergent production entails conversion of ideas into tangible solutions through translation and transformation. Consolidation of semantically unrelated knowledge and knowledge redefinition involves divergent production driven by unconventional patterns of creative thinking.

Thus, in addition to adoption and rejection, human actors' attempts to make sense of ideas sometimes result in other ideas being created, i.e. the ideas being multiplied. Such multiplication may happen when human actors experience conflict between frames created during informal evaluation. Hence, new ideas may have a generative fit that enables human actors to generate new and different ideas for new solutions to experienced problems [Avital and Te'eni, 2009]. This view of generativity is closely related to Couger [1996] who argues that idea evaluation may help transform seemingly unfruitful ideas to achieve real value in terms of novelty and usefulness. Such transformation happens when evaluation is used to nurture ideas through careful and methodological examination of the problem at hand [Couger, 1996].

During informal evaluation of an idea, conflict in negotiations between human actors with different technological frames may result in creation of neoteric ideas, i.e. through multiplication. Alternatively, conflict between frames may transform the original idea through negotiation into a new state in which its value is recognized by all human actors involved. However, previous studies have shown that human actors produce less novel ideas in groups than individuals working alone, which may be due to "collaborative fixation" when negotiating with others [Kohn et al., 2011; Kohn and Smith, 2011]. Due to their generative fit and human actors' generative capacity, multiplication of neoteric ideas may be the result of informal evaluation. Nevertheless, the novelty of ideas may decrease over time due to the ongoing process of negotiation and compromise among human actors.

To summarize, we suggest that informal idea evaluation may have creative outcomes. We suggest that informal evaluation of neoteric ideas leads to institutionalization when human actors reject or adopt them. In addition, we argue that informal evaluation results in multiplication of neoteric ideas, when human actors experience conflict during negotiations between rejection and adoption. Next, we synthesize our theoretical discussion in an integrated framework of the interplay between creativity and technology in organizations.

An Integrated Framework of the Interplay between Neoteric Ideas and Organizational Institutionalization

Up until this point, we have explored the close relationship between creativity, evaluation, and institutionalization by emphasizing how neoteric ideas are adopted, rejected, or multiplied. We argue that the sensemaking process is continuous—iterating between generations of ideas and institutionalization. More specifically, the creative actions and interactions of human actors establish connections between institutionalized ideas and neoteric ideas. By doing so, human actors frame new experiences based on individual backgrounds, knowledge, and values supporting their decision-making capabilities. For example, when human actors transform ideas according to their frames of reference, it eases negotiations and provides needed knowledge for idea adoption or rejection. When negotiations fail, the result may be further multiplication of ideas toward a solution that, for example, solves an identified problem.

Drawing on the theoretical perspectives presented above, we combine the theoretical constructs in an integrated framework (see Figure 1 below) to describe the interplay between creativity and technology in organizations as an iterative cycle. The lines between the different elements show paths of influence.

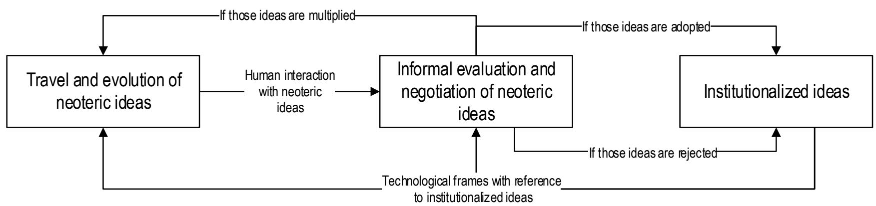

Figure 1: An Integrated Framework of the Interplay between Neoteric Ideas and Organizational Institutionalization

In brief, when human actors informally evaluate and make sense of ideas, they become institutionalized over time through sensemaking processes, or they multiply into neoteric ideas.

Initially, ideas travel to or evolve within the organization. These ideas emerge internally or externally as organizational members experiment with new technologies. When human actors informally evaluate those ideas, they draw on knowledge from previous experiences. During this informal idea evaluation process, human actors try to make sense of the incoming flux of neoteric ideas. This sensemaking is an ongoing interaction process during which the ideas are negotiated and bracketed according to existing technological frames. Negotiations between human actors may result in idea adoption if the idea fits with existing technological frames or rejected otherwise. If adopted, the idea becomes institutionalized and reaches an equilibrium or "black box" state. If rejected, the idea also becomes institutionalized in the form of experience-based knowledge or knowledge residing in documentation. This knowledge will influence future interactions with neoteric technology ideas by providing human actors with frames of reference.

Although diversity of frames among human actors has negative consequences, such as conflict and rejection of some useful ideas, it also has positive consequences, including emergence of neoteric ideas as opposing perspectives collide [e.g. Dougherty, 1992]. During informal evaluation of neoteric ideas, human actors may experience negotiation conflicts within or between groups. Conflicts may arise due to differences in human actors' frames of reference. However, conflict may also result in idea multiplication enabling future renegotiations. Multiplication of ideas involves convergent translation and transformation as well as divergent consolidation of semantically unrelated knowledge and redefinition of knowledge into something new. This sensemaking process may take place over several iterations producing new ideas until human actors reach some level of agreement. Hence, human negotiation and action in the sensemaking process may trigger their generative capacity, resulting in idea multiplication that leads to alternative solutions. In extension of Avital and Te'eni [2009] who describe how ideas generate novel solutions through human action, multiplication helps explain how those ideas evolve through human action or are "black boxed" until new stimuli (organizational flux) make them resurface.

In the following section, we illustrate the theory in practice through two case studies from the public and private sector respectively.

IV. AN ILLUSTRATIVE VIGNETTE OF THE THEORY IN PRACTICE

To provide illustrative examples of the theory in practice, we conducted a multiple case study [De Vaus, 2001; Yin, 2003] of two IT departments in Karlstown municipality and NavalSim[10]. Both cases provide varied views of creativity management practices and use of technologies, offering different settings for the theory in practice. Data were collected during spring of 2012 through six one-hour semi-structured interviews at the two research sites, using open-ended questions [Saunders, Lewis, and Thornhill, 2003]. To ensure breadth and diversity in the perspectives on creativity and technology management, we interviewed the CIO, a project manager, and a business developer from Karlstown municipality as well as the CIO, the head of innovation, and the head of product development from NavalSim. This diversity among interviewees provides insight into how human actors

[10] All names used in this article are fictitious to ensure confidentiality.

at different management levels engage with and evaluate neoteric ideas. Following the interviews, we set up an informal six-hour workshop at each case organization. During discussions at these workshops, we presented our preliminary findings, and asked the participants from Karlstown municipality and NavalSim to comment on them. At Karlstown municipality, eight key informants from the IT management unit participated. At NavalSim, the entire development and management team participated.

Data analysis was done in accordance with interpretive research principles (Walsham 1993, 2006), i.e. viewing the collected empirical data as social constructions by human actors. Hence, the social world that human actors are part of—both as private citizens and organizational members—is socially constructed through their actions [Walsham, 1993, 2006]. Our role as researchers took the form of outside observers [Walsham, 1995], witnessing human actors in their natural environment and using the collected empirical data as basis for interpreting their social reality and building new theory. In practice, we analyzed the interview data using an elaborate notation system as described by Bryman [2004]. We divided each section of each interview into different categories, using a coding scheme to capture among other things roles, themes, and in-depth notes on the subjects of discussion. Along with transcriptions of the empirical data, this coding scheme was instrumental in providing an overview and facilitating data analysis of key concepts. Moreover, we focused on decision-making processes in groups rather than at an individual level. This approach enabled us to identify how different groups within an organization negotiate with each other during informal evaluation of neoteric ideas.

Knowledge, Creativity, and Experimentation in Navalsim

NavalSim is a high-tech company with headquarters in Copenhagen, Denmark. It is a business unit of 30 employees within an engineering company that specializes in various aspects of engineering—from development and consulting in wind energy to offshore oil platforms. NavalSim focuses on naval ship simulators for international private and public maritime customers. Among other things, they create "full-mission" bridge simulation systems imitating, for example, the bridge of an oil tanker. In addition, NavalSim is a certified research-based technology service organization[11], provided with Danish government funding on a three-year basis. This funding enables NavalSim to create innovative technologies and services that benefit small and medium-sized companies. NavalSim is, however, mainly developing complex systems for external customers. Furthermore, they primarily develop their own technologies. They only rely on consumer technologies to a limited degree in order to create internal business value.

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[11] Also called GTS companies. For more information on GTS, see: http://en.gts-net.dk.

The NavalSim case illustrates informal evaluation in a different organizational setting from that of the municipality (see below). This case shows informal evaluation during requirements engineering when developing new technologies for the naval industry. With regard to the evolution of neoteric ideas, the NavalSim case also illustrates the critical selection processes during informal evaluation by showing why some ideas are adopted while others are not.

To a large extent, NavalSim bases its development on previous experiences from other projects. When asking the head of product development at NavalSim about the significance of experience (related to presumptive frames) in informal evaluation of neoteric ideas, he stated:

> "There are some we listen to more than others. In our development team, we will pull in the guys who have both market and development insight and the experience to back it up. They have the experience to evaluate new ideas and are part of our innovation group. Our head of innovation is one of those guys. He has been here for almost 30 years and was the father of the original version of our software. He still has many good ideas and has a real healthy approach. He is one of those guys we will listen to and is a decision-maker when new ideas are being evaluated."

Hence, people such as the head of innovation are critical in evaluations and decisions regarding neoteric ideas. They have years of experience within the organization and with the technology being developed. From the perspective of sensemaking and institutionalization, these human actors draw on frames and norms governing software development within the organization. Depending on their role in the organization in general and the software development process in particular they become gatekeepers in relation to the traveling of neoteric ideas.

Another group of gatekeepers in the evaluation process consists of business developers and customers. The research participants from NavalSim argued that customer experiences play an important role when developing ideas for new software. NavalSim has two business developers who possess training, personal experience, and in-depth knowledge of customers' business domain. The knowledge base of these business developers comes to good use when developing and evaluating neoteric ideas. They stay in close contact with their customers—customer relationships that have been built up over several years of cooperation, which enable them to pick up on new trends and ideas for further creative development. As the head of product development explained it:

> "Our customers are more partners than it is a customer-supplier relationship. With a lot of the customers we have close personal ties, built up over several years of cooperation. They will often visit us,

> or we will visit them around the world where we talk about all sorts of things, and then they have seen something new or we have seen something new, which enables the creativity to blossom between us."

These business developers are connected to customers' technological frames. They interact with the customers and communicate those frames to the rest of the development team. As NavalSim is continually developing on the same software products, multiplication of ideas is often a question of translating and transforming ideas to customers' technological frames through convergent production. In this process, both software and business developers play important roles as they identify new technology trends. Such trends contain ideas which then travel to the organization. For example, the CIO of NavalSim often receives e-mails from employees having spotted something new they can use. Business developers and individual employees in the development teams find inspiration and ideas on the Internet, business trips, trade conventions, and through interactions with customers.

These traveling ideas are subject to informal evaluation in context of existing software products. Everyone we interviewed at NavalSim agreed that their evaluation and creative processes are *ad hoc* during software development. However, dependent on the level of experience and the type of idea, different perspectives and opinions surface during evaluation in terms of how to adopt the idea. This results in a healthy debate, igniting a creative process that determines whether an idea is the best solution to the problem at hand, or if there are other ideas and better options. Hence, informal evaluation of neoteric ideas at NavalSim is a creative process in which ideas are presented and negotiated by human actors with competing technological frames. As such, the business developers apply frames obtained through customer interaction while the software developers will rely on frames from years of experience with the existing software. Conflicts between the opposing frames result in experimentation with neoteric ideas.

Experimentation happens when neoteric ideas are informally evaluated, and the development team relates new inspiration to their practices. In this process, they often supplement the neoteric idea with ideas that translate and transform the original concept to suit their own development projects. These ideas often result in new technology projects. Nonetheless, when software or business developers create ideas that transform and translate neoteric ideas, the newly generated ideas do not reach an equilibrium state immediately due to conflicting views between human actors. Instead, the ideas go through several iterations in which they are modified and recreated through comments and suggestions by colleagues before being embedded into new product or service innovations. When we asked the head of innovation at NavalSim whether they work with idea development, he answered:

> "Definitely! People will often come up with an idea, when they can see that the potential is there but that the idea still needs some further development before you can determine if it is feasible to adopt."

Such iterations entail negotiations between human actors, as those involved need to agree on the future direction of ideas. At NavalSim, approximately 30 percent of adopted neoteric ideas go through several iterations and negotiations within the development team before arriving at solutions. As the head of product development at NavalSim told us:

> "An idea can come from an individual or a group of people. Depending on the level of experience and the type of idea, there will always be other perspectives and opinions as to how such an idea should be adopted. There will always be a healthy debate and creativity to determine if the idea is the best solution to the problem, or if there are other approaches to it."

Because NavalSim works on software products with a 30 year old code base, neoteric ideas must be translated and transformed to that particular context. Hence, the negotiations in NavalSim constitute convergent processes in which business and software developers play key roles in the rejection or multiplication and selection of ideas to be adopted.

However, senior management is also an important gatekeeper of neoteric ideas at NavalSim. The fact is that NavalSim rejects ideas quite often using formal evaluation parameters that do not involve sensemaking on the part of human actors. When neoteric ideas are formally rejected, the main reason is mainly budgetary restrictions imposed by either business developers or senior management. Time, prioritization, and access to resources are also causes for rejection. As the head of product development at NavalSim explained:

> "It happens more often that we reject an idea than we approve it. We have a certain amount of hours a year we can use, and we have to prioritize among the many ideas we receive. We have to decide if we should go with the idea this year, reject it, or save it for later. We receive a lot more ideas than we have budget to deploy."

When neoteric ideas are rejected on budgetary grounds, the rejection is based on an investment decision rather than as the result of an evaluation of its business value [Ward, Daniel, and Peppard, 2008]. NavalSim uses business cases to both formally and informally evaluate neoteric ideas. The business cases are essential in formal evaluation. Predetermined evaluation parameters such as available resources can easily be identified. However, business cases or similar evaluation methods can also be applied to informal evaluation for the purpose of identifying problems, solutions, and benefits [e.g. Couger, 1996]. Sensemaking plays, however, an important role in informal evaluation, because it is based on both retrospective reflections and presumptive expectations. Human actors bracket ideas based on experiences, knowledge, and training, helping them determine their business value. The head of innovation emphasized that ideas of a general nature were more likely to be approved, because they can be used in several business settings, increasing the likelihood of the ideas multiplying into neoteric ideas and further increasing their potential business value. His comment espouses Avital and Te'eni's [2009] theory of generative fit, according to which open-ended ideas and technologies are more likely to trigger human actors' generative capacity. Using our framework as a reference, such highly generative ideas also entail a higher degree of flux, increasing conflicts in negotiations and hence the potential for multiplication. In the case of NavalSim, such open-ended ideas are selected, because they are less risky and more likely to succeed, as they can be deployed in multiple settings. When human actors at NavalSim prioritize ideas with a high generative fit that are likely to multiply over time, it reveals that the interplay between informal evaluation and multiplication is an important aspect of their innovation capability. For NavalSim, such ideas are simply more valuable. In prioritizing ideas with a high generative fit, NavalSim places value on expert knowledge and having lively discussions during informal evaluation. These practices illustrate that conflicting interests impact adoption and rejection in informal evaluation, leading to multiplication and increased value to the organization when resources and conditions supporting generativity are available.

Experimenting with Emerging Mobile Technologies in Karlstown Municipality

Karlstown is one of 98 municipalities in Denmark. Situated in Jutland, it is comprised of approximately 62,000 citizens. Karlstown has 5,500 employees and 240 executives across 17 different departments, and is equal in size to a large corporation. The IT department provides services to the entire municipality through its 20 employees in charge of operations and support, and the 13 employees who are part of a project and digitization management group. These two units face many of the same challenges as other Danish municipalities regarding digitization of the public sector, including increased government pressure to bring citizens closer to the public administration and to reduce unnecessary bureaucracy and expenses. Karlstown municipality's challenge is hence to rethink the use of IT as a strategic tool. The municipal IT strategy serves to foster a creative and innovative mindset among executives and employees across the organization in order to rethink the deployment of off-the-shelf IT systems to create value and push digitization forward.

Karlstown municipality has experienced users rejecting ideas. The municipality was recently involved in a project focusing on PDAs in care for the elderly. The implementation of PDAs in the eldercare was part of a larger nationwide mobile technology project across municipalities from 1998 to 2008 [Nielsen et al., 2014]. It was viewed as an innovation in the care due to the potential for reducing time and costs, for enhancing communication between employees, and for easing access to information about the elderly in the municipality. However, the experienced learning curve in adopting the PDA technology was steep among users. In addition, the project was marred by technical problems with regard to network coverage and adaptation of the PDAs to existing work practices. For example, users complained about the need for time registration, being under surveillance by the municipality. After several implementation attempts, the IT department discarded the PDAs and the underlying idea due to lack of business value. As the business developer in the municipality explained with regard to the project's failure:

> "The employees started to complain about time registration, and that they felt they got monitored, and that there was no time for the elderly. When they got a PDA, they could not figure out how to use it, and sometimes there was no network coverage. In addition, we could only use the PDAs for the specific purpose it was developed for … In the end, it did not provide needed benefits and it was discarded."

When the employees and people from the IT department worked with the PDAs, they interacted with the neoteric idea behind the PDA. During this interaction, the human actors attempted to make sense of it. In doing so, they informally evaluated and bracketed the idea according to retrospective and presumptive frames based on their tacit and explicit knowledge. These were existing frames from the human actors' past experiences of and future expectations regarding mobility, technology use, and work practices. These frames served as evaluation parameters. However, in the case of the PDAs, the frames were inconsistent with the technology and the underlying idea. For example, the idea was counterproductive to employees' work practices, which were based on autonomy and trust. Furthermore, the mobile technology was immature. Additionally, the PDAs had a low generative fit. Similar to Avital and Te'eni's [2009] example of the iPod, the PDA idea was too narrowly focused. Therefore, the idea was unable to accommodate suggested changes or lead to new and alternative configurations.

In the end, the human actors were simply unable to make sense of the idea behind the PDAs based on their existing technological frames. The low generative fit of the idea prevented the human actors from using their generative capacity. The human actors from the IT department were therefore not able to spawn alternative solutions through multiplication, leading to novel solutions in the eldercare. Instead, the result of negotiations between human actors in the eldercare and the IT department was rejection of the PDAs. However, as later experiments with neoteric ideas have shown, this rejection also paved the way for successfully introducing another mobile technology idea.

In 2012, mobile technology was again on the agenda when the IT department initiated an experiment with the local politicians to increase their technology awareness. In this experiment, the politicians were given tablet computers. Meanwhile, since tablet computers were developed for leisure purposes and only offered a few apps designed for the public sector, they had limited business value to the municipality in their existing form. Introducing this neoteric mobile idea caused concern within the IT department. As the project manager explained:

> "Five years ago, we would not have implemented tablet computers in the organization, as they did not fit into our concept. However, we can also see that we need to be ahead of new technological advances."

Obviously, as employees and managers within the IT department informally evaluated and discussed tablet computers, the lack of internal business value raised questions concerning the economics and reasonableness of sponsoring the technology when benefits were indeterminate. As the IT department had historically viewed technology as organizational artifacts delivering value, lack of obvious benefits was an implementation barrier. As the CIO explained:

> "We did not implement tablet computers to use them for something—because we could not use them for anything. They could use its mail and calendar. That was basically it; because they were not developed for work but private use, where they could be used for a lot of different things … This was a barrier we had to overcome, because we used to think about technology as something that must deliver something. Here, we did not deliver anything."

However, the tablet computers had two advantages over the PDAs. First, the mobile technology had incorporated ideas concerning usability into its design. Second, the technology was an open platform with a high generative fit. More importantly, when the IT department reintroduced the mobile technology idea through new tablet computers, they also introduced a neoteric idea about its deployment. It differed substantially from previous experiences with technology deployment by allowing for emergent discovery of value rather than requiring predetermination of value in advance. Instead of predetermining the business value as in the PDA case, the tablet computers were introduced as an experiment not serving specific purposes other than increasing the politicians' knowledge about digitization. To get approval from politicians, the CIO argued that the experiment would provide long-term benefit to the entire organization. The tablet computers would not improve business performance in measurable terms. Instead, they would enhance the politicians' understanding of modern technology's potential. As the CIO explained:

> "It was also an experiment to encourage people to see opportunities in the technology … The tablet computers have put new demands on the technology. But we did not establish any guidelines ahead of time regarding how it should be used."

From the perspectives of sensemaking and traveling of ideas, the deployment and mobile technology ideas were consolidated and introduced as an idea of mobile technology experimentation within the organization. The idea of using tablet computers was informally evaluated by the IT department based on existing technological frames. In their eyes, tablet computers did not constitute something substantially new as it could be related to previously created frames from their experiences with PDAs. This allowed them to identify benefits of the tablet computers above those of the failed PDA project. For the IT department the challenge was translating and transforming the tablet computers to the organizational context, convincing the politicians of the technology's merits despite the PDAs failure. Informal evaluation resulted in the idea of experimenting with the tablet computers. This constituted a paradigm shift for the IT department in how to evaluate technology and accepting value as emergent. The IT department had to consolidate different knowledge domains, combining value identification with experimentation and multiplying ideas from previous practices into a neoteric idea. Through divergent production, two semantically different ideas were consolidated into one that politicians and the IT department had to make sense of.

The experiment had an overwhelmingly positive effect. Even though the politicians were skeptical from the outset, they soon began interacting with the new tablet computers and negotiated their future development with the IT department. Through these negotiations and their interactions with the tablet computers, both parties created their own frames of reference with regard to the technology. This process allowed them to generate novel ideas in terms of how to provide business value for the municipality. As a result, introducing the tablet computers entailed a multiplication effect, a translation that led to novel ideas and demands for future use of the tablet computers. As the business developer from the municipality explained:

> "We gave the users the tablet computers and they said: 'I can check my mail and my calendar; what else can I use it for?' Then we had to tell the users that it was all they could use it for. They could only use it for mail or checking the calendar, and maybe read a PDF or take a picture. Then we got demands: 'why can I not access the ESDH[12] system; why can I not access my casework files etc.?'"

[12] Electronic System of Document Handling.

Hence, when the politicians started using the tablet computers, they informally evaluated the ideas behind the tablet computers. They bracketed the ideas within existing frames based on previous work practices using other technologies. New ideas arose which were brought into negotiations with the IT department. For example, conflicts arose with regard to technological frames based on institutionalized ideas from experiences with, e.g., the ESDH system. The politicians discovered that the technology did not fit their frames of reference with regard to work practices and existing technologies, such as casework management and the system used for document handling. This conflict in terms of technological frames came a surprise to the IT department, having framed the mobile technology idea as an experiment to increase the politicians' knowledge about digitization. The result was multiplication through convergent production, creating new ideas which translated and transformed the tablet computers to the context of the politicians. These ideas in turn changed both the politicians' and the IT department's interpretation and perception of the mobile technology, enabling them to make sense of it. As such, this multiplication had implications for mobile technology adoption within the organization of Karlstown municipality. The business developer further elaborated on these implications:

> "It actually makes it a bit difficult to follow the development, because as soon as they receive the technology they put new demands on us … This is a huge challenge for the IT infrastructure, which we have to overcome."

By allowing experimentation with the tablet computers, the IT department triggered the politicians' ability to informally evaluate the technology when interacting with and making sense of it. During this evaluation process, the politicians generated ideas, translating and transforming the tablet computers to their existing technological frames and work practices, which in turn reduced the flux represented by the neoteric idea. Moreover, these ideas enabled the politicians to negotiate future technology development with the IT department. During these negotiations, the IT department had to reevaluate the ideas behind mobile technologies. This coincided with the tablet ideas challenging the IT infrastructure and the IT department in handling the constant flow of user requirements (i.e. demands for new functionality). Quickly, the IT department realized that the increased demand for information on different devices would require them to provide alternative mechanisms for information delivery.

Looking back on the previous PDA project, the business developer in the municipality argued that the culture surrounding mobile technologies had changed, and that the project outcome would be different today if the users were provided with smartphones or tablet computers. For example, users from the failed PDA project would be able to draw on their own personal experiences with similar consumer electronics, which would render them less hostile toward using mobile technologies at the workplace. The business developer explained the changing user mindset:

> "I think that if we re-think it today and provide them with smartphones, we would receive user requirements about how to use it … Today, they would probably say: "nice that we have this smartphone", because they could make calls and use it to receive information about citizens, medicine, and stuff like that. A change in culture has happened, and tablet computers and smartphones are part of that, because people perceive it as being smart and handy. However, from an IT viewpoint it is not really mature for business implementation."

Interpreting this change by means of sensemaking theory, the users gathered ideas from previous experiences with mobile technology (the PDAs) and their private use of such technologies. Even though the PDA project failed, the ideas behind it have become institutionalized in the organization as human actors interacted and negotiated with them. Retrospective reflections and presumptive expectations based on institutionalized ideas assisted the users and the IT department in generating neoteric ideas. Such sensemaking activities relate to Orlikowski's [2000] perspective on technologies that reemerge from "black box" states when human actors receive training, gain new experiences, and change their perceptions of technology use. In this process, the human actors in Karlstown municipality bracketed the ideas within existing technological frames, thereby facilitating technology adoption and implementation.

The result of experimenting with mobile technologies in the municipality was a neoteric idea for a platform independent meeting and project portal, accessible anywhere regardless of device and operating system. This idea was the result of negotiations between the IT department and the politicians. In order to meet increasing demands by the politicians, the IT department informally evaluated and multiplied the flux of politicians' ideas according to their own institutionalized technological frames. As such, the platform idea incorporated knowledge from the IT department's previous experiences with inflexible mobile devices and the politicians' demand for flexible access to various information systems. As such, the platform idea enabled both the IT department and the politicians to reach consensus in their negotiations concerning the mobile technology. In turn, this consensus regarding the value of the technology provided the necessary impetus for adoption and institutionalization.

This process illustrates the inner workings of informal evaluation and multiplication of ideas. In this evaluation and sensemaking process, the IT department drew on ideas from different knowledge domains in their negotiation with the politicians. For their part, the politicians generated new ideas during this process. Both parties informally evaluated the ideas and bracketed them within existing frames based on previous experiences with mobile technologies. The end result was multiplication, translation, and transformation of the tablet computers into an idea that both parties could make sense of, namely the neoteric idea of a meeting and project portal. This idea met the politicians' demands, eased negotiations between the stakeholders, and facilitated adoption of mobile technology that had previously been rejected.

The process of identifying and creating value was informal throughout the evaluation. In the beginning, the mobile technology idea had little or no value in the eyes of the human actors. However, the informal evaluation process resulted in value being created as the human actors identified aspects that were inconsistent with their institutionalized knowledge, multiplied those ideas, and adopted the emerging solution.

Summary of the Illustrative Vignettes

Both cases demonstrate that ideas are often "black boxed" through adoption or rejection when human actors informally evaluate the ideas and are engaged in negotiations as part of the sensemaking process. Additionally, in both cases there are clear signs of multiplication. At NavalSim ideas multiply when software and business developers pick up on ideas from customers or technologies, translating and transforming them into their own practices. Moreover, as the case of Karlstown municipality demonstrates, neoteric ideas are developed through social interaction, involving the approval of all parties in the sensemaking process [Hirschheim and Heinz, 1989]. A neoteric idea that allowed for experimentation with tablet computers quickly became a driver for divergent production within the municipality. By trying to make sense of this mobile idea, human actors created multiple neoteric ideas over time. These ideas were then institutionalized, which restarted the sensemaking process.

V. DISCUSSION: CREATIVITY AND EMERGING TECHNOLOGIES AS A DUALITY

We opened this article by investigating the outcome of sensemaking when evaluating ideas. We presented a framework based on theoretical perspectives in the existing literature and provided three possible outcomes of informal evaluation—rejection, adoption, and multiplication. We elaborated and exemplified these outcomes through illustrative vignettes that corroborate our theoretical presuppositions. The following discussion highlights our contributions, offers directions for future research, and describes the limitations of our research.

The Intertwining of Neoteric and Institutionalized Ideas

We argue that human actors often focus on ideas previously institutionalized through technological artifacts to make sense of neoteric ideas. As such, we propose that organizational creativity may be viewed as a social system of idea generation and institutionalization. This system is a continuous process of sensemaking through which ideas are constantly evolving and institutionalized in the form of novel artifacts, practices, and norms regarding their use in organizations. This theoretical interpretation addresses important knowledge gaps in the existing literature. First, it connects institutionalization of neoteric ideas with human actors' ability to creatively act upon their informal evaluation of ideas. Second, it emphasizes the recursive nature of human interaction with technology [Orlikowski and Scott, 2008], both in making sense of it on a conceptual level (the neoteric ideas) and in institutionalizing the ideas in the form of innovative technologies.

Some scholars such as [Ancona and Caldwell, 1992; van Knippenberg, De Dreu, and Homan, 2004] argue that involving human actors with diverse backgrounds and knowledge may actually impede creativity because of conflicting interests among people and limit the exchange of ideas. We subscribe, however, to the perspective that bringing different human actors into the sensemaking process creates opportunities for interacting with people who have varying perspectives and approaches to work [see, for example, Amabile, 1998; Cooper, 2000; Tiwana and McLean, 2005]. This diversity of viewpoints fosters novel pathways of thought and action, and ultimately stimulates creativity—such as linking ideas from multiple sources and seeking innovative ways of performing tasks. Both case studies demonstrate that previous and new experiences play a major role in the development of neoteric ideas. The case of Karlstown municipality demonstrates that the culture of organizations can be amenable to change, displaying flexibility between periods of change and stability. Karlstown went from a period of the mobile technology idea being relatively stable, "black boxed", and rejected to see it remerge from its "black box" state in a neoteric form, changing human actors' perspective of the delivery of IT. During this period of change, ideas of how to digitize work practices were generated by experimenting with tablet computers and by allowing employees to share institutionalized ideas and integrate them with new input from others. The ability of human actors to reflect on their own practices and experiences is an important factor affecting their ability to evaluate and generate additional ideas. When human actors receive new input from the world around them, they reflect back on previously institutionalized ideas, which helps them organize the incoming flux [Weick et al., 2005]. The case of NavalSim corroborates this observation, as sensemaking and technological framing enabled business developers, executives, and customers to find common ground in informally evaluating neoteric ideas, translating and transforming them to fit the development of software. The case also demonstrates that the customer interaction at NavalSim was a driver in generating such ideas.

Adoption, Rejection, and Multiplication through Sensemaking

Both research and practice are dominated by a view of evaluation as a process that is separate from creativity [Blohm and Riedl, 2011; Elam and Mead, 1990; Elfvengren, Kortelainen, and Tuominen, 2009; Girotra, Terwiesch, and Ulrich, 2010; Osborn, 1953; Osterwalder and Pigneur, 2010; Sawyer, 2003]. However, as Sawyer [2003] points out, conscious and preconscious evaluation may work in parallel with creative performance and is isomorphic to social processes when adopted by creative people. Similar to Sawyer [2003], we challenge this dominant perspective on idea evaluation from a sensemaking perspective. Sensemaking helps human actors understand their surroundings by drawing on frames, which are shaped by past ideas having become institutionalized and that are part of experiences, knowledge, professional norms, and training. By doing so, we challenge the dominant view of seeing idea evaluation as being separate from the creative process. Instead, we demonstrate that evaluation is flexible and fosters creativity when it is informal. Moreover, we argue that informal evaluation of neoteric ideas based on existing frames determines whether those ideas are rejected, adopted, or stimulate creative action (multiplication) in the face of conflict. During this process, we argue that sensemaking in informal evaluation plays an important role in institutionalization and continuous development of ideas.

In summary, our framework describes three scenarios: When human actors use sensemaking to bracket neoteric ideas within existing frames of institutionalized experiences, knowledge, professional norms, and training, those ideas and technologies reach a temporary equilibrium state through adoption, are rejected, or are multiplied into new ideas. However, this is a complex and dynamic process of interaction, communication, and negotiation involving different human actors, eventually leading to adoption or rejection. When the different human actors cannot bracket novel ideas within existing frames, ideas risk being rejected before they are institutionalized. For example, the ideas behind tablet computers in Karlstown municipality acted as a catalyst for creative thinking when users required additional information to make sense of them. The IT department responded to user demands by embedding those ideas in a meeting and project portal. Hence, the sensemaking process associated with using the tablet computers resulted in multiplication, leading to new requirements, novel ideas, and institutionalization of those ideas within the organization.

Multiplication may occur when human actors experience conflict between adoption and rejection of an idea. Such conflict may come from lack of information about the idea. At NavalSim, ideas were translated and transformed through conflicts between groups during software development. Business and software developers brought neoteric ideas to the table, which developers and managers would then discuss, modify, be inspired by, and later include in new software products. Many ideas were rejected. A few were directly implemented while others went through several iterations of multiplication before managers and developers were able to make sense of them. Thus, when multiplication occurs, human actors attempt to negotiate or renegotiate an idea until they are able to bracket it within known frames. This process creates neoteric ideas supporting the original idea by further developing it, which makes it meaningful to the human actors. Such a process may lead to two outcomes. First, the iterative development process plays out over time, leading to institutionalization to the extent that human actors adopt or reject the idea or technology, thus removing sources of conflict. Regardless of an idea or technology's generative fit, the actors' generative capacity may be reduced during this process, i.e. their capacity to spawn novel configurations of the idea. The generative capacity is reduced through institutionalization along with the diminishing flux—and hence the potential source of conflict—that the idea represents. This may happen when existing ideas and emerging technologies are transformed into new technology structures through continuous design, development, adoption, and mediation. Hence, ideas stay "black boxed" until human actors enact them once again due to new input [Orlikowski, 2000]. Metaphorically speaking, if the generative capacity is a car and the flux imposed by neoteric ideas is the fuel that powers the car, then the car will stay put when out of gas until refueled by the driver. For example, the sensemaking process may be restarted when an idea is transferred to a new department within the same organization or to a new organization. After having been "black boxed" for years, the failed PDA project reemerged in Karlstown municipality. Technological frames from the PDA project enabled human actors within the IT department to make sense of a neoteric mobile idea (the tablet computers) and guided them in deciding what to do and what not to do. Second, multiplication results in something completely new as human actors generate, consolidate, and integrate neoteric ideas into emerging technologies, replacing existing patterns of thought and creating new flux that refuels the sensemaking process. For example, NavalSim often implemented open-ended ideas, as these ideas increased the likelihood of creating technologies with novel properties. Karlstown municipality integrated ideas that were generated during the mobile technology experiment into a platform independent meeting and project portal. During this process, Karlstown municipality developed new ideas thereby creating new flux that fuelled the sensemaking and multiplication process. In both cases, idea multiplication and technological innovation were iterative processes of informal evaluation, sensemaking, creativity, adoption, and institutionalization.

Distinguishing between generative fit, generative capacity, and multiplication is important. An idea's generative fit is its ability to provoke new ways of thinking and challenge existing equilibriums, enabling the generative capacity of human actors to spawn novel configurations [Avital and Te'eni, 2009]. Multiplication thus connects generative fit and generative capacity, which is just as important for creativity as the available resources in the organization. Multiplication for its part sheds new light on negotiations between human actors as an integral part of sensemaking processes.

Correspondingly, multiplication helps mangers in various ways:

- Multiplication provides an in-depth understanding of how organizations prepare themselves for receiving neoteric ideas by experimenting with, for example, technologies without any predefined value.
- Multiplication facilitates knowledge sharing among human actors. This article provides an understanding of how to use such knowledge to channel conflicts between human actors into organizational creativity.
- Multiplication may help practitioners in their innovation management planning by suggesting that ideas are part and parcel of innovative product and service technologies. Hence, experimenting with technologies embedded with neoteric ideas may facilitate creative thinking and multiplication of those ideas.
- In encouraging innovation, managers have to locate a sweet spot between rejection and adoption that stimulates creative thinking and technological development. This means that managers should view resistance to neoteric ideas as a source of inspiration rather than an implementation obstacle that needs to be overcome. Resistance helps managers identify ideas and opportunities for adoption and technologies for further development.

Future Research Directions

In this article, we discuss the concepts of informal evaluation and multiplication. We present an integrated framework of the interplay between neoteric ideas and organizational institutionalization. Though we do not claim it to be a parsimonious theory, we believe the multiplication concept to be an advance in our understanding of the isomorphic relationships between creativity and creative products, i.e. innovative technologies. Our framework may advance research into the traveling of ideas by consolidating various attributes of organizational creativity into one multiplier. Multiplication sheds light on the dynamics of creativity and institutionalization in organizations ([Ulrich and Mengiste, 2014] and helps researchers better understand the role of informal evaluation in creativity and innovation. Knowledge of idea multiplication may help researchers create models for resource allocation to creative activities [Seidel, Müller-Wienbergen, and Rosemann, 2010] or promote future studies of creativity and technology development practices [Aaen and Jensen, 2014; Aaen, 2008]. Furthermore, understanding multiplication in creativity and innovation helps researchers address the negative aspects of formal idea evaluation, e.g. prematurely eliminating ideas (Girotra et al. 2010) and subverting task motivation [Amabile, 1996, 1998]. Such research is easily extended to Group Creativity Support Systems [Di Gangi and Wasko, 2009; Müller-Wienbergen et al., 2011] or other information systems, for example idea rating systems in creative communities that continually evaluate novel ideas and other creative products [Blohm and Riedl, 2011].

We encourage future research to further empirically validate our claims. Such research may include in-depth case studies of high-tech organizations [Walsham, 1993, 1995, 1997, 2006] or additional experiments with idea generation using creativity support systems [DeRosa, Smith, and Hantula, 2007; Elam and Mead, 1990; Massetti, 1996]. Moreover, the presented framework is an interpretation of organizational creativity that adds the time aspect and the traveling of ideas to similar management perspectives on organizational creativity [e.g. Amabile, 1983]. Hence, we suggest developing creativity assessment tools [Amabile, Conti, Coon, Lazenby, and Herron, 1996] providing quantitative data for measuring idea and technology multiplication. Such tools may be combined with other assessment tools such as Amabile's [1989] creative environment scale or modified versions of the technology acceptance model [Venkatesh and Davis, 2000]. Such tools may help researchers and practitioners measure the potential for multiplication in specific ideas and technologies by assessing their generative fit and generative capacity [Avital and Te'eni, 2009], available resources [Seidel et al., 2010], and conflicts between stakeholders [Brody, 2003; Robey, Smith, and Vijayasarathy, 1993].

In addition to the proposed suggestions for future research, our own research in progress includes an application of the presented framework. This research has three aims. First, the research includes an in-depth systems theory analysis [Dhillon and Ward, 2002; Gurpreet Dhillon and Fabian, 2005; McBride, 2005] of evaluation frameworks supporting formal and informal idea evaluation. The purpose is to elaborate in detail on the inner workings of multiplication during informal evaluation, explaining why formal evaluation is unable to support multiplication. Second, we have conducted a prototypical laboratory experiment [Malaga, 2000] of formal and informal idea evaluation to test whether they motivate creative thinking. Third, a field experiment [Bryman, 2004] has been conducted using a creativity support systems prototype. This research provides practice-based evidence in support of the framework presented in this article. The contribution is synthesized in a design theory [Gregor and Jones, 2007] for Group Creativity Support Systems. The research in progress is currently being reviewed for journal publications.

VI. CONCLUDING REMARKS

This article demonstrates the importance of sensemaking of ideas during informal evaluation in organizations. We have highlighted the pervasive influence of sensemaking in the iterative process of framing novel ideas and institutionalizing them in practices and emerging technologies in organizations. Grounded in state-of-the-art IS-based creativity research and Scandinavian institutionalism, we have established a theoretical framework that promotes an understanding of the isomorphic relationship between creativity and informal evaluation in organizations. The framework suggests that neoteric ideas face adoption, rejection, or multiplication, and eventually reach an equilibrium state through institutionalization when human actors engage in sensemaking. This framework helps address important issues in IS and organizational research, including Group Creativity Support Systems, idea evaluation, and resource allocation.

Our research asks a very fundamental question about the nature of creativity and ideas by exploring the implications of sensemaking and technological frames. Hence, our framework raises new questions for future research to address. For example, is future technology development conditioned by the multiplication of neoteric ideas as human actors interact with and make sense of them when those ideas travel between organizations? Our theoretical framework provides an opportunity for future institutional research to explore this and other questions. For IS researchers, this study paves the way for creating new models of creativity and technology development. Researchers may establish new assessment tools for organizational creativity and technology development practices based on the concept of multiplication. Furthermore, our framework indirectly opens for new questions and research opportunities regarding evaluation of ideas and emerging technologies. For example, massive multiplication of ideas may influence the negotiated order of organizations, hindering the diffusion of useful technologies. Overall, this study addresses an important issue in IS and organizational research that is ripe for further exploration.

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Appendix C. Chaos and Creativity in Information System Artifacts

Information Technology & People, In review

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Abstract

Excellent ideas for innovative information technology (IT) products and services are crucial in modern organizations and markets. However, creativity requires information systems (IS) artifacts that supports its chaotic and sensitive nature in the structured environment within an organization. Chaos theory is about the behavior of dynamic and aperiodic systems and is key to understand the complex system behavior of creativity. In this article, we argue that chaos theory can break down creative information system artifacts into smaller components, hence, exposing their system behavior. Through this unit of analysis, we gain new insights into creative information systems artifacts, how new artifact components can be theorized, and ultimately, how artifacts can be improved. To demonstrate chaos theory in-use, we compare and contrast two opposing idea evaluation artifacts. Static idea evaluation focuses on convergent thinking to eliminate poor ideas. Dynamic idea evaluation seek out new knowledge to connect ideas and motivate divergent thinking. The analysis shows how static idea evaluation leads to preferences for less original ideas and actually discourages creative participants; it also shows how dynamic idea evaluation can counter these negative consequences. These findings have implications for idea evaluation management, designing creativity-support systems, and theorizing creative information systems artifacts.

Keywords: *Creativity, chaos theory, information system artifacts, idea evaluation.*

I. INTRODUCTION

Companies must continuously innovate to stay competitive in an increasingly hyper-competitive environment with rapidly changes markets and short-lived advantages (d'Aveni, 1995; Pearlson and Saunders, 2007). Many companies, e.g., Dell and Cisco, have therefore initiated creative programs to collect ideas to generate new products and services (Di Gangi and Wasko, 2009; Jouret, 2009). In the seminal work by Govindarajan and Trimble, (2010), they describe novel ideas as the stepping stones for innovation. Novel and useful ideas can create competitive advantages and increase sophistication of information systems (IS) and management processes (Couger, 1996), and more specifically they can shape better requirements for IS (Maiden and Gizikis, 2001; Maiden et al., 2004).

Creativity is known to entail unforeseen outcomes (Stacey, 1996). Chaos theory is hence particularly relevant to a qualitative study of such phenomena as creativity that have similar characteristics to non-linear, complex systems which seems to be unpredictable in their nature. Utilizing chaos theory is not new in IS research (Dhillon and Fabian, 2005; Dhillon and Ward, 2002; McBride, 2005) which we will use in this study, in addition to materials about how chaos theory has also been applied in creativity research (e.g., Hung and Tu, 2011; Richards, 2001; Schuldberg, 1999; Wilding, 1998).

The aim of this article is to use chaos theory as a theoretical lens to understand complex creative artifacts in an information system context. We propose that chaos theory is effective to understand these complex technological and organizational artifacts through the theory's capability to map the behavior of dynamic and aperiodic systems. We suggest that by breaking down creative IS artifacts into smaller components we can obtain a deeper understanding of their inner workings and how these contribute to understanding the system behavior as a whole. Hence, the research question addressed in this article is: *How do can chaos theory be used to understand creative information system artifacts?*

Answering this research question takes a particular class of creative information system artifacts, namely IS addressing idea evaluation. Existing research on IS driven idea evaluation addresses issues such as an ideas' novelty, relevance to a particular problem or workability, to name a few (e.g., Dean et al., 2006), as well as how to further enhance the creation of new and better ideas (Couger, 1996). A recent literature review on creativity within IS research (Müller and Ulrich, 2013) shows that the existing research literature on IS idea evaluation is limited (five articles in the last 15 years), and what has been researched so far is largely focused on improving creative processes, competences, and environments. This marked paucity of IS research into idea evaluation is what we seek to address with this article. Idea evaluation IS, irrespective of whether they are dominated by a technical component, by social arrangements, by group-based creativity-support systems (e.g., Klein & Dologite, 2000), or by idea portals (e.g., Di Gangi and Wasko, 2009) come with two opposing sets of features that we will refer to as static and dynamic idea evaluation. We use chaos theory to compare and contrast these two opposing feature sets to shed more light on some important differences between them.

The arguments put forward in this article are theoretical, because theoretical arguments can move beyond our assumed thinking by presenting new explanations that could be fruitful (Rowe, 2012). IS research is dominated by empirical research, and theoretical arguments demonstrating the implications of a theory are more rare though exceptions exist (Munir and Jones, 2004; Sambamurthy et al., 2003). Along similar lines, we maintain that a theoretical analysis of creative IS artifacts is beneficial and can later lead to empirical research and validation.

In section 2, chaos theory and its application to creative systems is presented. Section 3 provides a theoretical background for static idea evaluation and its alternative, dynamic idea evaluation. In section 4, we compare and contrasts static and dynamic idea evaluation based on chaos theory. In section 5, we use the analysis results to the implications for how to understand creative information system artifacts. In section 6, we conclude the article.

II. CHAOS THEORY AS A FOUNDATION FOR UNDERSTANDING CREATIVE ARTIFACTS

In Stacey's (1996) work on creative thinking and chaos theory, creativity is described as a messy and complex non-linear process that involves unforeseen outcomes. Creative thinking can be divided between divergent thinking, which can be wild and unpredictable, and convergent thinking, which can be narrow and focused (Guilford, 1967, 1977). Chaos theory may help us understand how divergent thinking can create unexpected results from dynamic interactions between collected knowledge and creative actors (Richards, 2001; You, 1993). Moreover, as chaos theory can explain the highly complex and dynamic nature of creativity in organizations (Stacey, 1996), it has the potential to discover and interpret patterns of interaction in such dynamic environments (McBride, 2005).

Since its mainstream introduction in the late 1980s, chaos theory has been proven to be a versatile beyond its original scientific starting-point in physics and mathematics (Gleick, 1987; Lorenz, 1963). Several scientists have drawn inspiration from chaos theory into areas such as organizational theory, psychology, and IS. Organizational scientists, including Levy, (1994), used chaos theory to construct managerial implications for decision making between the complex interactions among industry actors. Chaos theory has also found its way into interpretive IS research (Dhillon and

Fabian, 2005; Dhillon and Ward, 2002; McBride, 2005). For example, Guo et al., (2009) used chaos theory to interpret behavior dynamics in blogging platforms.

Chaos theory is about *"the qualitative study of unstable aperiodic behavior in deterministic nonlinear dynamical systems"* (Kellert, 1994, p. 2). However, to understand what chaos theory is, we first need to understand what a chaotic system is. A *linear* system is *deterministic* and *periodic.* Chaos theory is about *deterministic*, but *aperiodic,* and *dynamical* systems, where there is no predictability as the outcome is dependent on the previous state of the system. This is not complete randomness without any rules. Instead, a chaotic system is *nonlinear*, as these rules do not repeat. It is hence necessary to identify the rules for each step in the sequence to identify the next outcome. For example, when we know that "adding five" is the rule when we see the number three, we can predict the next number in that sequence will be eight. Hence, applying the changing rules for each step of the sequence continually is necessary to understand the complex nature of the system.

Several researchers have used chaos theory as the foundation for exploring creativity. Psychologists including Schuldberg, (1999) and Richards, (2001) deployed chaos theory to develop an understanding of the unpredictable behavior of creative thinking, while Stacey, (1996) did a similar study about creativity in the organizational context. Creativity is very similar to a chaotic system, as the outcome (ideas) is novel and unpredictable (Stacey, 1996) and hence aperiodic, nonlinear, and dynamic. Creativity is moreover governed by solving problems (Couger, 1996) and is deterministic in nature by being comprised in *"stages of generativity and consolidation, incubation, and elaboration"* (Schuldberg 1999, p. 186). Hence, ideas do not emerge out of thin air. Instead, ideas are products of human action that combine, construct, and elaborate upon existing human knowledge. This view is further elucidated upon by Couger, (1996, p. 8), who argues that the "eureka moment" has no substance as ideas are products of *"careful, methodological generation of alternatives".* Continuous creativity is governed by temporal changes that evolve over time through changes in the participants experiences and their adaptation to new emerging trends and movements (Schuldberg, 1999). Creativity is neither completely random, nor static or linear. Creativity is instead deterministic by building on the past but is simultaneously unstable, aperiodic, nonlinear, and dynamic in behavior and perceived outcomes.

Table 1 identifies five important key concepts about chaos theory, which we shall use to elaborate the connection between enhancing creativity and evaluating ideas. Each concept and their connection to creativity are elaborated on in detail in the following sub-sections.

Table 1. Key Concept in Chaos Theory in Organizational Research		
Key Concept	Description	Sources
Feedback	*Negative* feedback keeps the system in an equilibrium loop by countering initial changes, while *positive* feedback reinforces changes made in any of the variables.	(Dhillon and Fabian, 2005; Dhillon and Ward, 2002; McBride, 2005).
Sensitivity	Dynamic systems are *sensitive* to their *initial conditions* in the *domain of interaction*, influenced by *events and choices* from actors.	(Dhillon and Ward, 2002; McBride, 2005; Wilding, 1998).
Attractors	*Predictable* attractors permit the system to reach an equilibrium state. *Periodic* attractors enable the system to reach a periodical equilibrium state. *Strange* attractors are driven by *bifurcation*, which is a result of erratic and unbalanced positive and negative feedback on the initial changes of the system. Such erratic behavior drives the system towards an irreversible situation of chaos.	(Dhillon and Ward, 2002; Hung and Tu, 2011; McBride, 2005; Richards, 2001; Schuldberg, 1999; You, 1993).
Edge of chaos	The *edge of chaos* is where systems may shift to a new qualitative state caused by its shift towards new strange attractors.	(McBride, 2005; Stacey, 1996).
Iteration	*Iterations* of interactions between events and choices amplify even insignificant initial conditions, moving them towards the edge of chaos.	(McBride, 2005; Richards, 2001).

Feedback

Feedback provides new information to a system. This feedback can be either negative or positive. Negative feedback will provide corrective information that counter internal changes and keeps the system within equilibrium while positive feedback will provide contextual information that reinforces internal changes and potentially breaks the equilibrium (Dhillon and Ward, 2002; McBride, 2005).

Dhillon and Ward, (2002) examined the implications of chaos theory in IS research. Their research demonstrates that non-linear systems in general are determined according to their equilibrium state. From their perspective, systems are expected to enter an equilibrium state at a given time. This is similar to by Orlikowski's, (2000) study of technological change, which demonstrates how technologies enter a temporary equilibrium state or a *"black boxed state-for-now"* (p. 441) until they receive new organizational input through changes in practice, for instance when people tinker and rebuild the technology. From Dhillon and Ward's, (2002) viewpoint, an understanding of stability, instability, and rapid change in IS can be achieved by identifying the hidden order in the apparent chaos through the equilibrium of these IS. As a result, a non-linear system can be divided into three types of states (Dhillon and Fabian, 2005; Dhillon and Ward, 2002): First, by being *stabilized* when it receives *negative feedback* (stabilizing mechanisms), second, by undergoing *explosive instability* when it receives a vast amount of *positive feedback* (destabilizing mechanisms), and finally by entering in a *chaotic state* when it receives simultaneous and unbalanced negative and positive feedback.

An example on how negative feedback can keep a system stable is in lean manufacturing (c.f., Shah Ward, 2003). In lean manufacturing, a system can be kept in equilibrium and a stable state when all discrepancies are accounted for by creating negative feedback through continuous corrective actions. However, if corrective actions are delayed the system will begin to fluctuate (Dhillon and Ward, 2002). For example, if parts of the lean manufacturing breaks down or sudden changes happen, like product malfunction (positive feedback), managers must take additional corrective actions (more negative feedback) to ensure stability and reestablish the system's equilibrium. If actors take no corrective actions, the current manufacturing system will break down, resulting in explosive instability with an undesirable and unknown outcome.

Sensitivity

Sensitivity to the *initial conditions* is a key element for understanding any non-linear system, as it defines how systems move from one equilibrium point to another over time (Dhillon and Ward, 2002). Sensitivity happens within the *domain of interaction*, which is the defined and bounded space where entities exist and interact (McBride, 2005). These entities can be both social and technical, and are influenced by the initial conditions of the system and the level of sensitivity to the original conditions. When changes happen within the domain of interaction, the changes are a result of small deviations - amplified by positive feedback to the initial conditions which causes an enlargement of the deviation (Dhillon and Ward, 2002; McBride, 2005). Such deviation amplifications will keep increasing until the creation of a new system happens, which is different from the original system (Wilding, 1998). For example, traffic flow is extremely sensitive to changes. When a driver tries to avoid a cat running across the freeway (a sudden change), he may deviate from his path towards oncoming traffic. The cat changes the initial conditions (the path, setting, and rules) of the freeway system by breaking the equilibrium of cars driving on a predetermined path. Hence, the driver's action towards a new path may lead to a major accident with multiple cars until one or more drivers take evasive actions and change the trajectory of the incoming cars.

Attractors

When a system receives simultaneous and unbalanced negative and positive feedback, the system can reach a *chaotic state*. Figure 1 demonstrates a potentially chaotic situation. In this situation, unbalanced negative and positive feedback enables the dynamic system to reach three types of outcomes. Two of the attractors are predictable and one is chaotic (Dhillon and Ward, 2002): First, a *predictable attractor* can influence systems to act in a foreseeable way, where an equilibrium state is maintained (e.g., lean manufacturing). Second, a *periodic attractor* can influence systems to act in a predictable way, where they periodically reach an equilibrium state (e.g., technologies that shift between being black boxed and active). The first two attractors are also known as *point attractors*.

Point attractors: Constraints, cooperation, and dominant schemas can take the form of point attractors, which stabilize the system and decrease the creative output (Stacey, 1996). *Constraints* can take the form of amplified negative feedback stopping or decreasing the evolution in the system due to minor changes. For example, constraints can be the development budget, hardware and software issues and fear of risk taking (Couger, 1996; Rose, 2011). *Cooperation* can encourage instability and have a positive effect on creativity (Cooper, 2000; Thatcher and Brown, 2010), but can also stabilize systems by enabling adaptation to new situations through continuous learning (Stacey, 1996). Moreover, cooperation enables actors to survive in a dynamic environment through mutual dependence, which removes tensions and introduces stability (Stacey, 1996). *Dominant schemas* can shield against creative tensions by creating efficient processes and unquestioned assumptions, which discourages learning within the organization. Such dominant schemas encourage skilled incompetence and shield maladaptive evaluation practices (Stacey, 1996). As a result, when predictable and periodic attractors enable stability within a dynamic creative system, they then decrease the creative output of the system. Cooper's, (2000) case study about creativity in requirement and design processes in a large investment company is a perfect example of constraints at work, as lack of technology training, a conservative recruitment and innovation culture, lack of communication and clear goals, and missing incentives for risk-taking stifled any attempts to develop a creative environment.

Strange attractors: Finally, if changes not countered by negative feedback, the systems can act erratically which causes the system to *bifurcate.* Bifurcation is a punctuation or sudden shift in the qualitative behavior of a dynamic system that causes the system to change behavior or split (Hung and Tu, 2011; McBride, 2005; Schuldberg, 1999). Moreover, bifurcation creates and feeds *strange attractors*, which are multiple chaotic pointers towards new and unknown outcomes outside the initial system where they originated (Schuldberg, 1999). Bifurcation may involve large fluctuations within the system as a result (McBride, 2005; Schuldberg, 1999) by driving dynamic systems into an irreversible situation of chaos caused by unequal interactions between positive and negative feedback loops (Dhillon and Ward, 2002; McBride, 2005). The outcome of this interaction between positive and negative feedback loops creates a new order of apparent chaos (a new qualitative state). Hence, the strange attractors feed on bifurcation and drive systems out of their short-term stability towards multiple non-repeating trajectories, which can force systems to move from situation to situation without ever reaching any equilibrium state (Dhillon and Ward, 2002). In short, strange attractors represent stable, non-periodic behaviors or dynamics, which create non-repeating fractal patterns within a system. In similar situations, constraints can stifle creativity in idea evaluation by imposing fixed cognitive structures for the thought process.

In (Malhotra et al., 2001), a case study about creativity in virtual teams, human actors bifurcated the existing organizational equilibrium by implementing new information technologies and changing existing work practices. That resulted in the creation of a virtual team that had overwhelming success in their ability to create novel and useful ideas.

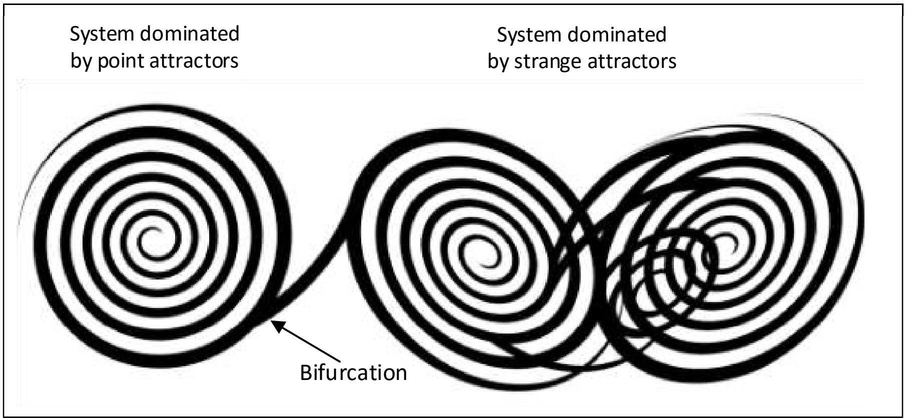

Figure 1. A Potentially Chaotic Situation

Edge of Chaos

As McBride, (2005) defines the *edge of chaos*, it is the breaking point when a system exits a current equilibrium and tumbles over the edge into a state of chaos. As such, the edge of chaos is the thin line between order and chaos. As the system bifurcates continuously it moves towards the strange attractors, which pull the changes towards new system trajectories. In this state a phase transition may happen, where global and temporal equilibriums may co-exist with chaos (Stacey, 1996). For example, an old idea may coexist with proposals for changing the idea until actions implement changes. When a system goes over the edge towards chaos, new strange attractors pull the trajectory of the system towards dramatic changes, which then causes a shift in the systems qualitative behavior (e.g., changes or new ideas dramatically alter the original idea). On the edge of chaos, a systems behavior, at this critical point, will move towards one of potentially many new strange attractors (McBride, 2005) such as new ideas or modifications to the original idea. These strange attractors enable a state of chaos which creates novelty in the form of a new stabilized system (Stacey, 1996). For example, a new fresh idea that emerges from identified fluctuations within existing creative systems.

Iteration

When changes occur within a dynamic system, events and choices by actors amplify the initial conditions of the system by providing positive feedback (McBride, 2005). As such, minor interactions can result in novel changes, which provide additional positive feedback for the amplification of the initial conditions. As a result, these periodic interactions continuously increase the changes made within the initial conditions of the dynamic system (Richards, 2001). The final result is bifurcation, which pushes the system over the edge of chaos using strange attractors (McBride, 2005). Ordinary linear systems are self-correcting by countering small changes with negative feedback (Dhillon and Fabian, 2005; Dhillon and Ward, 2002). However, creative and chaotic systems are hypersensitive and dynamic in nature, and even minor events will amplify small changes made to the initial conditions over an iterative cycle of time (Richards, 2001).

Figure 2 presents the overall theoretical framework. In summary, creative systems are initially extremely sensitive to their initial conditions. Hence, encouraging both positive and negative feedback in specific areas of a creative cycle is key when attempting to boost creative, divergent thinking. Negative feedback enables predictable and periodic attractors and convergent thinking, which is fed by constraints, cooperation, and dominate schemas. An overflow of negative feedback causes the system to reach a temporal or permanent equilibrium state by moving towards point attractors (c.f., the negative feedback loop in Figure 2). However, an overflow of positive feedback opens the idea to events, choices, and human actions which generates bifurcation and potential chaotic situations driven by strange attractors. As strange attractors pulls the creative system over the edge of chaos from the old qualitative state, each of the strange attractors has the potential to create novel creative subsystems in a new qualitative state (c.f., the arrows from strange attractors to the new qualitative state). As these aperiodic interactions are self-repeating, several iterations can happen over time. The new qualitative state can re-bifurcate, hence running from situation to situation by changing the initial conditions of the creative system or creating completely new subsystems (c.f., the arrows from bifurcation in the new qualitative state pointing over the edge of chaos). In short, decisions to iteratively transform an idea from identified knowledge may potentially create more novel idea or new and alternative ideas.

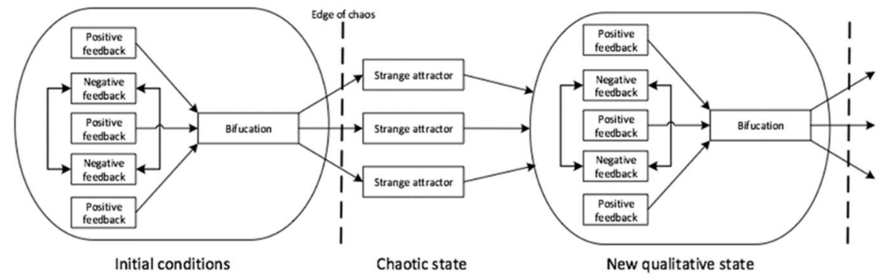

Figure 2. Summary of the Theoretical Framework

In the following sections 3 and 4, we map the state-of-the-art research about idea evaluation and deploy chaos theory to examine the differences in the internal components of two related organizational artifacts.

III. IDEA EVALUATION RESEARCH

In this section, we present the theoretical background for the two artifacts, respectively for idea evaluation (3.1), static idea evaluation (3.2), and dynamic idea evaluation (3.3).

Idea Evaluation

Idea evaluation is defined as a process where the aim is to engage human action by identifying quality parameters of the idea. Existing research into idea evaluation concerns the novelty, relevance, workability, and detail level of ideas (Dean et al., 2006; Lobert and Dologite, 1994); the quality of ideas (Reinig et al., 2007); success rate of products (Gomes et al., 2006); and the effects of evaluation on creative employees (Connolly et al., 1990). In more recent studies, researchers have focused on the design evaluation of new software products and services (Chan et al., 2011), and the use of collective intelligence from crowds (Blohm and Riedl, 2011; Leimeister et al., 2009; Sakamoto and Bao, 2011). In another and similar research areas, scholars have focused on measuring the creative work environment in organizations (Amabile et al., 1996) and evaluating the personal creativity of IS employees (Higgins, 1996). Only a limited amount of IS research has dealt with idea evaluation to enhance creativity (e.g., Couger, 1996).

Within the research literature, there is consensus that there are two types of idea evaluation (c.f., Couger, 1996). The traditional and static approach to idea evaluation is widely dominant within the literature and focuses on eliminating ideas using fixed parameters. The dynamic approach elaborates upon and improve ideas towards a state of novelty and usefulness and has a much less prominent place in the literature - so far. As the following review of the idea evaluation literature will demonstrate, the static approach has serious setbacks while the dynamic approach is underdeveloped.

Static Idea Evaluation

Traditionally, idea evaluation is based on ranking and prioritization of ideas (Chen, 1998; Elam and Mead, 1990; Sakamoto and Bao, 2011), which is perfectly reasonable when organizations have an abundance of ideas (Di Gangi and Wasko, 2009; Osterwalder and Pigneur, 2010). Hence, this traditional approach to idea evaluation generally serves to select the best ideas and typically contains the following steps: (1) actors create a vast pool of ideas; and the (2) they evaluate the ideas (Di Gangi and Wasko, 2009; Osterwalder and Pigneur, 2010). Evaluators (human actors) can be crowd sourced (Blohm et al., 2011; Riedl et al., 2010) or consist of expert judges (Amabile et al., 2005; Blohm and Riedl, 2011; Der Foo et al., 2005; Kennel et al., 2013; Lobert and Dologite, 1994; Reinig et al., 2007; Riedl et al., 2010). These evaluators will select ideas through ranking or rating mechanisms (Blohm and Riedl, 2011; Poetz and Schreier, 2012; Riedl et al., 2010) that determines originality, acceptability, implementability, applicability, effectiveness, completeness, explicitness, and clarity of ideas (Dean et al., 2006). When the evaluators have rated or ranked the ideas, they select the best ones from the initial pool by eliminating ideas with bad ratings (Osterwalder and Pigneur, 2010). Finally, evaluators identify connections between ideas in the remaining pool and construct portfolios of interconnected ideas that may be implementable into useful software solutions (Chen, 1998; Osterwalder and Pigneur, 2010; Sakamoto and Bao, 2011).

The main body of creativity research is built around Guilford's, (1967, 1977) notion of divergent thinking, where wild and unpredictable thought patterns create novel solutions. However, static idea evaluation is viewed to only support convergent thinking, where ideas ought to be narrowed down into a few tangible and correct solutions (Chen, 1998; Elam and Mead, 1990; Sakamoto and Bao, 2011). Hence, researchers have paid less attention to divergent thinking in idea evaluation. For example, Maccrimmon and Wagner (1994) stripped the evaluation module from the Group Creativity Support System (GCSS) they examined to focus on the system's ability to support idea development while other researchers argue that idea evaluation should only be conducted after all creative actions are concluded (Chen, 1998; MacCrimmon and Wagner, 1992).

Dynamic Idea Evaluation

In sharp contrast to the static approach, a few other scholars including Couger, (1996) and Isaksen and Treffinger, (1985) advocate for a dynamic alternative for idea evaluation that encourages creative thinking by including specialized creativity techniques in the idea evaluation process. In Iaksen and Treffinger's, (1985) research on creative problem solving, they argue for creating viable solutions through constructive criticism to modify and improve the ideas within the portfolio using both critical and creative thinking skills. Idea evaluators should create new solutions by identified weaknesses in existing ideas and exploit perceived strengths in the ideas they evaluate (Iaksen and Treffinger, 1985, p.117). Couger, (1996) builds on Iaksen and Treffinger's initial ideas by arguing for the use of creativity techniques in the evaluation process. Specifically, Couger argues for using a force field analysis technique that list the problems and benefits of the evaluated ideas, from this identified knowledge actors can use their creative thinking skills to modify and improve the evaluated ideas. Couger, (1996) further argues for progressively abstracting existing ideas within structures to systematically identifying other approaches that may solve a problem. In other words, Couger, (1996) argues for using knowledge obtained during evaluation to create new ideas that may support an overall solution. However, this branch of research is highly underdeveloped in comparison to its static counterpart.

IV. APPLYING CHAOS THEORY TO COMPARE AND CONTRAST TWO CREATIVE ARTIFACTS

This section explores the differences between static and dynamic idea evaluation exploring each concept in the theoretical foundation of chaos theory, cf. Table 2. On a basic level, static idea evaluation is built upon convergent thinking (Chen, 1998; Elam and Mead, 1990; Sakamoto and Bao, 2011) while dynamic evaluation draws upon divergent thinking. As such, where static idea evaluation decreases the amount of ideas into a few tangible solutions, dynamic idea evaluation potentially increases the amount of ideas and improves existing ideas from new knowledge identified throughout the evaluation process. Moreover, static idea evaluation is a periodic, linear deterministic system. Dynamic evaluation is however chaotic and yet deterministic. Its behavior is aperiodic, non-linear and unstable. Finally, where static idea evaluation combines the best existing ideas into a single portfolio, dynamic evaluation may create an entire portfolio from a single idea which may have initially been considered to be a poor idea. Table 2 summarize the detailed analysis that follows.

Feedback

Understanding feedback structures within dynamic non-linear systems is of great importance for idea evaluation in organizations. Feedback mechanisms provide information that stabilize or bring systems out of order, cf. section 2.1. Stability occurs when ideas receive negative feedback that counter changes and maintains the system within equilibrium. Explosive instability happens when positive feedback provides new input to the system. When ideas receive massive positive feedback that is not countered by negative feedback, they may bifurcate and will be pulled towards a state of chaos by strange attractors.

Table 2. Differences in Information System Properties of Static and Dynamic Idea Evaluation

Concept	Static idea evaluation	Dynamic idea evaluation
Feedback	Massive negative feedback restricts possibility for instability by imposing rigorous evaluation parameters that impede creative thinking.	Massive positive feedback creates new possibilities for instability that motivate actors to act divergently and create novel ideas.
Sensitivity	Ideas have little active sensitivity towards internal conditions due to corrective negative feedback loops that remove amplification from occurring divergent actions.	Ideas are highly sensitive towards internal conditions due to incoming positive feedback from actors and that amplify divergent actions.
Attractors	Motivation for evaluation parameters are constraints, cooperation issues, and dominates schemas, which create point attractors and convergent thinking, hence, keeping the system within equilibrium.	Motivation for evaluation parameters are constraints, cooperation issues, and dominant schemas, which creates bifurcation, motivate strange attractors, and encouraging divergent thinking. Hence, bringing the system out of its current equilibrium.
Edge of chaos	Ideas will never bifurcate and cross the edge of chaos due to corrective negative feedback loops. Actors simply eliminate ideas if they do not meet the rating criteria.	Ideas will potentially bifurcate repeatedly when human actors provide positive feedback. Hence, potentially creating strange attractors that pulls the idea over the edge of chaos towards new novelty.
Iteration	There is no iteration with ideas. If an idea is not the right answer to solve a problem, actors will eliminate the idea.	Actors can iteratively revisit, recreate, and re-evaluate ideas through repeated creative cycles. Hence, creating portfolios of ideas.

Static idea evaluation serves to narrow down the vast pool of generated ideas into a small selection of viable options (Osterwalder and Pigneur, 2010). Blohm and Riedl, (2011) argue for sorting out high quality ideas from less quality ideas using ranking mechanisms. Alternatively, static idea evaluation also can use these ranking mechanisms to capture user experiences within the ideas context (Riedl et al., 2010). The result is, however, the same; ideas that are implemented are those who achieve a high ranking while ideas that are lowly ranked are eliminated (Di Gangi and Wasko, 2009).

From a chaos theory perspective, the static idea evaluation artifact creates negative feedback when using ranking mechanisms to choose good ideas. This negative feedback is achieved by emphasizing convergent thinking which changes nothing in the fundamental structure of the ideas. Instead, convergent thinking eliminates 'bad' ideas and collects 'good' ideas as viable options (Osterwalder and Pigneur, 2010). The result is a negative feedback loop that keeps ideas within equilibrium through corrective actions; hence stabilizing the system.

Dynamic idea evaluation is a completely different approach compared to static evaluation. In short, dynamic idea evaluation uses evaluation parameters to provide contextual information for creativity techniques that motivates creativity. The starting point is often a single idea or a few ideas. Novelty, relevance, workability, and the detail level of ideas (Dean et al., 2006; Lobert and Dologite, 1994) can be maintained as quality parameters in idea evaluation. However, these quality parameters serves to collect contextual information about the evaluated idea. Instead of eliminating the poor ideas, we ask why they are not meeting the rating criteria. To answer that question, evaluators can deploy creativity techniques such as force field analysis and progressive abstracting (Couger, 1996). These techniques motivate convergent or divergent thinking by improving the existing ideas or by developing new ideas from the provided contextual information.

Through the lenses of chaos theory, the dynamic idea evaluation artifact changes the initial conditions of ideas using creativity techniques intended for divergent thinking. These techniques add positive feedback to the ideas. Positive feedback reinforces any actions caused by changes to the initial conditions. When these small changes accumulate over time, the result is explosive instability that makes any forecasting impossible (Stacey, 1996). For example, Couger, (1996) presents a creativity technique that progressively provides alternatives to an existing idea. By providing the information to correct existing ideas or create alternative ideas to solve a problem, such creativity techniques may progress positive feedback and instability in a dynamic idea evaluation artifact.

Sensitivity

Chaotic systems are sensitive towards even small changes in the initial conditions, which in the domain of interaction can lead to qualitative changes in the initial conditions of system, cf. section 2.2. Even small changes can create an entirely new subsystem if these changes are not countered by negative feedback that stabilizes the system.

A static idea evaluation artifact may contain little sensitivity from the perspective of chaos theory. It is built around rating mechanisms that collects data to identify the correct ideas for a given problem (Riedl et al., 2010). These rating mechanisms serve as events to formulate choices built on negative feedback that will keep the system within equilibrium, for example, by preventing positive feedback having impact on the sensitivity present within the evaluated ideas. Such events include removing small deviations from the collected knowledge within the domain of interaction by weeding out 'bad' ideas and stopping positive feedback from being amplified into creative actions. In essence, a dynamic idea evaluation artifact will have a strong focus on negative feedback loops that will remove incentives to creatively use the collected knowledge to arrive at alternative conclusions, for example, by asking why a bad idea is bad. Instead, supposedly 'bad' ideas are discarded and 'good' ideas are incrementally changed and implemented.

A dynamic idea evaluation artifact looks different from the viewpoint of chaos theory. This artifact is influenced by input into the evaluation process that creates sensitivity through the small changes to the initial conditions of an idea, for example, by locating when to further develop the idea or create alternative ideas. To explain sensitivity further, creativity is known to be hypersensitive to changes in the environment, which influences intrinsic motivation and the development of novel and useful ideas (Amabile, 1998). Stacey, (1996) defines this as sensitive dependence upon the initial conditions where positive feedback escalates tiny changes in the initial conditions. Such changes can be stakeholder feedback, technology changes, project timeline, and economic and organizational changes (Aaen, 2008). Changes cause events, which results in choices that require action. Therefore, in a dynamic idea evaluation artifact, actors could support divergent thinking by creating instability in specific areas of the evaluation process. In these areas, actors provide changes to the initial conditions of ideas they evaluate, for example, by identifying problems or benefits (e.g., Couger, 1996). Such information obtained through the evaluation process can trigger events that lead to new choices. Such choice can lead to divergent actions that bifurcates the evaluated idea when its initial conditions is changed through improvements or splintered through alternative ideas.

Attractors

Point attractors fuelling negative feedback can pull a system towards an equilibrium state while overwhelming positive feedback can create bifurcation within a system, which motivates strange attractors to pull the system towards a chaotic state, cf. section 2.3.

A static idea evaluation artifact works according to chaos theory by having point attractors that maintain the current order. As organizations are unique in structure, they can contain constraints or pitfalls that hinders creativity and innovation. Such pitfalls can be a limited development budget or a complex IT infrastructure (Iyer and Davenport, 2008). Moreover, cooperation issues with customers or stakeholders can control how ideas are generated and brought into life (Conboy and Morgan, 2011). Constraints, cooperation issues, and dominant schemas can provide negative and positive feedback through new qualitative information for an idea. When actors utilize a static idea evaluation artifact, it will maintain the current equilibrium, for example, by ending the creative process through elimination of unnecessary ideas and promotion of novel and useful ideas for a identified problem (Blohm and Riedl, 2011). In addition, Elam and Mead, (1990) argue that static idea evaluation only supports convergent thinking (which binds the idea to a specific path). Thus, they recommend starting idea evaluation after the creative process is complete and after all possible solutions are considered. Overall, Elam and Mead's, (1990) recommendation is a structural constraint for creativity in itself by only promoting the use of negative feedback and point attractors. Constraints such as eliminating ideas and removing divergent thinking do away with incentives for bifurcation. Instead, these constraints pull the ideas towards a specific point attractor that maintains their existing equilibrium.

A dynamic idea evaluation artifact can create new order from strange attractors when it is viewed through the lenses of chaos theory. As chaos encompasses novelty, creativity, innovation, and surprise (Stacey, 1996), most creative systems functions by creating bifurcation and by using strange attractors to discover new novel pathways (Richards, 2001). Discovering new pathways requires learning all possibilities of the object (the idea), which only can be obtained by evaluating it and amplifying the findings (You, 1993); *"The focus of evaluation, then, is on divergent thinking, or the ability to go beyond the predetermined objectives rather than on convergent thinking"* (p. 27). Hence, dynamic evaluation amplifies sensitivity from the initial findings in the evaluation process. The findings functions as positive feedback while the amplification creates bifurcation that brings the system out of its initial order. Finally, strange attractors feed on the bifurcation and pull the idea towards a chaotic and novel state. Strange attractors can, for example, be exploration of remote novel associations that draws a metal line to a specific problem (Mednick, 1962). By using analogies (Gomes et al., 2006) or metaphors (Malaga, 2000) created from knowledge in existing ideas or the evaluation process, such remote associations can help human actors to create a new and alternative solutions to the problem.

Edge of Chaos

The edge of chaos is the breaking point between stability and chaos, cf. section 2.4. In the context of idea evaluation and creativity, the edge of chaos is the breaking point between maintaining equilibrium and creating new novelty through divergent thinking.

A static idea evaluation artifact will in the lenses of chaos theory not support idea bifurcation. Bifurcation will not happen due to massive negative feedback and the use of point attractors that keep the system in equilibrium. This is achieved by eliminating ideas that does not fit current standards and receive low ratings (Riedl et al., 2010). As a result, static idea evaluation negatively impact divergent thinking by disregarding contextual information that actors could use to identify alternative pathways and possibilities. Hence, in a static idea evaluation artifact, ideas will newer cross the edge of chaos, which removes the potential to create new novelty from those ideas.

A dynamic idea evaluation artifact will, according to chaos theory, bifurcate ideas. Bifurcation happens when actors attempt to act upon events and choices. These events, choices, and actions are further fuelled by positive feedback from identified information that amplifies previous presumptions on the idea. If no corrective actions are taken, for example, by applying negative feedback that ignores the discrepancies, the idea will bifurcate and strange attractors could pull the idea over the edge of chaos. Such situations may create novelty in multiple directions dependent on the events, choices, and actions from the creative interaction between the actors. In other words, when actors identify new information using a dynamic idea evaluation artifact and they are encouraged to act divergently, they may attempt to solve those problems and exploit benefits through the creation of alternative ideas.

Iteration

Iteration is important to understand the internal dynamics between evaluation and enhancing creativity. Iterations serves to amplify interactions between events and choices, cf. section 2.5. Linear systems are self-correcting while chaotic systems are hypersensitive and dynamic, as small events will iteratively amplify small changes made to the initial conditions.

A static idea evaluation artifact is not iterative. In the eyes of chaos theory, it is linear and has a fixed outcome through its focus on selecting ideas. Hence, there is no interactions as static idea evaluation use convergent thinking to reject 'bad' ideas and keep 'good' ideas within a selected portfolio (e.g., Blohm and Riedl 2011). The outcome for not including iteration is that actors cannot add new information to their ideas. The results can be devastating. For example, the originality of even highly novel ideas can be underestimated (Licuanan et al., 2007), while fear of uncertainties can lead to eliminating even novel and useful ideas (Mueller et al., 2012).

A dynamic idea evaluation artifact is iterative. From the perspective of chaos theory, iterations can happen continuously throughout the dynamic evaluation cycle. As Richards (2001, p. 253) argues: "Clusters of ideas form self-similar clusters and clusters and further clusters." Hence, when a new idea is continuously evaluated through several cycles it has the potential to change its original form into something novel by clustering created ideas into a portfolio. Therefore, to enable creativity, dynamic idea evaluation is iterative as each cycle can identify additional novelty and discrepancies in the idea. Such information can lead to actors making changes to the evaluated idea, or provide inspiration for alternative idea development. These alternative ideas have the potential to increase the feasibility of the original idea and reduce uncertainty in the evaluation process. In essence, a dynamic idea evaluation artifact will encourage actors to revisit, recreate, and reevaluate ideas. Actors can make changes from the information provided in each evaluation cycle, which may amplify divergent changes made to the initial conditions of the original idea. Furthermore, when entering a state of chaos, the initial conditions can change over an iterative cycle of time as events, choices, and actions in the creative development further bifurcates the system and plunges it deeper into chaos (Stacey, 1996). As actors evaluate and create alternative ideas over time, the ideas become interconnected by sharing the same knowledge and properties from previous generations. As such, ideas will form clusters of self-similar ideas that are naturally combined into portfolios, hence reducing the need of convergent thinking in the idea evaluation process.

V. DISCUSSION

We have in the previous sections utilized chaos theory to analyze IS artifacts for idea evaluation. It is clear by now that there are two classes, namely the static and the dynamic; and these two classes display very different features. In this section we will discuss what the implications are for idea evaluation IS artifacts in particular and we will draw implications for creative IS artifacts.

We should first point out that chaos theory has been useful to explain the differences between static and dynamic idea evaluation. Table 2 summarizes five significant differences. That the differences are substantial has been explained in detail in section 4. These are differences that we were able to describe through chaos theory as the lens. Without chaos theory the explanation of the differences between static and dynamic idea evaluation would have been limited. It is important to see the five concepts from chaos theory (feedback, sensitivity, attractors, edge of chaos, and iteration) as generic features of creative IS artifacts and hence also of idea evaluation IS artifacts. As such they are features that will need to be designed – or to be more precise – they are features that a particular information system will need to be designed to meet, e.g., designing with the featured 'edge of chaos' in mind. Thus a static idea evaluation artifact will need requirements and specific properties to reduce bifurcation and to create a demarcation that retains the idea evaluation within the given boundaries; while a dynamic idea evaluation artifact will need requirements and specific properties for people to bifurcate and for the artifact to cross the edge of chaos.

The comparison between static and dynamic idea evaluation artifacts goes beyond that as we can also utilize the analysis in section 4 to be more precise on how the five features relate to existing research on creativity. It is worth noticing here that static idea evaluation artifacts are more limited (if that is what is called for), and that dynamic idea evaluation artifacts are unlimited and potentially also very creative leading to more novel ideas (if that is what is called for). Creativity is about creating surprise (Couger, 1996), newness, and uniqueness that others find utility and value in using. Moreover, creativity is a human endeavor that inherently is chaotic in nature by entailing a state of surprise and novelty in its outcome (Stacey, 1996). From these perspectives on creativity, static idea evaluation artifacts have several disadvantages: (1) by their inability to form surprises in the evaluation process, (2) not offering anything new or unique, and (3) by offering a linear process with a fixed outcome. The answers for these problems in current research are simple when viewed through the lens of chaos theory. Static idea evaluation artifacts focus solely on collecting the right ideas using convergent thinking. This fosters a strong focus negative feedback that is so massive that it overshadows positive feedback and sometimes even eliminates positive feedback. Chaos theory will find this to inhibit changes from happening, and they do this by eliminating all ideas not fitting into the current equilibrium. The presence of massive negative feedback also counters positive feedback that may emerge within the static idea evaluation artifact. From chaos thinking we can suggest that static idea evaluation artifacts will never bifurcate or support people in bifurcating, strange attractors will never be formed, and new novelty will not arise from existing ideas. Hence, the core of static idea evaluation artifacts is not to further creativity, nor is it built into existing creative processes. However, the purpose of the static idea evaluation artifacts also differs from its dynamic counterpart. Static idea evaluation artifacts are designed as efficient management tools that actors can use after all creative activities have ceased (c.f., Osterwalder and Pigneur, 2010). Hence, the strength of such efficiency also causes weaknesses.

Looking at dynamic idea evaluation artifacts in the light of the analysis in section 4 – from the viewpoint of creating more novel ideas – have more interesting prospects. There are three aspects of dynamic idea evaluation that seem particularly worthwhile when designing:

- **Positive feedback:** During the analysis, it became apparent that ideas might undergo transformation during dynamic idea evaluation. This transformation happens when ideas receives massive positive feedback which are not stopped or overshadowed by the introduction of negative feedback. This is crucial as negative feedback can easily ruin an otherwise good idea or an idea, which if elaborated, modified, other bits and pieces added, combined with other ideas turn out to be novel and useful. The concept of ‘massive positive feedback’ is however not an operational criterion in itself, neither is ‘massive negative feedback’, and in designing for innovative IS we should therefore strive to find operational ways of supporting positive feedback to keep the creative processes going and thus hopefully create more novel ideas. One way would be incorporating support for existing evaluation techniques that favors the positive rather than the negative, e.g., Couger, (1996); Couger et al., (1993), which may support the push for more positive feedback. Another way would be to support alternation and shift in users' attention away from the traditional negative feedback, e.g., simply by designing for reflection on what good can be said about a particular idea or which benefits it would entail.

- **Bifurcation:** Derived from the concept of 'bifurcation' that means splitting or transforming one system state into other system states, we can suggest that dynamic idea evaluation artifacts should support 'idea bifurcation'. Idea bifurcation should be understood as an idea moving from its original state to another state or as an idea splitting from its original state into multiple novel states. Idea bifurcation is related to existing research. Sternberg, (1999) explains that creativity arise when knowledge shifts domains; in chaos theory this would be bifurcation. More specifically, ideas can be transformed and improved using idea evaluation (Couger, 1996; Isaksen and Treffinger, 1985), and using chaos theory this would be bifurcating these ideas from their original state to another. In design studies and other creativity research, existing ideas have been extensively used to inspire new ideas (Kohn and Smith, 2011; Kohn et al., 2011; van der Lugt, 2000, 2002, 2005), and that line of research shows that idea bifurcation is more than just a theoretical construct, as ideas can form completely novel states. The concept of idea bifurcation explains in part what has previous been found in design and creativity research, but it also adds a new insight by including the chaotic design aspect of creativity. Ideas are themselves tangible knowledge objects open to receiving feedback that bifurcation can bring to them, bringing them out of stability, and moving them towards strange attractors across the edge of chaos towards novelty. To further plan for bifurcation we should operationalize how we will support it in the IS artifact. Ways of supporting bifurcation would be: suggest the splitting of ideas in the artifact, attaching ideas to strange attractors (see below), and reframing ideas as suggested in (Schön and Rein, 1994; Schön, 1983), etc. The design goal would be to support bifurcation, but the specific feature design would depend on the specific artifact.

- **Strange attractors:** Strange attractors feed on bifurcation, yet we may also see explicit artifacts that act as strange attractors. The use of metaphors and metaphorical thinking has been studied in design and creativity research, (e.g., Schön, 1983) and it has been studied in direct connection to IS (Blackwell, 2006; Lanzara, 1983; Madsen, 1994; Schön, 1993). The utility of a metaphor is to see something as something else, actually something completely different, and something that it definitely is not. Examples include perceiving a library systems as a warehouse (Madsen, 1994), the travel metaphor applied to navigating complex systems (Hammond and Allinson, 1988), or seeing the search of design spaces as an ant colony (Bilchev and Parmee, 1995). Designing for the inclusion of metaphors or metaphorical constructs in an IS artifact for idea evaluation seems almost straightforward. Chaos theory suggests that this in much more than a nifty feature it is a very necessary feature in order to support dynamic idea evaluation.

Through the lens of chaos theory, we can now say that dynamic idea evaluation may be divergent in nature and foster novel ideas by using the collected knowledge from the evaluation process to motivate divergent thinking and create interconnected idea portfolios. This offers a marked difference to much of the existing research that views idea evaluation artifacts in general as strictly convergent (e.g., Cropley, 2006; Elam and Mead, 1990; Osterwalder and Pigneur, 2010). However, dynamic idea evaluation is not new. Couger, (1996) and Couger et al., (1993) have explained earlier how actors can use creativity techniques as force field analysis and progressive abstraction to evaluate ideas and enable divergent thinking from the results. The issue is that dynamic idea evaluation is underdeveloped despite its ability to encourage more novel ideas. The contribution of this article is meant to shed light on these two conflicting views of idea evaluation artifacts. This comparison can spawn future research within designing idea evaluation artifacts. For example, design science researchers can apply the theoretical foundation presented here as a *kernel theory* (c.f., Abbasi and Chen, 2008; Markus et al., 2002) when creating new design artifacts (Iivari, 2007) for evaluation in GCSS (e.g., Malaga, 2000; Kletke et al., 2001).

VI. CONCLUSION

In this article, we demonstrated the potential of chaos theory to understand the inner workings of creative IS artifacts. We provided an in-depth explanation of chaos theory and creativity. Moreover, we investigated two oppositional idea evaluation artifacts using chaos theory. The basic premise was to present the characteristics of each artifact and their differences in context with the theoretical evidence on creative thinking. As the use of chaos theory showed, the dynamic alternative to static idea evaluation may have a higher capability to maintain divergent thinking within the evaluation process. Moreover, dynamic idea evaluation offers several advantages over the static approach when evaluating ideas. First, dynamic idea evaluation captures the complexity of the creative act in creating and evaluating ideas, which enables new ideas to emerge from the evaluation process. Second, this dynamic approach provides an iteration to the evaluation process, which enables actors to switch between obtaining new knowledge and utilizing it to encourage divergent thinking patterns. Third, dynamic idea evaluation could potentially eliminate the need for convergent thinking as continuous iteration could create portfolios of self-similar and interconnected ideas. In addition, we theorized that system feedback, idea bifurcation, and strange attractors are important components when encouraging divergent thinking in dynamic idea evaluation artifacts. Overall, the theoretical discussion demonstrates how chaos theory is a versatile addition to our existing knowledge about creative IS artifacts that practitioners and researchers should further explore.

VII. REFERENCES

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Appendix D. Encouraging Divergent Thinking from the Knowledge Generated during Idea Evaluation: A Design Experiment with Creativity Enhancing Systems

Communications of the Association for Information Systems (Accepted).

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Abstract

This paper reports on an experiment to explore the extent to which idea evaluation supports divergent thinking. Within the state-of-the-art literature on creativity and Creativity Enhancing Systems (CES) there are conflicting views on whether idea evaluation is only supportive of convergent thinking. Meanwhile, the question has not been explored experimentally. Using a web-based software prototype for idea evaluation in a controlled experiment, we demonstrate how knowledge from idea evaluation can encourage divergent thinking using CES. Our findings show that when idea evaluation does not encourage participants to act creatively, it is less effective compared to alternative approaches. However, when combing knowledge generated during idea evaluation with creative encouragement, the result is at least and sometimes more effective than standardized idea generation techniques, as it results in more elaborate ideas than all other approaches. Our findings show that designers of CES can use knowledge from idea evaluation to encourage divergent thinking and that we need to rethink the design of CES support for idea evaluation. Our findings challenge conventional wisdom and give impetus to new creativity research and future CES development.

I. INTRODUCTION

Technology supported creativity has been a part of the Decision Support Systems (DSS) sciences for almost three decades [58]. Software supporting creativity is commonly known as Individual Creativity Support Systems (ICSS) for individual use or Group Creativity Support Systems (GCSS) for group collaboration [66,67]. For the sake of simplicity, we treat both as Creativity Enhancing Systems (CES). Research has shown that CES stimulate and support creativity above and beyond that of verbal communication [24] and pen and paper creativity techniques [62]. Recently, CES for group collaboration have become part of large companies' portfolios of IT systems. Companies such as Best Buy (see http://forums.bestbuy.com/t5/Best-Buy-IdeaX/idb-p/IdeaX), 3M (see http://solutions.3m.com/wps/portal/3M/en_US/Submit/YourIdea), Dell (see http://www.ideastorm.com) and Starbucks (see http://mystarbucksidea.force.com) have successfully implemented CES in the form of external idea portals. Other companies are using similar systems internally for idea management, for example 'ThinkPlace' at IBM, 'Innovation Grapevine' at Accenture, 'Innovation E-space' at Whirlpool, and 'IdeaBoxes' at Ericsson. These and other companies are using such systems to harvest and take advantage of ideas from customers and employees, for example in terms of how to improve products and services.

CES are flexible tools helping people generate novel ideas [23]. In the CES literature, emphasis has been put on implementing creativity techniques such as brainstorming, e.g. [1,2,15,23,25,37,79,86]. Researchers have also investigated the influence of knowledge management on creativity [13,16,50,67] and the impact of virtual creative environments on development teams [45,80,87].

Ward [84] describes ideas as being knowledge products generated through human creativity. Idea evaluation serves to identify valuable ideas that are cost-effective, solve current problems, are implementable, and sometimes lead to innovation [22]. Human actors must identify strengths and weaknesses of ideas to arrive at quality solutions at the other end of the innovation funnel [20,22,41,51]. This is due to the fact that quality ideas are rare [3]. However, Information Systems (IS) researchers have paid little attention to understanding idea evaluation compared to understanding the creative environment, interpersonal and task-related skills, and strategies for training and improving productivity [66]. At the same time, research points to conflicting views on convergent thinking (associated with decision making) and divergent thinking (associated with idea generation) in idea evaluation. Some researchers argue for the use of divergent thinking during evaluation to facilitate idea generation [20,40] while others suggest that idea evaluation leans itself toward convergent thinking as it seeks to convert many ideas to few solutions [15]. According to the latter perspective, idea evaluation should be used only after any 'free-form' (divergent) activity as convergent thinking patterns may hinder further idea generation [26].

This study examines if knowledge from idea evaluation encourages divergent thinking. Previous IS studies have looked at convergent thinking in idea evaluation [10,17,73], but there is a lack of experimental research investigating the interplay between knowledge and encouraging divergent thinking in CES supported idea evaluation. To investigate the role of knowledge in encouraging creativity, we look at different types of creative encouragement. For our present purpose, we define creative encouragement as design elements in CES that support creative thinking. These design elements draw on various creativity techniques [19,20], for example image or textual stimuli [58].

This paper differs from previous studies on idea evaluation and CES in our focus on combining knowledge generated during idea evaluation with techniques and stimuli to encourage creative thinking. Judging from extant theory, consensus within CES research is that idea evaluation only encourages convergent thinking [15,26,27]. There is, however, also evidence to suggest that actors can generate novel ideas out of ideas created by others [46,52,53,54,68]. Moreover, previous creativity studies indicate that idea evaluation may encourage divergent thinking when creativity techniques are integrated into the evaluation process [19,20,40]. Through a quantitative study, we examine whether idea evaluation has a positive influence on divergent thinking by supplementing the evaluation process with creativity techniques. In this process, human actors may draw on knowledge generated during idea evaluation to identify new problems and solutions, leading to divergent ideas. Thus, the study addresses the following research question: “To what extent do Creativity Enhancing Systems support divergent thinking when incorporating knowledge generated during idea evaluation?”

This paper reports on a controlled experiment in which knowledge from idea evaluation and creativity techniques are used to encourage divergent thinking within a CES setting. First, we review the state-of-the-art literature and present two hypotheses. Next, we describe the experimental setting and our analytical approach. Finally, we report the results and discuss the implications of our findings for future research and practice.

II. THEORETICAL BACKGROUND

Divergent thinking is attributed to Guilford [33]. Divergent thinking encapsulates unconventional thought patterns [33,34] and results in diverse solutions to a given problem [38]. The opposite of divergent thinking is convergent thinking [33]. Convergent thinking reduces rather than broadens the solution space [38] and manifests itself as thought patterns that limit ideas to a few viable solutions. [33,34].

Moreover, creative thinking is intimately linked with knowledge [21,81]. Convergent thinking involves manipulation of exiting knowledge to identify the best solution, whereas divergent thinking draws on knowledge to produce multiple and alternative answers [21]. This theoretical background explores extant literature in terms of support for divergent thinking when reusing knowledge in CES supported idea evaluation.

Idea evaluation and convergent thinking in CES. Both convergent and divergent thinking are central themes in CES research, see e.g. [15,26,27,36,38,39,44,59,62,65,67,70,78,85]. However, in studies of creativity and decision support, idea evaluation is believed to support only convergent thinking [15,26,27]. Hence, researchers have proposed that evaluation should only be conducted toward the end of creative activities [15,26,71]. For example, Elam and Mead [26,27] suggest that idea evaluation is added to the creative process only after having concluded an idea collection phase, since the evaluation process may steer ideas in certain directions and prevent novel solutions from emerging. In another study by MacCrimmon and Wagner [55], the evaluation module of the system being investigated was stripped away to focus solely on idea generation. Grounded in the perspective that idea evaluation best supports convergent thinking, e.g. for the purpose of narrowing down ideas to viable alternatives [15,26,27,29], research has focused on idea evaluation techniques and methods that inhibit divergent thinking. Such techniques and methods include the development of quality standards and criteria for post hoc evaluation of ideas [11]. In their review of the evaluation literature, Dean et al. [22] argue that ideas should be measured on a multi-dimensional scale, including novelty, implementability, relevance, and level of detail. Several recent studies have adopted this perspective on evaluation and have developed evaluation schemes based on such parameters, for example in studies of crowds rating and selecting novel and useful ideas from large pools of user-generated ideas [10,48,75]. Other studies have focused on evaluating designs of new software products and services [14]. This practice of identifying the single most appropriate idea is rational when a company runs an innovation community with thousands of user-generated ideas (see [28]). For example, Blohm and Riedl [10] and Riedl et al. [74] propose evaluation schemes that help identify useful ideas in such innovation communities. However, the same practices may impede creativity in organizations for reasons explained below.

Ideas emerge from knowledge that encourages creative problem solving [34]. For example, Sternberg [81] explain that introducing new knowledge to established fields may spark creativity by replicating, redefining, incrementing, redirecting, reconstructing, or reigniting existing knowledge in new ways. Moreover, Gurteen [35] define ideas as goals, insights, concepts, visions, or applications of untested knowledge, while Nagasundaram and Dennis [68] and van der Lugt [52,53,54] suggest that human actors may create novel ideas when exposed to existing ideas. Hence, when eliminating ideas, human actors also eliminate the knowledge embedded in those ideas, which otherwise might have fostered more novel and useful ideas. In addition, Amabile [6,7,8] argue that task motivation is key to organizational creativity. When actors experience their ideas being discarded, it has a negative impact on their intrinsic motivation and willingness to engage in future creative activities. This negative effect has been illustrated in several management studies. In these studies, overcritical idea evaluation has been criticized for its negative impact on creativity by leading to risk aversion, human actors favoring unoriginal ideas, and employees being demoralized and disincentivized to contribute creatively [3,4,8,9,64]. These finding from the literature may affect the design of CES support for idea evaluation. As shown in the literature, motivation is key in supporting creativity. When CES contain knowledge from idea evaluation, but are not designed to encourage creative thinking, such systems may have a negative effect on divergent thinking, making CES less effective. Based on this exposition of extant literature, we propose the following hypothesis for CES to be tested:

Hypothesis 1. If knowledge generated during idea evaluation is not combined with creative encouragement in the use of Creativity Enhancing Systems, participants' divergent thinking abilities are negatively impacted.

Knowledge from idea evaluation and divergent thinking. A few researchers have suggested that idea evaluation may be helpful during creative activities [20,40,63]. Moeran and Christensen [63] recently conducted an ethnographic study of the creative industries. The research included case studies from creative companies such as Bang and Olufsen and Royal Copenhagen. Moeran and Christensen [63] conclude that in practice idea evaluation is central to creative cognition. In their view, idea evaluation happens as a formative process during a project rather than being a summative process at the end of a project. In a similar vein, Couger [20] argues that the 'eureka' moment is a myth, though creative people often experience such moments. Instead, novel ideas emerge from careful and methodological examination of a problem, resulting in alternative ideas that are developed over time [20]. Couger et al. [19] examined 20 creativity techniques suitable for IT organizations in a multiple case study and conclude that "techniques add value not only in 'kickstarting' a project or activity but also in providing breakthrough-thinking when an impasse occurs in the midst of a project" [19; p. 391]. Hence, according to Couger [19], creativity techniques are useful at all stages of the creative process and may extend beyond idea creation to being used as mediating tools during evaluation processes (see also [20]).

Creative processes also involve sensemaking that share the same characteristics as idea evaluation by drawing on the participants' previous experiences [11]. Another research study shows that better ideas are produced during brainstorming if participants engage in creativity and evaluation anonymously [17]. Moreover, ideas are often incremental improvements or combinations of existing ideas [71]. In a recent psychology study by Kohn et al. [46], the value of using creativity techniques when evaluating other people's ideas is emphasized. Their study used electronic brainstorming to allow participants to build on others' ideas by combining existing ideas into new ideas. Their results show groups and individuals combining existing ideas into fewer but more novel solutions. Work by Briggs and Reinig [11] corroborated Kohn et al.'s [46] study in their focus on generating fewer ideas of higher quality. Similarly, the goal of CES supported idea evaluation should not be to generate large quantities of ideas of varying quality. Instead, it should aim at developing and improving existing ideas simultaneously by, on the one hand, stimulating divergent thinking to foster idea novelty and create new knowledge pathways, and, on the other hand, by motivating convergent thinking to ensure idea quality. However, our study differs from Kohn et al. [46] in that we focus on using the knowledge created during creative processes and evaluation, whereas Kohn et al. [46] focused on existing ideas as sources of inspiration. As such, we use a single pre-evaluated idea to encourage divergent thinking in contrast to Kohn et al. [46] who used a multitude of different ideas that had not been evaluated in advance. Our approach provides new insights into the role of idea evaluation during creative processes. Currently, there is only scant evidence to suggest that knowledge from idea evaluation will be effective in promoting divergent thinking. This evidence is based on the previously mentioned ethnographic study done in the creative industries, which concludes that evaluation practices often happen during creative activities [63]. The evidence is therefore limited in the sense that there is no empirical studies demonstrating whether knowledge generated during idea evaluation will be effective in encouraging divergent thinking. This study fills this research gap by comparing and exemplifying the differences between three different approaches that use CES to support idea evaluation, creativity, or both. By designing CES to incorporate knowledge from idea evaluation to encourage divergent thinking, we provide new insights and contribute to the body of knowledge on creativity, idea evaluation, and CES. Consequently, we propose an analogous hypothesis for CES to be tested:

Hypothesis 2. If knowledge generated during idea evaluation is combined with creative encouragement in the use of Creativity Enhancing Systems, participants' divergent thinking abilities are positively impacted.

III. THE EXPERIMENT

To test the hypotheses, we conducted a controlled experiment using a pre-evaluated idea for a children's TV show. To ensure the reliability and validity of the experiment, we invited four independent researchers with decades of expertise in software experimentation and quantitative data analysis to evaluate the research approach and provide suggestions for improving the quality of the research design. Sections 3.1-3.6 describe the overall experimental design, the tasks and techniques, the software design, the research participants, and the procedures used in the experiment.

Experimental Design

For the experiment we used a 3 x 1 factorial design (see Table 1) with one independent variable—the type of setting (knowledge from idea evaluation *without* creative encouragement, knowledge from idea evaluation *with* creative encouragement, and creative encouragement *only*). The design contained five dependent variables, namely fluency, elaboration, flexibility, originality, and the total divergent thinking score (explained in section 4.1.1).

We divided the experiment into three test cases and tested the degree of divergent thinking in each case. We compared two of the test cases (knowledge from idea evaluation *without* creative encouragement and knowledge from idea evaluation *with* creative encouragement) with each other and with the control experiment (creative encouragement *only*).

Table 1. Experiential Design

Measurement: Divergent thinking	**Test case 1** Knowledge from idea evaluation *without* creative encouragement
	Test case 2 Knowledge from idea evaluation *with* creative encouragement
	Control Creative encouragement *only*

Creative Encouragement used in the Experiment to Encourage Divergent Thinking

To encourage creativity, a range of different techniques and stimuli is commonly used within CES [66,76]. These techniques are also known as creativity stimuli [58]. Brainstorming is the oldest [71] and by far the most popular technique used in CES research, e.g. [18,23,46,47,79,86]. However, only few studies have compared brainstorming with other creativity stimuli in CES environments, e.g. [37], and since the discovery of the brainstorming technique researchers have developed numerous other types of creativity stimuli. For example, http://www.mycoted.com, a Wiki site dedicated to creativity research, lists 192 different techniques that stimulate creative thinking.

Table 2 shows the techniques used in the experiment to encourage divergent thinking. As explained in the following, we limited our experiment to the use of words, images, and structure of knowledge to encourage divergent thinking. We used textual and image stimuli as they are commonly used in CES research and are amenable to multiple purposes. Moreover, to facilitate participants' divergent thinking, we structured and presented the knowledge embedded in the idea as well as the knowledge generated during idea evaluation (explained below). The following summarizes the techniques.

Table 2. Creative Encouragement used in the Experiment to Support Divergent Thinking

Creative encouragement	Description	Sources
Image stimuli	Image stimuli can encourage creative thinking by forming associations with problems and previous experiences.	[42,58,67,69]
Textual stimuli	Textual stimuli can encourage creative thinking, e.g. by providing words associated with problems or by "nudging" participants in an expected direction.	[38,42,55,58,62]
Structure of knowledge from ideas and idea evaluation	Structuring knowledge can encourage creative thinking when participants create associations between new knowledge and previous experiences.	[11,19,20,46,71]

Image stimuli is a creativity technique commonly used in CES [42,58,67,69]. Images function by forming associations with problems, drawing on the users knowledge and memory [58,67]. Textual stimuli is another creativity technique often used in CES research and commercial product development [38,42,55,58,62]. Textual stimuli provide words or sentences that encourage the user to act creatively, for example by providing words that users associate with problems [38,58]. The type of textual stimuli we used in the experiment is strongly associated with "nudging". As Thaler and Sunstein explain [82], textual or visual stimuli are among the cues that "nudge" participants in an expected direction by appealing to the participants individual psychology. As such, we gave participants keywords and written (creative) encouragement with a high degree of interpretive flexibility that would stimulate their creative thinking skills. It has been shown that image stimuli are more effective in encouraging creative thinking than textual stimuli [58]. However, a combination of images and words may foster new mental models in people [30], improving their creative thinking abilities [42]. Drawing on this existing research, we inserted keywords into the images that were used.

Structuring knowledge is an equally important technique in encouraging creativity [13,67]. As explained earlier, stimuli from other ideas are known to stimulate creative thinking when participants establish associations between ideas they encounter and ideas they have memories of [11,46,71]. Knowledge generated during idea evaluation can also be structured to encourage creative thinking. Couger [20] and Couger et al. [19] suggest that knowledge from idea evaluation be divided into positive (opportunities) or negative (problems) forces for an idea. Positive forces and negative forces can be used to create novel ideas that exploit opportunities or eliminate problems. In this experiment, this technique is used to structure knowledge from idea evaluation.

Experimental task

In the experiment, we provided the participants with different tasks and creative encouragement. As shown in Table 3, the three test cases used CES prototypes that we designed with different levels of creative encouragement. The prototype used in the first test case contains no creative encouragement. The prototype used in the second test case contains image and textual stimuli. Moreover, the knowledge embedded in the idea and generated during idea evaluation was structured in the second test case. Finally, the prototype used in the third, control test case contains only image and textual stimuli.

The first task was to view a pre-evaluated idea. The idea concerned a children's TV show from Denmark, which had not previously been aired in Northern America[13]. In the second task, participants were encouraged to comment on the show and create novel ideas for new TV shows aimed at children. We decided to focus on children's TV shows in the experimental tasks due to the wide appeal of this type of TV across different demographics. Also, the research participants did not require any prior knowledge to evaluate the idea or create new ideas.

The first test case took the form of idea evaluation without creative encouragement. As such, the participants received no textual or image stimuli and the presented knowledge was not structured to encourage divergent thinking. The participants were presented with a detailed description of the TV show along with six ready-made comments. Three of these comments were positive toward the show, while the other three comments were negative. The balance between positive and negative comments

[13] Verified by the TV network producing the show.

supports reliable rating. However, we shuffled the comments to reduce their influence as creative encouragement. Participants partaking in the idea evaluation without creative encouragement were only encouraged to write down their thoughts and comment to the idea. However, they were not encouraged to act creatively.

Table 3. Design of Creative Encouragement in the Experiment (see Section 3.4. and Appendix)

Creative Encouragement	Test case 1	Test case 2	Control
Image stimuli	We provided no image stimuli to participants.	We provided participants with images from other TV shows as image stimuli.	We provided participants with images from other TV shows as image stimuli.
Textual stimuli	We provided no textual stimuli to participants that would encourage their creative thinking.	We provided participants with textual stimuli. These stimuli included encouragement to act creatively and keywords embedded into the images that were presented to participants.	We provided participants with textual stimuli. These stimuli included encouragement to act creative and keywords embedded into the images that were presented to participants.
Structure of knowledge from ideas and idea evaluation	We structured knowledge from idea evaluation as random comments to reduce their influence as creative encouragement. Moreover, we presented knowledge associated with the idea without connecting it to other types of creative encouragement.	We structured knowledge from idea evaluation, separating problems (negatives) from benefits (positives) as creative encouragement. Moreover, we designed the prototype to display the knowledge associated with the presented idea together with image and textual stimuli.	We included no knowledge from idea evaluation. Moreover, we limited the knowledge associated with the presented idea to one sentence, suggesting that we were creating a TV show for kids about a teddy bear and a chicken.

The first task was to view a pre-evaluated idea. The idea concerned a children's TV show from Denmark, which had not previously been aired in Northern America[14]. In the second task, participants were encouraged to comment on the show and create novel ideas for new TV shows aimed at children. We decided to focus on children's

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The second test case concerned idea evaluation with creative encouragement. Like the first test case, it included the idea (TV show) and the same accompanying description. However, we structured the comments from the first test case as positive and negative forces. We also structured the positive and negative comments into problems (negatives) and benefits (positives). Moreover, we displayed the knowledge embedded in the title and description of the idea together with textual and image stimuli. Finally, participants partaking in the second test case were encouraged not only to comment on the idea but also to act creatively.

The third test case contained the control group subjected to extensive creative encouragement. Since we are measuring whether the knowledge from idea evaluation stimulates participants' divergent thinking, we constructed the control test to mimic standard idea generation processes. This enabled us to compare the effectiveness from the two evaluation tests with standard idea generation techniques known to support divergent thinking. Hence, the control test used creativity stimuli (textual and image). Moreover, we encouraged the participants to generate new ideas based on the same TV show presented during the other two test cases. However, we provided no details or previous idea evaluations.

Software used in Experiment

Because existing commercial software does not support divergent idea evaluation, we developed a web-based prototype in PHP and MySQL, which served as the base software for the experiments. We selected a web application to simulate the functionality of existing idea portals that support idea evaluation and creativity. Integration with a MySQL database served to store the ideas created by research participants and enabled easy integration with the SPSS™ software package. The software prototype displayed three different user interfaces depending on the test case. Figure 1 shows a screenshot of the software used for test case 2 in the experiment. This prototype uses knowledge from idea evaluation to encourage divergent thinking. Screenshots for test case 1 and 3 are shown in the Appendix.

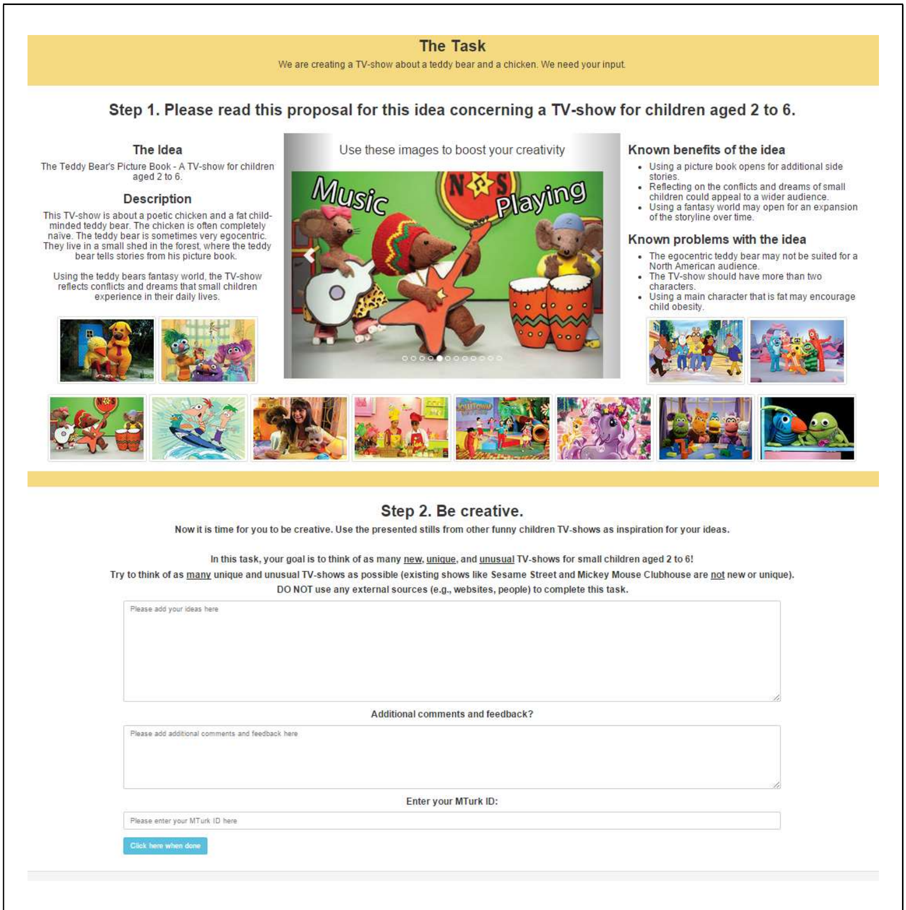

Figure 1. Screenshot from Prototype used in Test Case 2

Research Participants

We conducted the study using Amazon's Mechanical Turk. Mechanical Turk is a crowdsourcing platform offering "businesses and developers access to an on-demand, scalable workforce" (https://www.mturk.com) that can work on so-called human intelligence tasks [12,43,72]. Participants (called workers) are given micropayments for these tasks and are identified with unique IDs. Using services such as Mechanical Turk for research purposes can be criticized, because participants might be extrinsically motivated and might therefore not take the assignment seriously, thus influencing the quality of the experiment. However, Buhrmester et al. [12]

demonstrate that Mechanical Turk workers are not always motivated by payment, but are also intrinsically motivated to participate in studies like ours. In their study, Buhrmester et al. [12;3] conclude that "compensation rates do not affect data quality; and the data obtained are at least as reliable as those obtained via traditional methods". This is furthermore confirmed by Mason and Watts [61]. Moreover, Paolacci et al. [72] show that using Mechanical Turk reduces experimenter bias and results in substantial higher response rates and significantly lower response errors compared to online forums. Finally, the demographic diversity of Mechanical Turk workers is greater compared to other online samples and samples drawing on a student population, e.g. American college samples [12]. Meanwhile, the risk of self-selection bias cannot be ruled out, which is a methodological issue in this type of study.

We decided to include 100 participants in each test case of the experiment, which is substantial more than a previous experiment on creativity stimulus by Malaga [58]. In total 305 participants took part in the experiment—100 of these in the control group. All participants were from North America, as people from this part (region) of the world have not previously been exposed to the ideas being evaluated in the experiment. Except region, we did not select who participated in the experiment. Instead, individual participants opted to join the experiment through Mechanical Turk. Hence, all participants were self-elected and anonymous.

Experimental Procedures

We conducted the experiment over several weeks. For all test cases, we used the same experimental procedure:

- Prior to the experiment, we provided participants with written instructions on how to access the prototypes and the assignment in each test case.
- When clicking a link in Mechanical Turk, participants were shown the specific prototype for that test case.
- Each participant was asked to provide his or her Mechanical Turk ID.
  If the ID had already been registered in the database, the experiment was terminated and the participant returned to the Mechanical Turk start page.
- Participants with valid IDs were allowed to participate and presented with the assignment.
- Participants in the first test case were not encouraged to generate ideas, whereas participants in the second and third test case were encouraged to freely generate new ideas from the available information.
- Each participant was given 15 minutes to complete the assignment.
- Having finished the assignment, the participants were thanked for their participation and were given codes for them to submit to Mechanical Turk verifying their participation. This code in return transferred a micropayment of 0.6 USD to their account.

- Finally, the results were transferred from the MySQL database to SPSS™.

IV. RESULTS

This section focuses on the findings from the experiment. Section 4.1 explains our data analysis approach, measurement procedure, and inter-reviewer reliability. Section 4.2 describes the analysis results.

Data Analysis Approach

305 participants took part in the study. 5 participants were replaced because the prototypes failed, and 16 participants had clearly misunderstood the task and focused on existing TV shows. Having ended the data collection, the data were transferred to tables—one for each test case—that were used in evaluating and measuring each idea according to fluency, elaboration, flexibility, and originality. Subsequently, the results were loaded into SPSS™ for the purpose of calculating the total divergent thinking score. In total, the research participants generated 628 ideas across the three test cases.

Measurement Procedure

Using standardized measurements eliminate the need to involve expert judges, see e.g. [5], whom have been used in similar studies [55,58,62,77]. Hence, to measure the degree of divergent thinking, we used a standardized measurement framework [49] used in a similar experiment. Individuals' capacity for divergent thinking is commonly measured in terms of fluency (the number of ideas), elaboration (the amount of novel content in each idea), flexibility (the number of different themes in each response), originality (the degree of novelty compared to all responses), and the total divergent thinking score calculated by combining the other variables [31,32,33,49].

First, fluency was measured by counting all the ideas submitted by each participant (one point for each idea). Participants often numbered their ideas or gave them headlines followed by an elaboration, which made them easy to identify. Second, elaboration was measured by counting the number of sentences that were provided as elaboration of the idea (one point for each sentence). Consequently, elaboration was measured by coding the explanation of each idea according to breaks in sentence structure in the text. These breaks included punctuation, parentheses, "and", "or", and "but" or "however". For example, a participant added an idea about “a young girl and her frog friend”. This idea was followed by two sentences in which the participant wrote: “The frog is her stuffed animal that comes alive when she is alone” and “they have all sorts of imaginary adventures”. Third, flexibility was measured by categorizing ideas based on themes (one point was given for each unique theme).

Themes were identified throughout the analysis and were grouped into different categories (e.g. "characters", "learning", and "setting"). For example, ideas related to a story playing out at a farm would be categorized under "setting", while ideas about aliens would be categorized under "characters". In cases where an idea was related to more than one theme, the theme with the highest degree of elaboration was selected. This approach enabled us to identify new themes and group similar responses together. Fourth, originality was measured by allocating one point for each theme that was only represented by two percent of the ideas across all responses. Two points were given for themes that only occurred among one percent of the ideas across all responses. Thus, originality measures how unique an idea is.

However, the number of ideas (fluency) influences the other variables. For example, a high level of fluency may result in a high elaboration score, although each idea has limited elaboration. Hence, we divided participants' elaboration, flexibility, and originality scores by their fluency scores to avoid bias. Finally, the total score was calculated by adding up the four variables for each participant.

Inter-Rater Reliability

For the purpose of measuring inter-rater reliability, we used SPSS™ to calculate Cronbach's alpha. We coded a random sample of 20 from the 305 participants together during which we discussed how to code and measure their responses. The sample accounted for 72 ideas. This "check coding" enabled us to identify and resolve disagreements, which in turn allowed us to strike common ground in terms of the remaining coding process. Subsequently, each of us coded a sample of 20 responses, allowing us to measure the degree of inter-rater reliability. The coefficient was 1.00 for fluency, 0.94 for elaboration, 0.96 for flexibility, 0.75 for originality, and 0.96 for the combined creativity score. The Cronbach's alpha score was within the same range and in most instances well above measures in similar studies [26,58], hence demonstrating a high level of inter-rater reliability.

Divergent Thinking

To test the hypotheses, the mean score for each dependent variable was calculated through a descriptive analysis (shown in Table 4) along with a full factorial analysis of variance using an ANOVA test (Table 5). For hypothesis 1 and 2, the descriptive analysis and the ANOVA test showed significant differences between the test cases and the control group. In terms of fluency, the participants produced 628 ideas in total across all test cases. However, test case 1 with knowledge from idea evaluation but without creativity encouragement produced far less ideas than the test cases that included creative encouragement (M=0.46). These differences are statically significant (fluency = $F_{2,304}$ = 73,735, $p < .000$, $\eta^2 = .328$). With regard to elaboration, test case 2, which used knowledge from idea evaluation to encourage divergent thinking, produced ideas that were more elaborate than the other test cases (M=2.74). As with fluency, test case 1 contained ideas that were far less elaborate (M=0.1944). These differences are also statically significant (elaboration = $F_{2,304}$ = 38,310, p < .000, η^2 = .202). In relation to flexibility, we identified 91 unique themes across the 628 ideas. As with fluency and elaboration, flexibility in test case 1 was below that of the other test cases (M=0.3268). These differences are also statically significant (flexibility = $F_{2,304}$ = 100,684, p < .000, η^2 = .400). We found similar results for test case 1 in terms of originality (M=0) and total divergent thinking score (M=1.0131). The ANOVA test for originality (originality = $F_{2,304}$ = 56,819, p < .000, η^2 = .273) and the total divergent thinking score (total score = $F_{2,304}$ = 243,983, p < .000, η^2 = .618) show both results to be statically significant.

Table 4. Descriptive Statistics of Divergent Thinking Scores

	Measurement	Treatment	Mean	SD	N
Divergent thinking score	Fluency	Test case 1	0.46	0.727	102
		Test case 2	2.74	2.024	103
		Control	2.99	1.845	100
	Elaboration	Test case 1	0.1944	0.50251	102
		Test case 2	2.74	2.024	103
		Control	2.0788	2.43505	100
	Flexibility	Test case 1	0.3268	0.46371	102
		Test case 2	0.9415	0.17305	103
		Control	0.9322	0.36428	100
	Originality	Test case 1	0	0	102
		Test case 2	0.6390	0.66267	103
		Control	0.7208	0.63057	100
	Total score	Test case 1	1.0131	1.50772	102
		Test case 2	7.2793	2.88721	103
		Control	6.7218	2.18848	100

To account for multiple comparisons, we used Fisher's Least Significant Difference (LSD) post hoc test. The LSD test (Table 6) reveals that idea evaluation without creative encouragement (test case 1) is outperformed by both idea evaluation with creative encouragement (test case 2) and the control test with creative encouragement only (fluency, elaboration, flexibility, originality, and the total divergent thinking score = p < .000). Hence, the results support hypothesis 1.

As for hypothesis 2, the LSD post hoc test (Table 6) shows that test case 2 only outperforms the control test with extensive creativity stimuli on elaboration (p = .007), whereas it is equally effective on fluency (p = .273), flexibility (p = .852), originality, (p = .271), and the total score (p = .079). There are no significant differences between idea evaluation with creative encouragement and the control group on fluency, flexibility, originality, and the total divergent thinking score.

However, test case 2 outperforms the control test on elaboration (MD = .88207, SE = .32421, p = .007). Hence, the results support hypothesis 2.

Table 5. ANOVA Test of Divergent Thinking Scores

		Mean square	F	Sig.
Fluency	Between groups	197.341	73.735	.000
	Within groups	2.676		
	Total			
Elaboration	Between groups	204.318	38.310	.000
	Within groups	5.333		
	Total			
Flexibility	Between groups	12.639	100.684	.000
	Within groups	.126		
	Total			
Originality	Between groups	15.833	56.819	.000
	Within groups	.279		
	Total			
Total	Between groups	1239.110	243.983	.000
	Within groups	5.079		
	Total			

Table 6 – LSD Post Hoc Test of Divergent Thinking Scores

Dependent variable	(I) Group	(J) Group	Mean difference (I-J)	Sig.
Fluency	Test case 1	Test case 2	-2.277*	.000
		Control	-2.529*	.000
	Test case 2	Test case 1	2.277*	.000
		Control	-.252	.273
	Control	Test case 1	2.529*	.000
		Test case 2	.252	.273
Elaboration	Test case 1	Test case 2	-2.76641*	.000
		Control	-1.88434*	.000
	Test case 2	Test case 1	2.76641*	.000
		Control	.88207*	.007
	Control	Test case 1	1.88434*	.000
		Test case 2	-.88207*	.007
Flexibility	Test case 1	Test case 2	-.61473*	.000
		Control	-.60542*	.000
	Test case 2	Test case 1	.61473*	.000
		Control	.00932	.852
	Control	Test case 1	.60542*	.000
		Test case 2	-.00932	.852
Originality	Test case 1	Test case 2	-.63902*	.000
		Control	-.72079*	.000
	Test case 2	Test case 1	.63902*	.000
		Control	-.08177	.271
	Control	Test case 1	.72079*	.000
		Test case 2	.08177	.271

Table 6 – LSD Post Hoc Test of Divergent Thinking Scores – Continued				
Dependent variable	(I) Group	(J) Group	Mean difference (I-J)	Sig.
Total	Test case 1	Test case 2	-6.29724*	.000
		Control	-5.73976*	.000
	Test case 2	Test case 1	6.29724*	.000
		Control	.55748	.079
	Control	Test case 1	5.73976*	.000
		Test case 2	-.55748	.079
*: The mean difference is significant at the 0.05 level.				

V. DISCUSSION

We opened this paper by asking to what extent Creativity Enhancing Systems support divergent thinking when incorporating knowledge generated during idea evaluation. In this section, we discuss the results of the study in relation to existing research.

In the theoretical background section of the paper, we argue for a design approach that uses knowledge generated during idea evaluation to encourage divergent thinking. The design approach is grounded in existing views on creativity, idea evaluation, and knowledge creation [11,19,20,46,63]. These views provide the theoretical backing for a design approach that combines knowledge generated during idea evaluation with creative encouragement. To measure the effectiveness of this design approach, we compare three different CES prototypes. We designed the first prototype (test case 1) to include knowledge from idea evaluation without creative encouragement. This design choice is grounded in a dominant view on how idea evaluation should be designed. This design view argues that idea evaluation can only support convergent thinking and should be conducted independent of divergent thinking activities, c.f. [15,26,27,71]. We designed the second prototype (test case 2) to combine knowledge from idea evaluation with creative encouragement. Finally, we designed the third prototype to act as a control by only including creative encouragement.

The results of the experiment shows that CES, which do not combine knowledge from idea evaluation with creative encouragement, are less effective in supporting divergent thinking than CES that combine knowledge from idea evaluation with creative encouragement or that only use creative encouragement. Moreover, CES that combine knowledge from idea evaluation with creative encouragement (test case 2) yield more elaborate ideas than in the two other test cases and were just as effective in terms of the total divergent thinking score as the control group that only uses creative encouragement. Overall, the experiment shows that CES are effective in encouraging divergent thinking when CES are designed to combine knowledge from idea evaluation with creative encouragement. This finding is useful for future design of CES incorporating idea evaluation.

The findings have consequences for our current understanding of idea evaluation, especially for the branch of research that has previously excluded idea evaluation from the creative process, e.g. [15,26,71]. The findings confirm previous design research into CES using idea evaluation. When CES do not combine knowledge from idea evaluation with creative encouragement, CES should exclude idea evaluation from the creative process because of the negative impact on divergent thinking. However, such idea evaluation processes serve a different purpose in that they aim at narrowing down the number of ideas to fewer tangible solutions through rigorous use of fixed evaluation parameters, e.g. [22,29]. As mentioned in the theoretical background section, management research has previously criticized these evaluation practices for having a negative impact on creative thinking abilities [3,4,8,9,64]. CES that are designed in accordance with these idea evaluation practices and exclude creative encouragement are therefore best used after the completion of all creative activities.

Existing research has only to a limited extent investigated idea evaluation approaches, which use creative encouragement to stimulate participants' divergent thinking abilities to expand rather than reduce the number of ideas being generated, e.g. [20,40]. As our results demonstrate, CES that combine knowledge from idea evaluation with creative encouragement are equally or more effective than the two other prototypes (cf. the test cases). In particular, the participants improved in terms of being able to elaborate on their own ideas when using the prototype that combines knowledge from idea evaluation with creative encouragement. This observation suggests that CES supporting idea evaluation can be designed to encourage divergent thinking abilities. Future studies should extend this finding to convergent thinking. Both are equally important when creating novel and useful ideas [21]. Moreover, the study of Elam and Mead [26] points out that even small improvements in software supported creativity may influence the quality of the ideas produced. Hence, the outcome of the creative process and idea evaluation relies on how such activities are designed into CES. We encourage future research studies to address this issue, especially in CES and design science, which are discussed in the following section.

Implications for Future Design Studies of CES

In the study by Elam and Mead [26] small differences in the process model of their two software prototypes caused one of the prototypes to produce far less creative ideas. Their study show that if the creative process or CES environment is changed even slightly, it may have substantial consequences for human actors' creative performance. Similarly, the presented CES prototypes that include knowledge from idea evaluation represent three very different process models. The first type of CES is designed not to combine knowledge from idea evaluation with creative encouragement, whereas the second is designed to encourage divergent thinking using knowledge generated during idea evaluation. Similar to Elam and Mead's [26] observation, small differences in our design meant that the prototype without creative encouragement stimulated almost no creative thinking, whereas the prototype with creative encouragement came out as more efficient in the experiment. Our findings question parts of the extant literature that recommend relying on convergent thinking only in idea evaluation, e.g. [15,26,71]. The assumption that idea evaluation does not support divergent thinking may be a self-fulfilling prophecy in the sense that idea evaluation without creative encouragement may be designed to limit human actors' divergent thinking abilities. However, future research needs to address this import issue in CES design.

As such, CES researchers may draw on our findings when integrating idea evaluation into CES environments in support of creativity as an alternative to focusing on idea evaluation as a process of eliminating unwanted ideas. Moreover, researchers may use our findings to break with traditional thinking, expand current knowledge regarding creativity processes, and discover new evaluation principles and methods used in connection with CES.

Our findings are also of interest to the new branch of design science research that studies CES, e.g. [67,83]. Design science is the study and creation of artifacts that serve human needs [60], and based on our findings researchers may work to create novel design requirements for future CES. For example, research in creativity and requirements engineering [56,57] may use our findings to develop new processes or systems for generating requirements. Finally, design theories can be created for CES that aim at identifying and creating value during concept and product development.

Overall, this study results in important findings for CES research and creativity management focused on idea evaluation. We encourage researchers to expand on our research in new and unexplored directions.

Limitations

The study has its limitations. First, the 15 minutes time restriction on completion of the tasks may in principal influence divergent thinking. Some participants stated that they would have liked more time to complete the assignment. The lack of sufficient time may have had a negative impact on some responses. However, the average response time was 6 minutes and 35 seconds, and each participant in the experiment provided between 0 and 11 ideas depending on the task. Hence, we have no reason to think that time, in general, had an adverse effect on the outcome of the experiment.

Second, we have not examined the overall quality of the submitted ideas by, for example, evaluating idea novelty and usefulness, e.g. [22]. Nor have we addressed the issue of selecting the right ideas using idea evaluation, e.g. [29]. Instead, we have focused on whether knowledge from idea evaluation can encourage divergent thinking in CES environments or not. Future research should address the issues of quality and idea selection.

Finally, idea evaluation with creative encouragement is inherently a process that generates ideas and evaluation content, e.g. comments and ratings, iteratively over time. In real life situations, users could potentially revisit the same idea multiple times and build on existing knowledge. For the sake of maintaining a controlled experiment, we introduced a pre-evaluated idea with limited possibility for iterating over the same idea. Future research should address whether multiple iterations influence divergent thinking and idea quality levels.

VI. CONCLUSION

In this paper, we test three different CES prototypes in terms of their ability to encourage divergent thinking through a controlled experiment. Two of these prototypes use knowledge obtained during idea evaluation whereas the third act as a control group. To design the prototypes, we drew on extant literature concerning idea evaluation, CES, creative encouragement, and knowledge management. Our findings show that the CES prototype we designed to combine knowledge generated during idea evaluation with creative encouragement is more effective in encouraging divergent thinking than the prototype that does not combine knowledge generated during idea evaluation with creative encouragement as well as the prototype that only uses creative encouragement. These findings contribute to existing research on idea evaluation and CES. First, our findings confirm existing research on idea evaluation. As such, CES that are designed in accordance with idea evaluation approaches that exclude creative encouragement are best used after divergent activities are concluded. CES that use these idea evaluation approaches are relatively ineffective in encouraging divergent thinking compared to competing approaches. However, the findings also suggest that CES supported idea evaluation can be effective in encouraging divergent thinking when small changes are made to the design. This finding challenges the dominant view on idea evaluation, which suggests that idea evaluation can only encourage convergent thinking. Instead, our findings suggest that this view have resulted in the creation of idea evaluation approaches that exclude divergent thinking. Overall, this paper makes an important contribution to the CES design community by confirming research which suggests that small changes in CES design can have a profound effect. Moreover, we provide an important contribution to researchers working with CES and idea evaluation by showing that the knowledge obtained during idea evaluation can be used to create more elaborate ideas. We especially encourage researchers within the emerging field of design science to use our findings to establish better design requirements for CES.

VII. REFERENCES

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VIII. Appendix

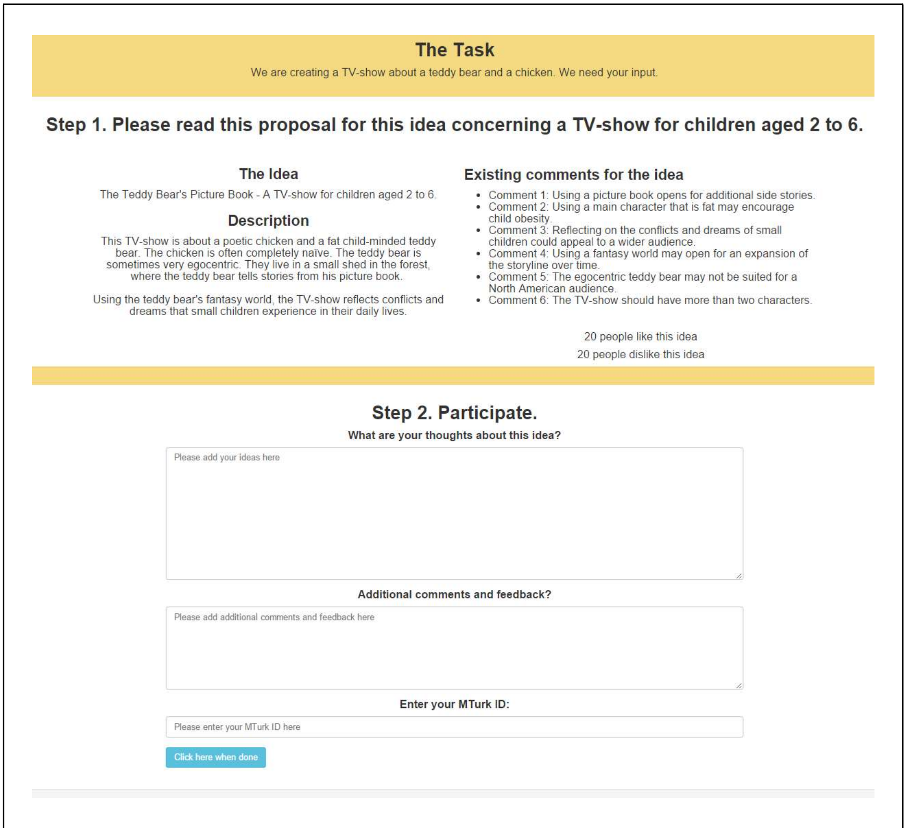

Figure A.1. Screenshot from Prototype used in Test Case 1.

Figure A.1 is a screenshot from the prototype used in first test case. The prototype does not combine knowledge from idea evaluation with creative encouragement.

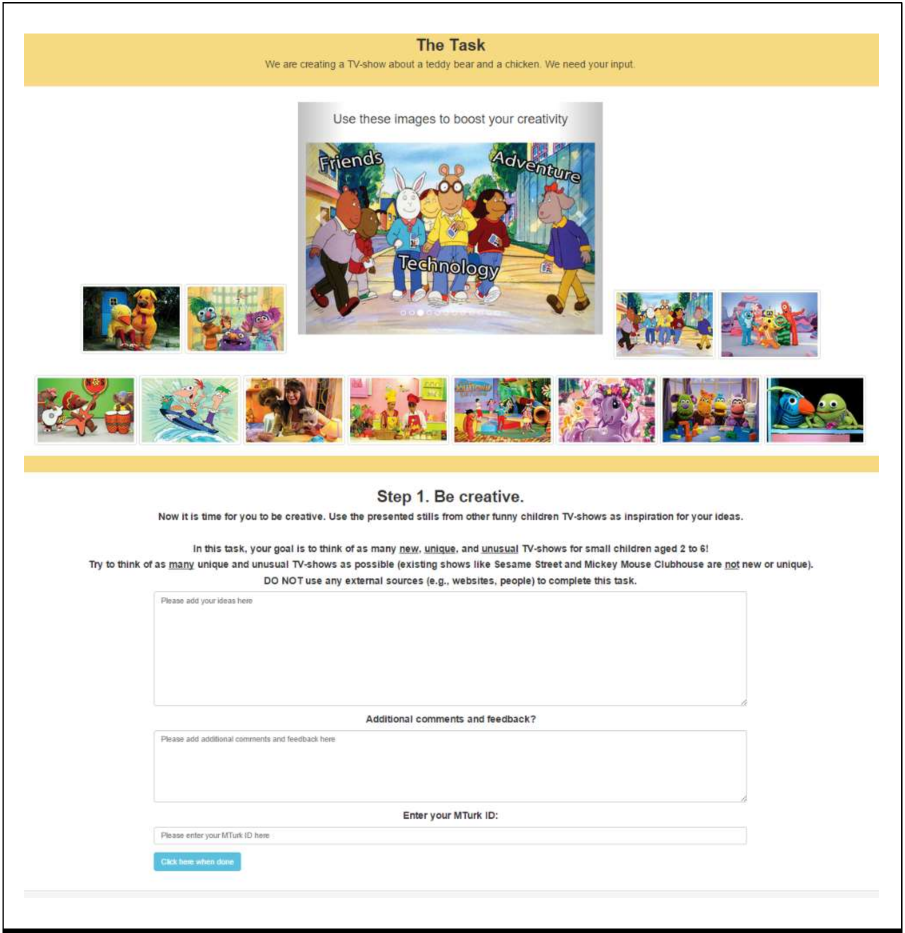

Figure A.2. Screenshot from Prototype used in Test Case 3.

Figure A.2 is a screenshot from the prototype used in third test case. The prototype only encourages divergent thinking.

Appendix E. A Group Creativity Support System for Dynamic Idea Evaluation

6th Scandinavian Conference on Information Systems (SCIS 2015). Published in Lecture Notes in Business Information Processing Vol. 223, p. 137-151.

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Abstract

Idea evaluation is necessary in most modern organizations to identify the level of novelty and usefulness of new ideas. However, current idea evaluation research hinders creativity by primarily supporting convergent thinking (narrowing down ideas to a few tangible solutions), while divergent thinking (the development of wildly creative and novel thoughts patterns) is discounted. In this paper, this current view of idea evaluation is challenged through the development of a prototype that supports dynamic idea evaluation. The prototype uses knowledge created during evaluative processes to facilitate divergent thinking in a Group Creativity Support System (GCSS) designed from state-of-the-art research. The prototype is interpretively explored through a field experiment in a Danish IS research department. Consequently, the prototype demonstrates the ability to including divergent thinking in GCSS driven idea evaluation.

Keywords: Idea evaluation · Creativity · GCSS · Group support

I. INTRODUCTION

In recent years, creativity has achieved a comeback in Information Systems (IS) research and practice [42]. Creativity as a business trend has also influenced activities in both the private and the public sectors. In the private sector, creativity has become the foremost driver for sustaining the advantages needed to succeed in an increasingly hyper-competitive environment. Creativity supports this objective by forming the foundation for generating innovative products, services, and the redesign of organizational processes [5, 21]. In the public sector, creativity has become key to sustaining the increased economic requirements for delivering innovative products and services to end users in the most efficient way [10, 55].

However, innovation do not magically fall from the sky. Novel product development are, rather, a process where creative and novel ideas are transformed into useful designs, services, and organizational processes [24]. Moreover, many innovations fail due to a lack of business value, resulting in many innovation projects never leaving the initial (and resource-consuming) experimentation stages [18]. Hence, there is a growing need to evaluate both radical and incremental ideas to determine their business value before resources are allocated to them as prototype projects.

Traditional approaches to idea evaluation rank ideas according to fixed parameters such as novelty and usefulness to identify the best possible candidate for implementation, e.g., [6, 17, 22]. However, this traditional approach has been heavily criticized for having a negative impact on creative thinking [3, 4, 35]. To counter this view, this paper sheds a new light on the process of idea evaluation. Firstly, by viewing it as the creative ability to add value to novel impressions and secondly, by diversifying knowledge identified in the evaluation process towards creative thinking.

This paper deploys a prototype through an exploratory and interpretive field experiment to explore how managers can utilize idea evaluation in a IS setting to create the fuel for generating novel ideas. To achieve this goal, the prototype presented here and its underlying processes supports a dynamic and iterative process that uses evaluation methods to conceive novelty from identified knowledge. To guide the research the following question is asked: *"How can idea evaluation support creative thinking through a GCSS?"*

The remaining paper is arranged within the following sections. Initially, the paper presents a perspective for idea evaluation built on state-of-the-art research, where the emphasis is on the issues of idea evaluation and the complexity of creativity. Then it deals with the setup of the explorative field experiment. Next, the paper explores a GCSS prototype that encourages creativity through idea evaluation. Finally, lessons learned from the field experiment are provided and implications and avenues for future research are discussed.

II. RELATED THEORY

This section will introduce two ways of creative thinking and elaborate upon two opposite approaches for idea evaluation.

Creativity is commonly separated into thinking patterns considered to be either divergent or convergent [27, 28] While both ways of thinking leads to the production of ideas [15], they are different in structure and output [27, 28]. Divergent thinking is considered to be the production of diversity and novelty whereas convergent thinking is considered to be the result of a review of narrowing solutions [15, 28]. Moreover, divergent thinking handles problem solving through broad searches for requirements using large quantities of ideas, few and lax restrictions through trial-and-error, and loose and vague structures whereas convergent thinking handles problem solving through restricted searches for requirements aimed at forming correct and well-defined solutions, coping with many rigorous and demanding restrictions, and sharp and well-defined structures [27].

IS enhanced creativity is normally divided between Individual Creativity Support Systems (ICSS) for personal use and Group Creativity Support Systems (GCCS) in a collaborative settings [43]. GCSS is moreover, a class of diverse systems that supports sharing of ideas and creative collaboration. For example, Di Gangi and Wasko [22] explains how Dell used an idea portal to collect ideas from their customers while Müller- Wienbergen et al. [43] provided extensive specifications for a GCSS supporting divergent and convergent thinking in a movie location environment by extending the users personal knowledge. However, a full review of the GCSS and CSS literature would be overwhelming. Instead, this paper relies on 43 contributions on the subject from Müller and Ulrich’s [42] literature review of creativity in the IS literature.

Idea evaluation consists of two different management objectives. The first is identifying the values suggested by the idea. Such values are identified by creating input upon known quality parameters such as usefulness and novelty [17], hence creating evaluation content or knowledge about the idea. In this context, knowledge is defined by Alavi and Leidner [2] as “the result of cognitive processing triggered by the inflow of new stimuli” (p. 109). Moreover, knowledge can be stored, manipulated, and accessed which enables actors to know, learn, and influence future outcomes through their actions [2]. The second management objective is to identify the best ideas or creating portfolios of valuable ideas that can solve specific problems [12]. Guilford [28] argues that evaluation is a corrective and selective ability that collects feedback from the individuals’ memory storage (past practices and experience) to facilitate divergent or convergent production. However, Guilford [27] also claims that formal evaluation was strictly convergent due to its rigorous structuring and its emphasis on deduction and decision-making. In his later work, Guilford [28] further applies this view by stating that evaluation can decrease divergent thinking abilities. Over the last 45 years, Guilford's view on convergent idea evaluation has influenced both research, e.g., [19] and practice, e.g., [45]. However, the introduction of IS has changed the playing field for creative support by providing solutions that are more effective than traditional pen-and-paper techniques [41].

Novel ideas are often identified as rare, unusual, or uncommon [12, 51]. Accordingly, they are an object for subjective testing and judging by others [36]. As such, a clear distinction is needed between creativity and idea evaluation. Where creativity is about generating novel and useful ideas for specific or loosely defined problems [3, 12], idea evaluation is about identifying specific qualities in ideas (e.g., novelty and usefulness) that can provide an implementable and effective solution for identified problems [17]. Hence, where creativity is about producing novel and useful knowledge for specific or loosely defined problems, idea evaluation is about generating knowledge about the quality of the data provided through creative activities. However, recognizing idea quality is not an easy task and idea evaluation has been criticized for demotivating organizational creativity by finding reasons to terminate ideas through rigorous critique [3, 4] and ultimately underestimating truly novel ideas [35].

Using knowledge to enhance creative thinking is not a new research subject. Existing research includes reusing knowledge embedded in existing ideas, management practices, and existing innovations [11, 38]. Moreover, researchers have explored how managers can use knowledge management systems to access diverse domain knowledge across departments [9, 20]. Knowledge created during an idea evaluation process can materialize when users provide comments or numerical values to a given criteria for a specific idea [6, 7]. According to Sternberg [49], participants can use knowledge for creative activities by (1) viewing it in new light (2) reconstructing it (3) redirecting it (4) transferring it (5) extending it to a new domain, (6) migrating within an existing domain beyond its accepted border or (7) radically redefining the knowledge for a completely new domain. Divergent thinking is about shifting context, branching out, and crossing boundaries whereas convergent thinking is about staying within limits, applying what is known, and avoiding risks [15, 27, 28]. Thus, divergent thinking produces ideas from knowledge by shifting or extending the boundaries within an existing domain. Moreover, divergent thinking can extend knowledge to another domain or radically redefine it for a new domain. Due to its focus on explicit requirements, convergent thinking, however, will only produce ideas within a specific and well-defined domain within clear boundaries.

To further explore the concept of knowledge creation in idea evaluation and its influence on creativity, this paper introduce a new and alternative approach that uses idea evaluation to glean knowledge from existing ideas. The purpose of this approach is to use the generated knowledge from the evaluation process to support both divergent and convergent thinking. This approach is coined as dynamic idea evaluation.

Table 1 demonstrates the overall differences between the approach and focus of traditional and dynamic idea evaluation. The table also include the influence from divergent and convergent thinking on the two evaluation approaches. Both traditional and dynamic idea evaluation involves a secondary convergent process of idea selection or consolidation. The focus of this paper is to elucidate how dynamic idea evaluation uses the knowledge creation process intended to facilitate idea consolidation to enhance divergent thinking.

Table 1. Differences between Dynamic and Traditional Idea Evaluation

	Traditional idea evaluation	Dynamic idea evaluation
Approach	Focus is on selecting the best idea for a solution	Focus is on creating a working solution iteratively over time
Focus of knowledge creation	Knowledge creation works in a linear fashion by identifying the correct idea that can form a novel solution	Knowledge creation works actively and iteratively by identifying knowledge in multiple ideas that can improve an existing idea, create novel ideas, and form novel solutions from a portfolio of existing ideas
Influence from divergent thinking	Divergent thinking happens beforehand and does not play any role	Divergent thinking plays a key role when creating novel ideas from identified knowledge in the evaluation process
Influence from convergent thinking	Convergent thinking plays a key role when identifying the correct idea for the correct solution	Convergent thinking plays a key role when improving existing ideas and forming novel solutions from knowledge identified in existing ideas

The purpose of traditional idea evaluation is to identify the best ideas that can fix a specific problem [6, 32, 47]. After all creative activities are concluded [19, 44], traditional idea evaluation achieves this goal by collecting specific domain knowledge concerning the qualities of each individual idea. Such knowledge about quality can include the novelty and usefulness [14, 17, 46] of the idea. Hereafter, this knowledge is used convergent in idea selection to separate the valuable ideas from those less valuable [23].

Dynamic idea evaluation is a creative alternative to traditional idea evaluation approaches. First, the purpose of dynamic idea evaluation is to collect the necessary knowledge to support idea consolidation through convergent thinking. Idea consolidation is a process that collates group knowledge from ideas and evaluation content within a common focus or theme [1]. For example, innovation managers can group knowledge from ideas and evaluation content within the focus or theme of a specific innovation. Moreover, identified knowledge can be used to improve existing ideas [12, 30]. Second, dynamic idea evaluation reuses the existing knowledge, e.g., [11, 38] from ideas and evaluation content to enhance divergent thinking processes simultaneous to the evaluation process. Such creativity enhancing activities can be further supported by using creativity techniques in combination with the generated knowledge, e.g., [12, 13]. As such, dynamic idea evaluation is embedded in the creative process, where it iteratively crafts working solutions over time while reusing the generated knowledge to enhance further creative thinking.

III. RESEARCH APPROACH

To explore dynamic idea evaluation, data was collected using a field experiment [8, 31] and interpretively analyzed [53, 54]. The approach for the field experiment and interpretive analysis is presented here.

Universities have previously been used in a variety of different settings when researching creativity and IS [37, 39, 41]. Hence, 15 members of a computer science department at a Danish university were selected to participate in the field experiment. To participate they had to have been employed in the department for at least nine months so that they would have some sense of the organizational structure and culture. Besides 12 research staff members, three administrative personnel participated, including the head of the department. To analyze the influence of practice, two secretaries without research tasks were added to the experiment.

The procedure for collecting data was constructed around five iterations. However, findings identified when using the prototype may cause changes to its underlying construction [52]. For this purpose, an initial Wizard of Oz (WoZ) HTML prototypical initiation [16, 29] was developed, which enabled the experimenter (the "Wizard") to act as the system when collecting user input, see [25]. The two initial iterations also functioned as learning stages to help the subjects become familiar with the system, see [50]. The starting point of the first iteration was a challenge to identify new ice cream flavors and evaluate an idea for a liquorice-flavored ice cream.

Between the first and second iteration a functional prototype was developed in PHP and MySQL. Incremental changes were made from the interaction with the subjects during the first iteration. During the second iteration, the subjects were reintroduced to the new prototype due to its redevelopment. In the third iteration, the subjects were introduced to a specific real-world challenge for a new travel expense system while the subjects controlled the fourth and fifth iteration. When the five iterations were complete, each subject was interviewed using an open-ended approach [48] to identify reoccurring patterns. Finally, the subjects participated in an open focus group meeting to present preliminary results and collect final feedback. Overall, the data collection lasted 14 weeks. Development of the functional prototype took one month between the first and second iteration. Each subsequent iteration lasted around 14 days. Each interaction with the participants took between five minutes and one hour. In total, 35:12 h of experiment and interview data was collected. To emulate real-world applications, the subjects participated randomly in each iteration [31]. Three subjects left the experiment after the first iteration. Two subjects left their position at the university while a third left the experiment due to other time commitments. Table 2 summarize the data collection procedure.

Table 2. Procedure for Data Collection

Iteration	Objectives	Task
1	1. To deploy an initial Wizard of Oz (WoZ) HTML prototypical initiation 2. To gather information to redevelop the WoZ prototype and provide learning to the subjects about this class of systems	The subjects learned to use the WoZ prototype and provide feedback on its functionality by evaluating an idea for a liquorice-flavored ice cream
2	1. To deploy a redeveloped PHP and MySQL prototype 2. To reintroduce the subjects to the redeveloped prototype	The subjects learned to use the redeveloped prototype by continuing their evaluation of the ice cream idea
3	1. To introduce the subjects to a specific real-world challenge	The subjects iteratively created and evaluated ideas for a new travel expense system
4-5	1. To enable the subjects to act freely when using the prototype	The subjects used the prototype at liberty
Post evaluation		
Open-ended interviews followed by a focus group session		

Throughout the five iterations, the collected data was continually analyzed using a flowchart. To establish connections between the different ideas or their evaluation content, subjects were asked about the origin of their ideas. Thus, the subjects became the reviewers of the data they provided. However, while some improvement ideas were added correctly, the subjects embedded other improvements in their comments or added them as new ideas. These improvement ideas were extracted from the evaluation content. Following the data extraction, all ideas were compiled into Fig. 2 shown in Sect. 5. Moreover, a field experiment report [56] was used to continuously record data and time duration from each prototype iteration, interviews, and the focus group. The data was then analyzed using an interpretive approach [53, 54] by identifying reoccurring themes [34] in relation to dynamic idea evaluation. Moreover, the interpretive analysis was supplemented with Sternberg's [49] view about knowledge and the concurrent view on divergent and convergent thinking [15, 27, 28]. This approach enabled an in-depth content analysis of the data to understand the prototypes influence on the subjects' creative actions. The prototype is presented in Sect. 4; the analysis is presented in Sect. 5 and further discussed in Sect. 6.

IV. THE PROTOTYPE

The prototype was constructed as an idea portal. In this portal, users could post initial and open-ended problems (listed as challenges in the design) and ideas solving those problems. Figure 1 shows a screenshot of the evaluation module. Once a user posted an idea (cf., top of Fig. 1), other users could activate the evaluation module. From there, they could evaluate the idea by adding comments and suggesting problems and potential benefits (cf., the 'Comment on Idea', the 'Add Benefit', and the 'Add Problem' action buttons in the top right corner of Fig. 1). Moreover, users could comment on submitted benefits and problems, providing additional knowledge to enable other users to create new improvements for the evaluated idea or proposed challenges and ideas (cf., the 'Add new Comment' action button in benefits or problems in Fig. 1). In both benefits and problems, users could propose improvements that suggested solutions for the selected problem or exploited any selected benefit (cf., the 'Add new Improvement' action button in benefits or problems in Fig. 1). Users could also supplement added content with word tags (cf., 'Tags:' in Fig. 1).

For enhancing divergent and convergent thinking, the evaluation module used a creativity technique called force field analysis, which is intended to encourage creativity in idea evaluation by collecting user input [12]. Couger's [12] evaluation technique enables users to provide benefits, and discuss problems around an idea and suggest improvements or novel ideas from the collected knowledge. This technique was modified to fit the design of the prototype. Furthermore, the prototype used words and images creativity techniques [39], which were embedded into the design. Besides the manually added tags, the system automatically generated a tag cloud from the content added by the users (cf., the tag cloud in the top of Fig. 1). When a user clicked on a manually or auto-generated tag, they were transferred to a Google image search for that tag. From this image search, users could find associated images that might improve their creative thinking.

The system supported both convergent and divergent thinking. The users were encouraged to work convergent within existing ideas by generating ideas as improvements to other ideas. Users could also work divergently by proposing novel ideas for a challenge or by initiating new challenges that might spawn a whole range of ideas (cf., the 'Create new Idea' action button in Fig. 1). When users created any improvement ideas, the prototype would encourage convergent thinking by facilitating knowledge around that content. However, the prototype could also facilitate divergent thinking through knowledge embedded in existing ideas and evaluation of content, enabling users to develop novel ideas with far wider capabilities than being limited to standard idea improvement.

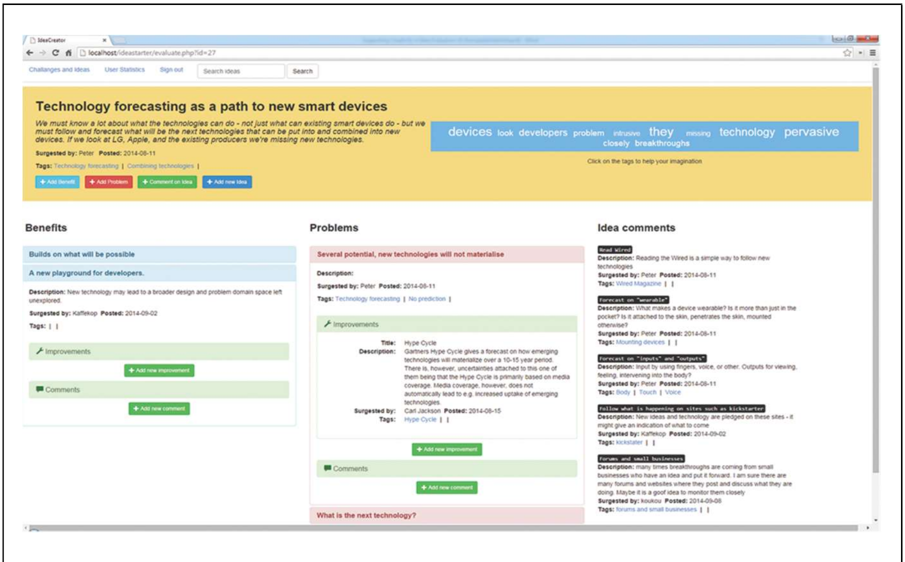

Fig. 1. Screenshot of the Idea Evaluation Module

V. RESULTS

During the five iterations, 64 ideas and 10 improvement ideas over 12 challenges were added to the prototype. Three challenges and one idea were added to facilitate the experiment. Moreover, the 15 subjects added 210 entries of evaluation content. Of these, 123 were comments on ideas and challenges, 42 were identified benefits, and 45 were identified problems. From the evaluation content, 26 improvement ideas were extracted during the post-analysis of the data. In total, the subjects added 294 entries to the prototype over the five iterations.

Figure 2 shows the relationships between challenges and ideas created by the subjects during the five iterations. The numbers in Fig. 2 referees to the individual challenges and ideas. The artifact is genetic to different types of user groups. However, it is also designed for the specific purpose of supporting divergent thinking through the exploitation of valuable knowledge added via ideas and evaluation content. The following interpretive analysis will account for the inner workings of the prototype as a platform for knowledge and divergent thinking on the data embedded in Fig. 2. The results are further discussed in Sect. 6.

To illustrate the workings of divergent thinking and the transfer of knowledge, the challenges (blue circles with dashed borders) contains an outer border as its knowledge domain (blue circles with straight borders). These domains contain the ideas for each challenge and evaluation content for the challenge itself (green circles at the edge of the blue circles). The ideas (white circles) have their own knowledge domain of evaluation content (green circles in the white circles) and improvement ideas (yellow and purple circles).

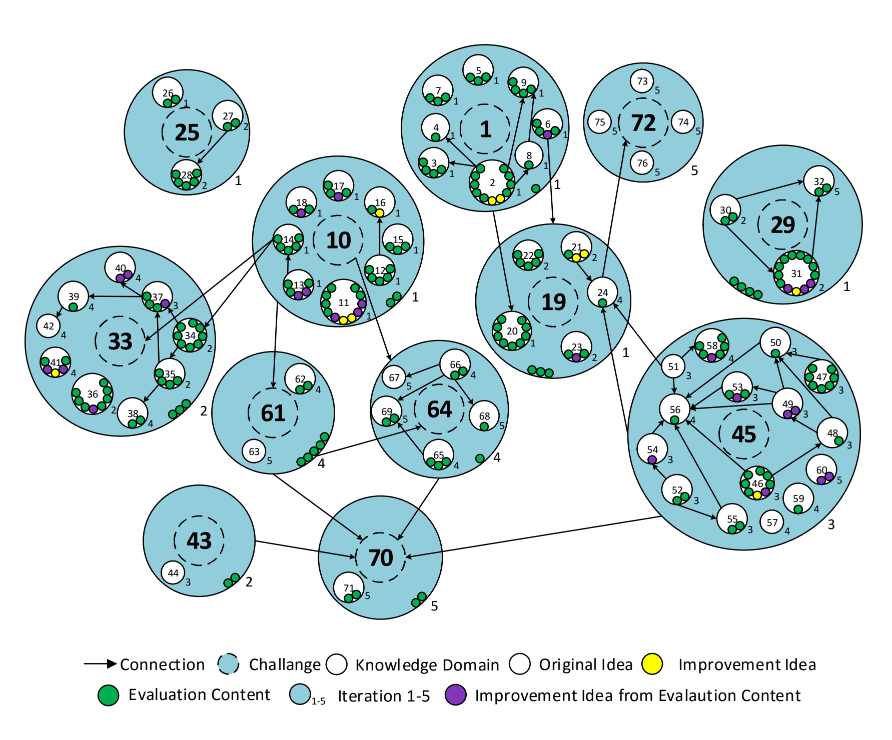

Fig. 2. Context Map showing Connections between Knowledge Items and Domains (Color Figure Online)

Extracted from Fig. 2, the subjects' divergent production (the result of divergent thinking) has extended the borders of each knowledge domain surrounding the challenges. This divergent production happens when participants act upon a specific challenge by adding novel ideas. For example, one subject created three ideas (47, 59 and 69) over three iterations for the challenge of building a better travel expense system (45). He created these ideas by reflecting on his own experiences and practice and the challenge at hand. Within the same challenge, another subject created two ideas in the third iteration. The subjects identified knowledge embedded in a discussion on efficiency in an existing idea (52), which triggered a reflection of his own practice and enabled him to generate two novel ideas (54 and 55) that could make the travel expense system more efficient.

The subjects' divergent production would also extend a domain by applying missing information. For example, one subject scanned the added ideas in the challenges of the travel expense system (45). Evaluating these ideas helped him to placing value the current knowledge he was experiencing. This process enabled him to reflect on his own practice and propose a new idea (56) that was missing in the domain. In addition, another subject continuously used this technique to add ideas and new challenges. For example, she created the challenge of the Christmas lunch (70) after evaluating newly added challenges and concluding that they were too serious. The production is considered divergent when novel alternatives are provided from the available knowledge [28]. Hence, the subjects used divergent thinking when they evaluating exiting content according to their personal experiences and desire for change and alternative practices.

As shown in Fig. 2, the subjects' divergent production transferred existing knowledge from one domain to another by using the available knowledge in the first domain to create novel ideas in the second. For example, when evaluating the challenge of the travel expense system (45) and an idea on usability (51), a subject related the identified knowledge to an idea about university sports clubs (21) in another challenge (19). He argued that usability is usually associated with websites. First, he combined 'website' with the concept of 'system' from challenge 45. Second, he looked in challenge 19 and found the idea about sports clubs (21). Finally, he argued that there is a department website, but there are also unknown sport clubs at the university. Hence, he created an idea for a website for the university sports clubs (24).

The participants' divergent production also radically redefined existing knowledge from one domain to create an entirely new domain. In the first iteration, one of the younger research staff members evaluated the idea of selling ice cream in each zip code (6). Within this domain, he suggested an improvement idea of having an ice cream vendor on the campus. The knowledge embedded in the improvement and the domain of the original idea made him rethink the concept of having activities on campus. This knowledge he identified during evaluation and his own practice as a former student enabled him to create a new challenge about a way to improve campus life for students (19).

In the idea domains, the participants' convergent production has reconstructed existing knowledge for improvements while maintaining what is safe and within the accepted borders of the original idea. Subjects would generate ideas that improved upon existing ideas, for example by expanding another usability idea (46) by suggesting that usability testing should be done with users. In another example, a subject suggested adding the suggestion of sorbet to the initial liquorice ice cream idea (2).

Two subjects were deliberately inserted into experiment, specifically because they did not share day-to-day duties with the others subjects. The first subject left the experiment after the first iteration. The second subject added a challenge and an idea on improving an administrative system that only she used (43 and 44). This content added by the second subject was largely ignored by the other subjects, as they were unable to correlate that content to their own practice.

Overall, the prototype had the capability to support both divergent and convergent thinking, despite including idea evaluation in the creative process.

VI. DISCUSSION

The initial research question was: *"How can idea evaluation support creative thinking through a GCSS?"* To answer this question, a field experiment was deployed and the results were analyzed using an interpretive approach. Throughout the experiment, divergent and convergent thinking patterns were identified.

The results from the field experiment are consistent to Sternberg's [49] view on knowledge. Firstly, divergent production happened when the subjects extended the borders of each knowledge domain surrounding a challenge. In this situation, divergent production happened when the subjects created ideas for challenges from the knowledge they identified in another challenge. Secondly, the ideas clearly shifted context and branched out by deploying existing knowledge in novel ways. Moreover, ideas expanded the knowledge domain of the challenge. Supported by Cropley [15], such production is divergent when it cross boundaries. Thirdly, subjects transferred knowledge from one domain to another by creating novel ideas from one challenge using knowledge identified in another. The activity was divergent when subjects crossed these boundaries. In addition, the participants produced 64 unique ideas during the five iterations. Guilford [27] defines this ability to generate multiple novel ideas for a specific domain as fluency; a clear sign of divergent production.

During the field experiment, several signs of convergent thinking were identified, for example, when the subjects suggested improvements to existing ideas. According to Cropley [15], convergent thinking applies what is known and stays within borders. The results are consistent with Cropley [15] and Sternberg [49] views, as the subjects' production was convergent when they remained within the domain of the idea and only applied incremental changes. The experiment demonstrates that supporting divergent thinking is not enough. In his seminal defense of convergent thinking, Cropley [15] explains that divergent and convergent thinking needs to co-exist to be effective. Divergent thinking transforms and reinterprets while convergent thinking prefers simplicity and rules. Thus, divergent thinking can result in overconfident breakthroughs and in worst-case disastrous changes. Convergent thinking used alone can equally result in missed opportunities and stagnation. Hence, convergent and divergent thinking needs to co-exist in a healthy environment to produce both novel and effective solutions. Overall, the field experiment demonstrated that it is possible to create a GCSS that use dynamic idea evaluation to enable the user's divergent thinking. Support of divergent thinking is especially plausible, if designers insert idea evaluation into an iterative creative group process and support it with specialized creativity techniques.

The experiment raises some fundamental question about how current evaluation processes are structured. Guilford's [28] key argument is that formal evaluation may reduce information retrieval from memory storage and should not be included in divergent production. Researchers including Elam and Mead [19] and practitioners such as Osterwalder and Pigneur [45] have taken Guilford's view even further and suggested that idea evaluation can only support convergent thinking due to its emphasis on deduction and decision-making. Without claiming exhaustiveness, current research may have overlooked an important connection between the knowledge creation processes of idea evaluation and divergent thinking. This experiment shows a different side of idea evaluation, where knowledge creation can support retrieval from memory storage for divergent production. It shows how participants evaluated existing ideas on both formal and informal levels, how they identified knowledge from these evaluations, which triggered knowledge from past practices and experiences in their memory storage, and how these triggers result in their divergent production of novel ideas. Moreover, the experiment demonstrates the potential of structuring an iterative creative and evaluative process, which is transferable to a GCSS. Hence, this paper opens up a new branch of research within GCSS that offers a great deal of opportunities for new discoveries.

These findings entail several recommendations for future studies and practice. GCSS researchers and practitioners can use the findings from the experiment to rethink how they deploy idea evaluation in their creative process. Using design science [26, 40] the results from this field experiment can be extended to form novel design requirements, constructs, and principles for this class of systems. Moreover, there is a range of uncertainties connected to this experiment that future research can address. For example, the observations from the field experiment showed how the ranking mechanisms pushed participants to focus around ideas with a high activity and negatively influenced their incentives to explore other ideas. Idea evaluation researchers and practitioners should explore new avenues for placing knowledge on ideas that are based on subjective input from the participants, rather than relying on normative ranking metrics that are best suited for web analytics. In the same context, researchers and practitioners should shift their focus from pursuing one great idea, e.g., [23, 33] by eliminating lesser ideas through normative ranking metrics. Instead, they should focus on developing great solutions by using idea evaluation for collective divergent and convergent production. Such a shift in focus could enable managers and developers to identify novel solutions by collecting best available knowledge from many different ideas and opinions.

VII. CONCLUSION

Existing research in idea evaluation and GCSS have not approached idea evaluation as a divergent process that could create new novel concepts. Instead, the focus has been on supporting evaluation schemes that only included convergent thinking. This paper sought to provide a shift from this traditional view about idea evaluation by presenting an alternative view, where idea evaluation is integrated directly into the creative process. This exploratory field experiment demonstrated a capability to use knowledge collected through dynamic idea evaluation that triggered the participants' memory storage and encouraged their divergent thinking abilities. These results encompass several implications for future research, including rethinking the current views about idea evaluation and suggestions for conducting future empirical research that may advance and guide further development of dynamic idea evaluation. Although the proposed prototype is limited by focusing on the knowledge creation process of idea evaluation and not consolidation, it also presents an interesting shift in research where GCSS driven idea evaluation can be embedded into the creative process. Hence, the design theory and findings from this paper can initiate and guide future research and practice within GCSS and idea evaluation. Researchers are encouraged to investigate the concept of divergent idea evaluation and its implementation in GCSS while practitioners can use the proposed suggestions for idea evaluation to create new features in running GCSS or to develop new state-of-the-art systems.

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ISSN (online): 2246-1248
ISBN (online): 978-87-7112-526-9

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