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Exploring Divergent and Convergent Production in Idea Evaluation: Implications for Designing Group Creativity Support Systems

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Abstract:

Most organizations need to evaluate novel ideas to identify their value. However, current idea evaluation research and practice hinder creativity by primarily facilitating convergent production (narrowing down ideas to a few tangible solutions) but discounting divergent production (the development of wildly creative and novel thoughts patterns). In this paper, I challenge this dominant view on idea evaluation by presenting a new theory I call dynamic idea evaluation and exploring the theory through a group creativity support system (GCSS) prototype. I designed the GCSS prototype as an idea portal that uses the knowledge created from the evaluation process to facilitate both convergent and divergent production. I designed the GCSS using an inductive and theory-building design science research (DSR) approach and interpretively analyzed it through an exploratory study in a Danish IS research department. I found that the GCSS demonstrates the ability to facilitate both divergent and convergent production during idea evaluation. Moreover, I add four design requirements and process architecture to help designers to build dynamic idea evaluation into this class of systems.

Keywords: Dynamic Idea Evaluation, Creativity, GCSS, Group Creativity Support Systems.

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1 Introduction

In recent years, creativity has achieved a comeback in information systems (IS) research and practice (Müller & Ulrich, 2013). 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 principal 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 (Amabile & Khaire, 2008; Florida & Goodnight, 2005). In the public sector, creativity has become key to sustaining the increased financial requirements for delivering innovative products and services to end users in the most efficient way (Castelnovo & Simonetta, 2007; Warkentin, Gefen, Pavlou, & Rose, 2002).

However, innovation does not magically fall from the sky. Novel product development is, rather, a process in which one transforms creative and novel ideas into useful designs, services, and organizational processes (Govindarajan & Trimble, 2010). Moreover, many innovations fail due to a lack of business value, which results in many innovation projects' never leaving the initial (and resource-consuming) experimentation stages (Desouza et al., 2009). Hence, we can see 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., Blohm & Riedl, 2011; Dean, Hender, Rodgers, & Santanen, 2006; Di Gangi & Wasko, 2009). However, researchers have heavily criticized this approach for having a negative impact on creative production (Amabile, 1996, 1998; Licuanan, Dailey, & Mumford, 2007). To counter this view on idea evaluation, I shed new light on the research topic by 1) considering idea evaluation as the creative ability to add value to novel impressions and 2) using the knowledge identified in the evaluation process to facilitate creative production.

I deploy an exploratory and interpretive field study to explore how managers can use idea evaluation in a IS setting to generate novel ideas. I focus on a dynamic and iterative process that uses idea evaluation to conceive novelty from the identified knowledge. Overall, I address the following question:

> **RQ**: How can a dynamic and iterative idea evaluation process be designed into a group creativity support system (GCSS) to facilitate creative production?

This paper proceeds as follows: in Sections 2 and 3, I bridge creative production with state-of-the-art research on idea evaluation. In Section 4, I discuss the design science research (DSR) approach and the explorative study. In Section 5, I deploy a GCSS prototype that facilitates creative production through a dynamic process of idea evaluation. In Section 6, I compare and contrast the results to the theory on knowledge creation and creative production. I then translate the results into four design requirements and a GCSS process architecture. Finally, in Section 7, I discuss implications and avenues for future research.

2 Supporting Theory

Researchers typically divide IS enhanced creativity into individual creativity support systems (ICSS) for personal use and group creativity support systems (GCCS) in collaborative settings (Müller-Wienbergen, Müller, Seidel, & Becker, 2011). GCSS is a class of systems that allow individuals to share ideas and collaborate creatively. In support this perspective, I rely on 43 contributions on GCSS and CSS from Müller and Ulrich's (2013) review of creativity in the IS literature. To design the GCSS prototype that I present in Section 3, I elaborate on knowledge creation in relation to creative production and idea evaluation in this section.

2.1 Creativity and Knowledge

Researchers commonly separate creativity into production patterns that they consider to be either divergent or convergent (Guilford, 1967, 1977). While both ways of production lead to ideas (Cropley, 2006), they differ in structure and output (Guilford, 1967, 1977). Divergent production concerns creating diversity and novelty, whereas convergent production concerns narrowing down what is already known (Cropley, 2006; Guilford, 1977). Moreover, divergent production 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 (Guilford, 1967). Convergent production, however, treats problem solving

through restricted searches for requirements to form correct and well-defined solutions, to cope with many harsh and onerous restrictions, and to define sharp and well-defined structures (Guilford, 1967).

Enhance creative production with knowledge is not a new research subject. Existing research includes reusing knowledge embedded in existing ideas, management practices, and existing innovations (Cheung, Chau, & Au, 2008; Majchrzak, Cooper, & Neece, 2004). In this context, Alavi and Leidner (2001) define knowledge as "the result of cognitive processing triggered by the inflow of new stimuli" (p. 109). However, knowledge can be tacit and explicit; it can organize the flow of information, and it can provide meaning to data that is otherwise confusing (Nonaka, 1994). To that extent, knowledge can be stored, manipulated, and accessed, which enables actors to know, learn, and influence future outcomes through their actions (Alavi & Leidner, 2001). In this paper, I define knowledge accordingly by viewing it as a product of cognitive processing of information and data that can be organized in an information system. According to Sternberg (1999), human actors can use such 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 it within an existing domain beyond its accepted border, or 7) radically redefining the knowledge for an entirely new domain. Through the lense of divergent production, human actors generate ideas from knowledge by shifting context, branching out, and crossing boundaries in an existing domain. Divergent production may also radically redefine knowledge to create new domains. Through the lense of convergent production and its focus on explicit requirements, ideas will only be generated within a distinct domain within clear boundaries.

2.2 Idea Evaluation and Knowledge

Idea evaluation generates quantitative and qualitative knowledge (e.g., Blohm & Riedl, 2011; Bragge, Merisalo-Rantanen, & Hallikainen, 2005; Dean et al., 2006) when the ideas are objects that others can subjectively judge (Lobert & Dologite, 1994). To explore knowledge creation in creativity and idea evaluation further, one needs to clearly distinguish between the two. Creativity concerns generating novel and useful ideas for distinct or loosely defined problems (Amabile, 1996; Couger, 1996) or multiplying existing knowledge into new novelties (Ulrich, Mengiste, & Müller, 2015). Idea evaluation concerns identifying particular qualities in ideas to identify if they are implementable and effective solutions for the identified problems (Dean et al., 2006). Hence, whereas creativity concerns generating ideas for specific or loosely defined problems, idea evaluation concerns generating knowledge about the ideas' quality.

Guilford (1977) argues that divergent or convergent production use evaluation as a corrective and selective ability that collects feedback from the individuals' memory storage (past practices and experience). Building on Osborn's (1953) early work, Guilford (1967) claim that evaluation can become strictly convergent when it is rigorously structured and it emphasizes deduction and decision making. In his later work, Guilford (1977) further states that evaluation can decrease divergent production. Even though Guilford's view on convergent production and idea evaluation lack empirical evidence, it has influenced both research (e.g., Elam & Mead, 1990) and practice (e.g., Osterwalder & Pigneur, 2010). Osborn's and Guilford's claims are problematic at best. They have resulted in idea-evaluation processes that researchers have criticized for demotivating organizational creativity by terminating ideas through rigorous critique (Amabile, 1996, 1998) and underestimating the perceived originality (Licuanan et al., 2007). Moreover, the introduction of IS has changed the playing field for creativity support by providing solutions that are more effective than traditional pen-and-paper techniques (Massetti, 1996).

3 Bridging Knowledge Creation to Idea Evaluation

Idea evaluation can either be formative or summative depending on whether it occurs at the end of the creative process (Moeran & Christensen, 2013). Idea evaluation is traditionally a convergent and summative approach that is formal and prearranged (Elam & Mead, 1990; Osborn, 1953), that identifies only the best ideas for implementation (Blohm & Riedl, 2011; Kennel, Reiter-Palmon, de Vreede, & de Vreede, 2013; Riedl, Blohm, Leimeister, & Krcmar, 2010), and that mainly uses quantitative parameters to guide fast decision making (Blohm & Riedl, 2011; Girotra, Terwiesch, & Ulrich, 2010; Kudrowitz & Wallace, 2013; Reinig, Briggs, & Nunamaker, 2007; Riedl et al., 2010; Verhaegen, Vandevenne, Peeters, & Duflou, 2013). Thus, as Figure 1 illustrates, idea evaluation's focus on creating knowledge involves a linear process in which one uses identified knowledge to facilitate decision making and identify the best idea from all the alternatives (Girotra et al., 2010). First, one generates a lot of alternative ideas using divergent production. Second, one stops all divergent production. The divergent production is replaced by a process of evaluation and convergent production that helps human actors to identify value, select the

best ideas, refine those selections, and support the final decision on implementation. This presented evaluation process is common practice and advocated in a range of management books (e.g., Couger, 1996; Osterwalder & Pigneur, 2010). Moreover, it manifests in a range of different information systems. For example, OpenIDEO (openideo.com) uses a very similar evaluation process in which one initially outsources ideas and then evaluates, selects, improves, reselects, reevaluates, and, finally, reselects it for implementation.

Figure 1. The Traditional Idea-evaluation Process (Adapted from Couger, 1996)

To explore the concept of knowledge creation in idea evaluation and its influence on creativity, I introduce a dynamic approach to idea evaluation. This approach bridges knowledge creation with idea evaluation to support divergent and convergent production.

Dynamic idea evaluation is a creative alternative to traditional idea-evaluation approaches. In dynamic idea evaluation, creativity does not refer to the production of novel and useful ideas. Instead, creativity is a multiplier of human knowledge in which human actors informally evaluate and negotiate incoming ideas and, during this process transform, translate, consolidate, or radically redefine those ideas according to a particular context (Ulrich et al., 2015). Hence, dynamic idea evaluation is foremost a formative approach because it 1) is a part of the creative process, 2) views all ideas as being potentially valuable over time and through consideration, and 3) continuously revisits ideas to improve their value (e.g., Couger, 1996; Moeran & Christensen, 2013). For the same reason, dynamic idea evaluation deploys an informal and ad hoc strategy in which actors negotiate ideas over time (for clarification, see Ulrich et al., 2015) rather than rating and selecting them using set parameters such as novelty and usefulness (e.g., Dean et al., 2006). This strategy helps one to identify a working solution over time by creating portfolios of self-similar ideas from the values identified in the evaluation content from other ideas. Hence, dynamic idea evaluation is open-ended in its outcome and deploys qualitative evaluation parameters to achieve this goal such as written or oral opinions about the ideas being evaluated (e.g., Ulrich et al., 2015). These qualitative evaluation parameters serve to help human actors negotiate ideas and creatively multiply them in and beyond the existing portfolio of ideas.

Cropley (2006) argues that convergent and divergent production need to coexist to be effective and suggests a creative production model that involves both. In the same fashion and as Figure 2 shows, dynamic idea evaluation focuses on creating knowledge in order to collect the necessary knowledge to support idea consolidation, which either convergent or divergent production influences. Idea consolidation is a process that gathers group knowledge from ideas and evaluation content in a common focus or theme (Aiken & Carlisle, 1992). Idea consolidation is convergent when the result is self-similar to the original ideas and divergent when the consolidation is combined with other knowledge and output a radically different concept (e.g., Cropley, 2006; Ulrich et al., 2015). Equally, human actors can use convergent production to transform and translate ideas and divergent production to radically redefine ideas to make them fit their own contexts (Ulrich et al., 2015). One can consider both as a form of bifurcation, where the idea changes its qualitative properties from one state to another (Schuldberg, 1999; Stacey, 1996).

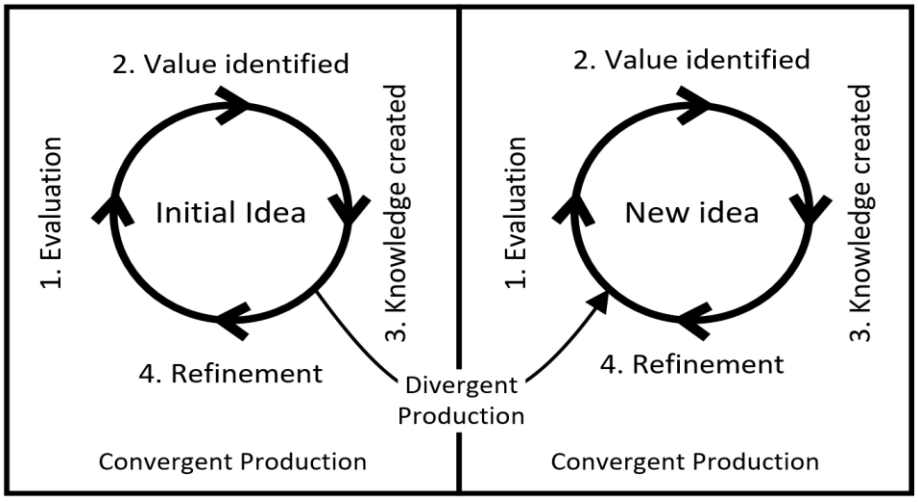

Figure 2. The Dynamic Idea-evaluation Process

For example, innovation managers can consolidate knowledge from ideas and evaluation content (represented as triangles in Figure 3) in the focus or theme of a particular innovation, which I define in this paper as an idea portfolio. Using Sternberg's (1999) view of knowledge, we can also define the idea portfolio as a specific domain that contains self-similar knowledge. Moreover, one can use identified knowledge to improve existing ideas using convergent production (Couger, 1996; Cropley, 2006; Isaksen & Treffinger, 1985). Moreover, dynamic idea evaluation reuses the existing knowledge (e.g., Cheung et al. 2008; Majchrzak et al., 2004) from ideas and evaluation content to enhance divergent production 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., Couger, 1996; Couger, Higgins, & McIntyre, 1993). As such, dynamic idea evaluation is embedded in the creative process where it iteratively crafts working solutions over time. At the same time, it reuses the generated knowledge for convergent production to improve existing ideas and for divergent production to generate novel alternatives.

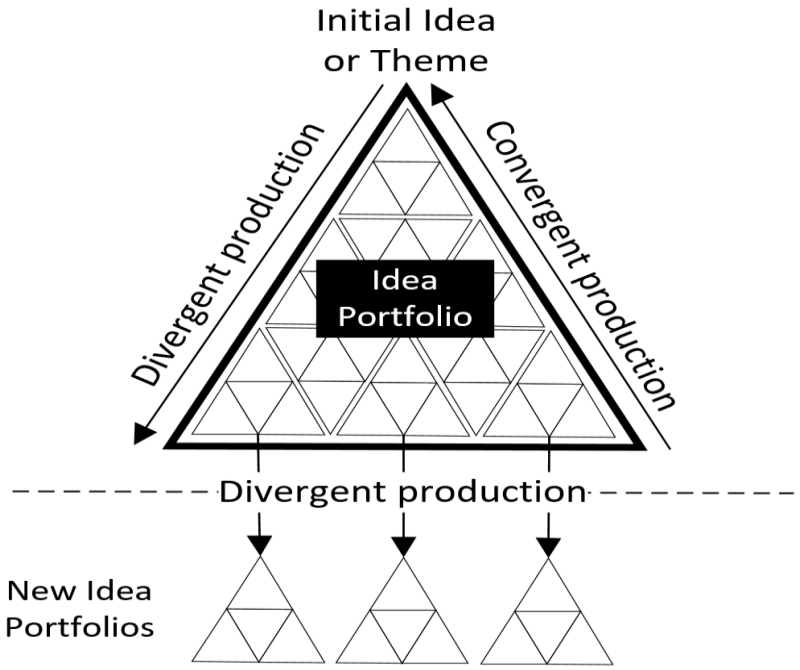

Figure 3. Portfolio Creation in Dynamic Idea Evaluation

As I elaborate throughout this paper, dynamic idea evaluation manifests in information systems that iteratively use ideas and evaluation content to support convergent and divergent production and, thereby, create idea portfolios and novel alternatives over time. In Section 4, I demonstrate and explore such a system.

4 Research Approach

Design theories are theories of action (Gregor, 2006) and can be applied in theorizing to guide learning and problem solving (Lee, Pries-Heje, & Baskerville, 2011). To explore dynamic idea evaluation, I deploy a DSR approach (Gregor & Jones, 2007; Hevner, March, Park, & Ram, 2004; March & Smith, 1995; Pries-Heje & Baskerville, 2008). Inspired by Baskerville and Pries-Heje's (2010) approach for explanatory design theories, the DSR approach demonstrates how initiated features satisfy theory-driven requirements. Moreover, I draw inspiration from Sein's et al., (2011) action design research approach by combining theory with practice. As such, the design theory does not follow a deductive and applied science approach as Gregor and Jones (2007) describe in which one translates kernel theories into principles of form and function and then evaluates them. Instead, the selected DSR approach is 1) inductive by combining theory with experiences collected from practice through continuous learning (Sein et al., 2011) and 2) iterative by identifying general requirements from the theoretical constructs and translating those into form and function (Baskerville & Pries-Heje, 2010). As such, the applied DSR approach is theory generating and explanatory where theory informs the design artifact and user participation in the design artifact informs theory.

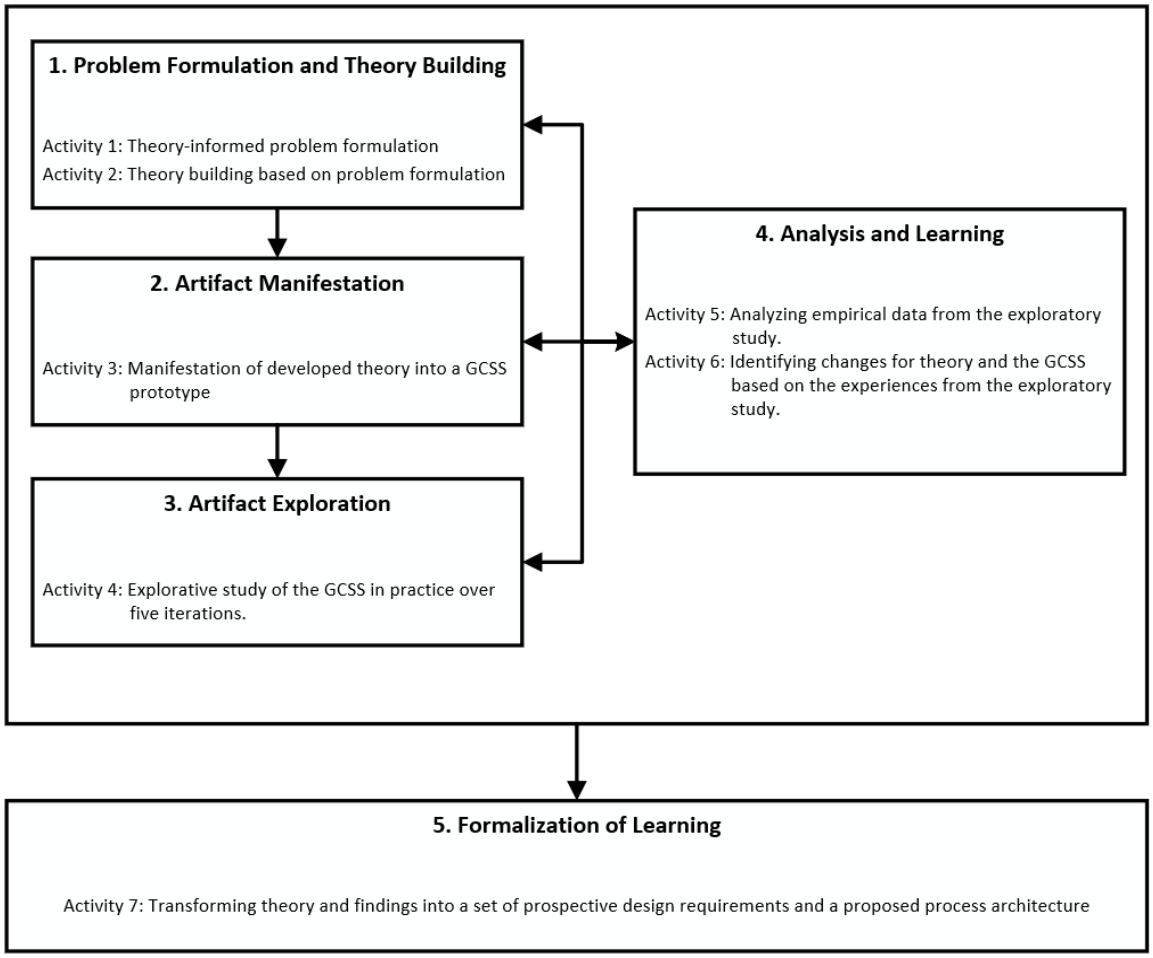

Figure 4. Research Approach (Adapted from Figure 1 in Sein et al., 2011)

As Figure 4 shows, the DSR approach contains five design processes with seven activities. For this study, in the problem-formulation and theory-building process (see Section 1), I outlined the research question with a theory-driven problem-centered initiation (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2008;

Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011) and developed a new theory on idea evaluation (see Sections 2 and 3). In the artifact manifestation (see Section 5), I integrated the theoretical constructs from dynamic idea evaluation in the design principles for the GCSS prototype trough material properties and guidelines for action (Chandra, Seidel, & Gregor, 2015). In the artifact-exploration process, I demonstrated the developed GCSS prototype in use and explored it with participant observation in a Danish research department (Bryman, 2004; Järvinen, 2004). In the analysis and learning process, I interpretively analyzed the findings from the explorative study (Walsham, 1993, 2006). Moreover, the exploratory study ran over five iterations. Hence, I continuously iterated on the findings and the experiences from the exploratory study (Peffers et al., 2008) to improve the developed theory and the GCSS manifestation. In the formalization of learning process (Sein et al., 2011), I finally translated the developed theory and findings from the explorative study and theoretically grounded them into a set of prospective design requirements and a proposed process architecture.

Researchers have previously used universities in a variety of different settings when studying IS-supported creativity (MacCrimmon & Wagner, 1994; Malaga, 2000; Massetti, 1996). Hence, I selected 15 members of a computer science department at a Danish University to participate in the exploratory study. To participate, the department had to have employed them 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. One of these three administrative personnel was the head of the department. To analyze the influence of practice, I also added two secretaries without research tasks to the study.

Within a selected case study (De Vaus, 2001; Yin, 2003), the participants used the prototype according to their practice and in their natural setting at the university. The participants first used an initial mockup prototype followed by a fully functional prototype. I inserted artificially data into the system only to help the participants to learn the systems functionalities at the beginning of the data collection, to follow up on significant changes made to the system, and to start the selected task after a training session. In total, I artificially added three challenges and a single idea to the data collection. Table 1 summarizes the design evaluation framework.

Table 1. 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 participants about this class of systems.	The participants learned to use the WoZ prototype and provide feedback on its functionality by evaluating an idea for a licorice-flavored ice cream.
2	1. To deploy a redeveloped PHP and MySQL prototype. 2. To reintroduce the participants to the redeveloped prototype.	The participants learned to use the redeveloped prototype by continuing their evaluation of the ice cream idea.
3	1. To introduce the participants to a specific real-world challenge.	The participants iteratively created and evaluated ideas for a new travel expense system.
4-5	1. To enable the participants to use the prototype freely.	The participants used the prototype at liberty.
6	1. Collection of final feedback from the participants using the prototype.	Open-ended interviews with the participants followed by the presentation of the results.

I constructed the procedure for collecting data around five iterations. However, findings identified when using the prototype may cause changes to its underlying construction (Voigt, Niehaves, & Becker, 2012). For this purpose, I developed an initial Wizard of Oz (WoZ) HTML prototypical initiation (Dahlbäck, Jönsson, & Ahrenberg, 1993; Hajdinjak & Mihelic, 2003), which enabled me (the “wizard”) to act as the system when collecting user input (see Green & Wei-Haas, 1985). The two initial iterations also functioned as learning stages to help the participants become familiar with the system (see Ulrich & Mengiste, 2014). The first iteration began with a challenge to identify new ice cream flavors and evaluate an idea for a licorice-flavored ice cream. Between the first and second iteration, I developed a functional prototype in PHP and MySQL. I made incremental changes to the prototype from the participants’ interactions with one another during the first iteration. During the second iteration, I reintroduced the participants to the new prototype due to its redevelopment. In the third iteration, I introduced the participants to a particular real-

world challenge for a new travel expense system while they controlled the fourth and fifth iteration. After the five iterations finished, I interviewed each participant using an open-ended approach (Saunders, Lewis, & Thornhill, 2003) to identify reoccurring patterns. Finally, the participants joined a 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, I collected 35 hours and 12 minutes of experiment and interview data. To emulate real-world applications, the participants participated randomly in each iteration (Järvinen, 2004). Three participants left the study after the first iteration (two participants left their position at the university, while a third left the study due to other time commitments).

Throughout the five iterations, I continually analyzed the collected data using a flowchart. To establish connections between the different ideas or their evaluation content, I asked the participants about the origin of their ideas. Thus, the participants became the reviewers of the data they provided. However, while the participants added some improvement ideas correctly, they also embedded other improvement ideas in their comments or added them as new ideas. I extracted these improvement ideas from the evaluation content. Following the data extraction, I compiled all ideas into Figure 9 (see Section 6). Moreover, I used a field experiment report (Yin, 2003) to continuously record data and time duration from each prototype iteration, interviews, and the focus group. I then analyzed the data using an interpretive approach (Walsham, 1993, 2006) by identifying reoccurring themes (Layder, 1998). Moreover, I supplemented the interpretive analysis with Sternberg's (1999) view about knowledge and the concurrent view on divergent and convergent production (Cropley, 2006; Guilford, 1967, 1977). With this approach, I could conduct an in-depth content analysis of the data to understand the prototypes influence on the participants' creative actions. I elaborate on the prototype in Section 5. I present and further discuss the analysis in Sections 6 and 7, respectively.

5 Design of the GCSS Prototype

In this section, the theoretical framing of dynamic idea evaluation is integrated in the proposed design artifact. As such, the design artifact is a manifestation of the theory put into practice. I constructed the GCSS prototype as an idea portal (e.g., Di Gangi & Wasko, 2009; Voigt, Bergener, & Becker, 2013). Table 2 explains how the dynamic idea evaluation has been manifested in the GCSS prototype. The design artifact manifestation is inspired by Chandra, Seidel, and Gregor's (2015) conceptualization of design principles as materiality (how the artifact is designed) and action (how the design is useful). In the conceptualization, manifestation replaces principle as I implement the design in the GCSS prototype. Figure 5 shows a screenshot from the front page of the prototype that lists the participants' ideas. Figure 6 is a mockup of the evaluation module. Finally, Figure 7 is the physical initiation of the evaluation mockup in the prototype (shown as a screenshot from the prototype). I elaborate on the form and function (Gregor & Jones, 2007) of the GCSS prototype in the following sections.

Table 2. How Dynamic Idea Evaluation is Manifested in the Initial Design Principles for the GCSS

Theoretical constructs	Dynamic idea evaluation	Design manifestation (materiality)	Design manifestation (action)
Creativity	Creativity refers to a multiplier that transforms, translates, consolidates, or radically redefines ideas.	The prototype features a design that includes a front page and an evaluation module.	Both modules facilitate creative multiplication by enabling the participant to create novel ideas from the evaluation content.
		The front page uses a hierarchical design.	The front page facilitates creative multiplication through scanning and browsing.
		The evaluation module features a design centered around a dynamic evaluation approach by embedding creativity techniques into the module.	The evaluation module guides negotiation through submission of evaluation content and facilitates creative multiplication during idea evaluation by using the evaluation content for creative activities.

Table 2. How Dynamic Idea Evaluation is Manifested in the Initial Design Principles for the GCSS

Divergent and convergent production	Divergent and convergent production include: A) Improvements of existing ideas. B) Identification of novel alternatives.	The prototype includes action buttons on the front page and in the evaluation module. These buttons open a dialog for creating improvements and original ideas.	Action buttons and creativity techniques facilitate both convergent and divergent production by using the evaluation content either by creating improvement ideas for existing ideas or original ideas for a new knowledge domain.
		The design of the evaluation module embeds digitalized creativity techniques (force field analysis and image and text stimuli). The creativity techniques use evaluation content to facilitate creativity.	
Knowledge creation	A dynamic and iterative focus on: A) Using the evaluation content to create original alternatives from the knowledge at hand. B) Improving existing ideas or consolidating them into portfolios.	The prototype features a design that facilitates knowledge creation using the front page and the evaluation modules.	One can generate new knowledge by creating new challenges, ideas, or evaluation content. One can create idea portfolios when forming novel challenges and when one creates ideas within the knowledge domain of those challenges.
		The hierarchical design list ideas within portfolios on the front page and continuously iterates the acquired knowledge. The force field analysis technique structures the evaluation content between problems and benefits. The image and text stimuli transform the knowledge into images and tag clouds.	Dynamic iteration of the acquired knowledge facilitates creative production by creating more ideas and more evaluation content.
Evaluation approach	Formative and iterative.	The prototype features a design around a formative and iterative process that integrates idea evaluation as a part of the creative production.	Evaluation of ideas can happen at any time during the creative process. Easy transitions between evaluation and idea generation.
Evaluation strategy	Informal and qualitative.	The prototype uses open-ended evaluation parameters such as benefits and problems.	The open-ended evaluation facilitates informal evaluation that guides negotiations.
		The prototype features a design that support easy browsing between ideas and their evaluation content.	Easy browsing facilitates idea generation and idea evaluation. Removes barriers between idea generation and idea evaluation.
		The prototype mainly uses qualitative and open-ended qualitative information. This includes commentary input and identification of problems and benefits.	Qualitative evaluation guides negotiations and increases ability to explore multiple ideas by removing fixation on ideas with high quantitative scores.

5.1 Multiplying Ideas

I designed the GCSS prototype to multiply ideas when the participants evaluate, negotiate, and create novel alternatives from the knowledge derived from the ideas and the evaluation content (see Ulrich et al., 2015). Multiplication has the following functionality: when the participants use the prototype, they can create challenges that may lead to ideas. Those ideas may lead to evaluation. The evaluation can generate knowledge about the value of the ideas and the context surrounding the ideas. The participants use this knowledge to negotiate the outcome of the ideas. However, participants can also iterate on the knowledge to create novel challenges and ideas when they transform, translate, consolidate, or radically redefine the ideas.

To support multiplication, the prototype has two main parts: the front page (see Figure 5) the evaluation module (see Figures 6 and 7). First, when people use information systems, they can scan and browse the content for known items, look for specific topics, inspect content, and identify useful items (Belkin, Marchetti, & Cool, 1993). One can use this process of scanning and browsing to enhance creative

production (Müller-Wienbergen et al., 2011). Hence, I designed the front page facilitate scanning and browsing of the submitted ideas by listing challenges and ideas hierarchically. Thus, with the hierarchical design, scanning and browsing will ideally facilitate a participant's informal idea evaluation and their creative production when they identify useful ideas or topics and can relate them to their own practice (e.g., Müller-Wienbergen et al., 2011).

Second, as Ulrich et al. (2015) exemplify, evaluation is a sensemaking process that guides negotiation and action. Hence, the evaluation module guides negotiations between the participants by using a *formative* approach and by using *informal*, ad hoc, and *qualitative* evaluation. Moreover, the evaluation module guides action and, thus, divergent and convergent production by embedding creativity techniques directly into the evaluation module. I describe this design approach in Section 5.2.

5.2 Convergent and Divergent Production

The GCSS prototype facilitates both convergent and divergent production. The participants can work convergently in existing ideas by generating improvement ideas that improve existing ideas. They can also work divergently by proposing novel ideas for a challenge or by initiating a new challenge that might spawn a new portfolio of ideas (see the “create new idea” action button in Figure 5). When the participants create any improvement ideas (see the “add new improvement” action buttons in Figure 6 and 7), the prototype will facilitate convergent production by using the knowledge around that content. However, the prototype can also promote divergent production through the knowledge embedded in the existing ideas and evaluation content. This approach removes limitations of standard idea improvements and allows one to develop novel ideas with far wider capabilities.

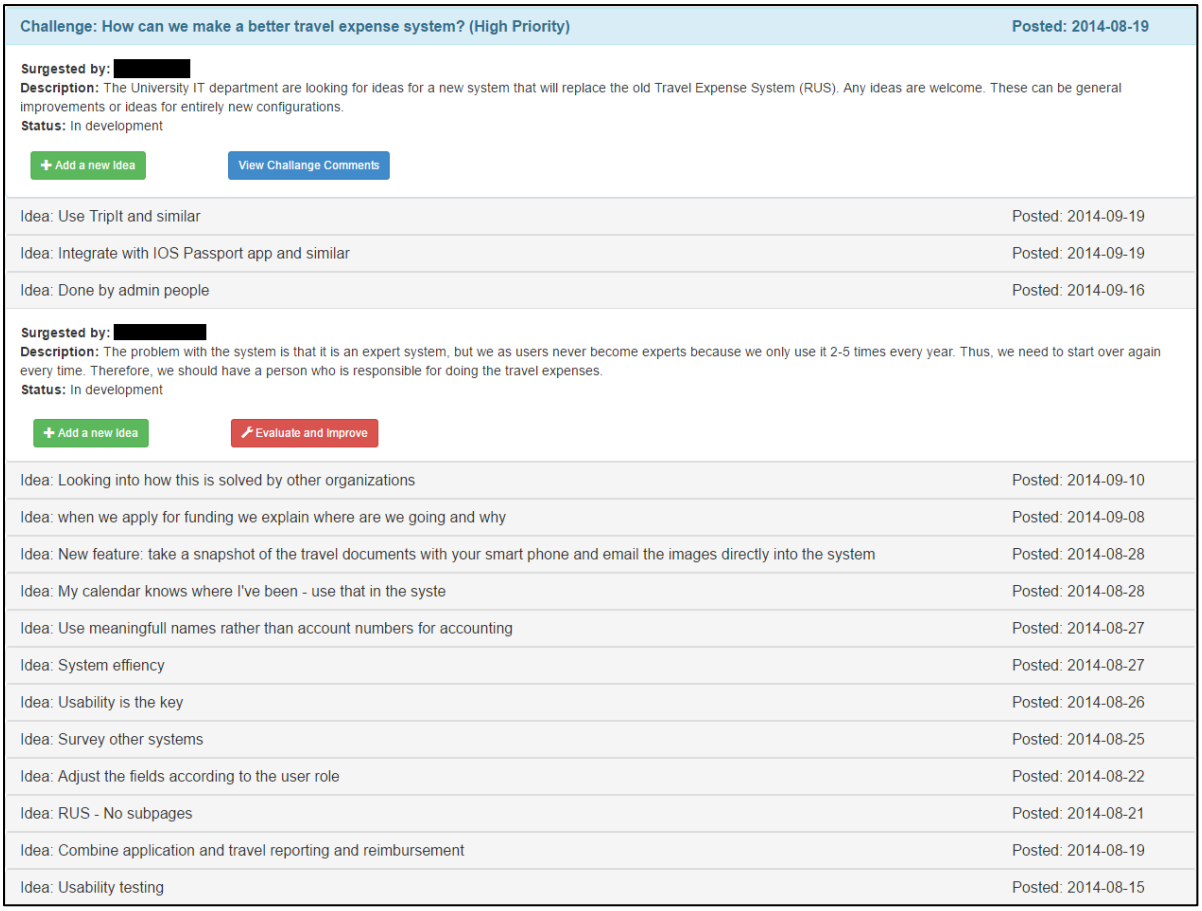

Figure 5. The Front Page

To facilitate divergent and convergent production, the evaluation module includes creativity techniques (see Figures 6 and 7). A substantial body of literature has examined the use of creativity techniques (Couger, 1996; Couger et al., 1993; Maiden, Gizikis, & Robertson, 2004; Osborn, 1953) and the

digitalization of those techniques (Dennis, Aronson, Heninger, & Walker, 1999; Hender, Dean, Rodgers, & Nunamaker, 2002; Lubart, 2005; Malaga, 2000; Yuan & Chen, 2008). Modern creativity techniques are inspired by the early development of brainstorming (Osborn, 1953). Since then, researchers and practitioners have developed several hundred techniques (see mycoted.com). Force field analysis encourages creative production in idea evaluation by collecting user input (Couger, 1996). Couger's (1996). This evaluation and creativity technique identifies benefits and problems associated with an idea (see “add benefit”, “add problem”, and “add new comment” buttons in Figures 6 and 7). The technique also enables the participants to suggest improvements from the presented evaluation content (see the “add new improvement” buttons in Figures 5 and 6). I modified the force field analysis technique to fit the design of the prototype. Furthermore, I embedded word and image stimuli (Malaga, 2000) into the prototype. Besides the manually added tags (see “tags” in Figures 6 and 7), the system can automatically generate a random tag cloud from the added content (see the tag cloud at the top of Figures 6 and 7). When a participant clicks on a manually or auto-generated tag, they are transferred to a Google image search for that tag. From this image search, the participants can locate associated images that can improve their creative production.

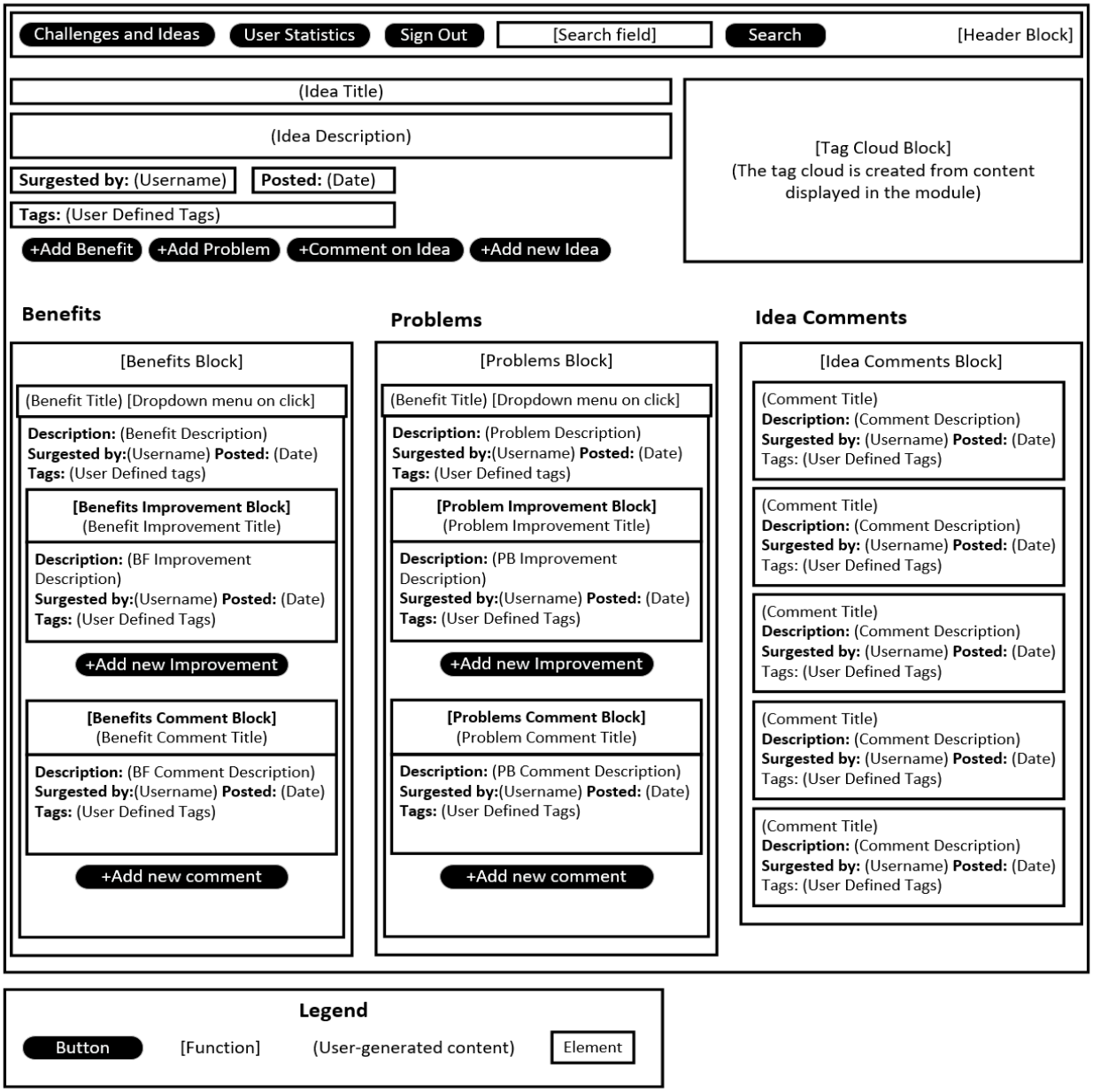

Figure 6. Mockup of the Evaluation Module in the GCSS Prototype (See Full Feature List in Appendix A)

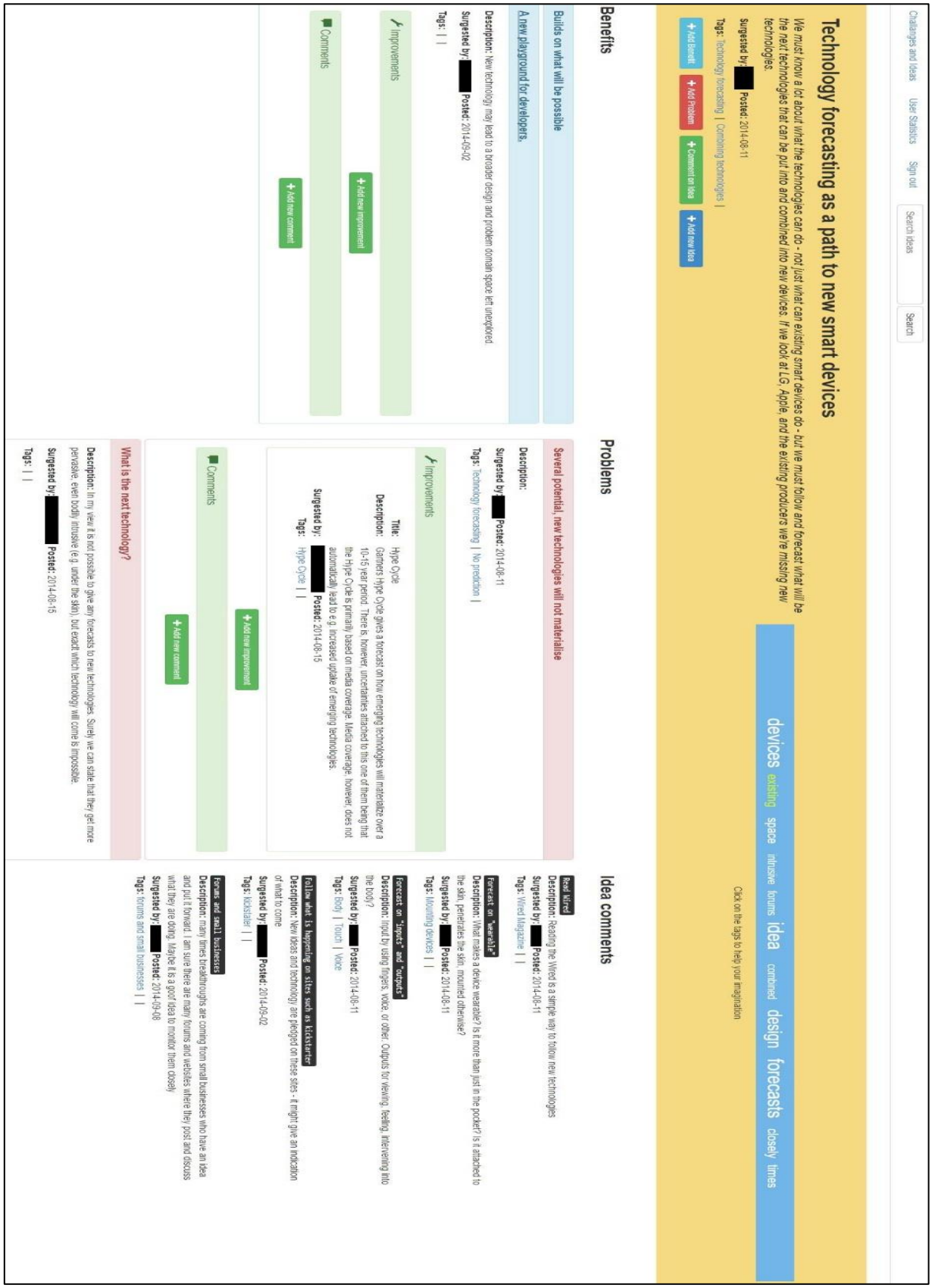

Figure 7. Screenshot of the Idea-evaluation Module

5.3 The Focus is on Dynamic and Iterative Knowledge Creation

I designed the GCSS prototype to facilitate knowledge creation during evaluation. As Figure 8 shows, the prototype draws on both Ulrich's et al. (2015) conceptualization of creativity as a knowledge multiplier and Sternberg's (1999) view on knowledge domains and creativity. In this paper, I also define these knowledge domains as idea portfolios and represent them as challenges in the prototype (Figure 5). The idea portfolio (the knowledge domain) comprises the challenge, the created ideas, their evaluations, and any improvement ideas. When a participant uses the front page to create a new challenge, others can create new ideas and then use the evaluation module to evaluate those ideas. The embedded creativity techniques and hieratical design of the front page then iterate the acquired knowledge from the created ideas and their evaluation content back into improvement ideas, new challenges, and new ideas. Hence, the prototype is a dynamic, iterative process that combines the knowledge generated with the participants' own memory storage to facilitate creative production. The creative outcome can either be in an existing knowledge domain by adding ideas for an existing challenge or a completely new knowledge domain by creating a new challenge. This GCSS design is in line with Ulrich's et al. (2015) idea of creative multiplication. The prototype multiplies ideas when the participants negotiate ideas during the evaluation and use the presented knowledge to transform or translate those ideas using convergent production or consolidate or radically redefine them using divergent production. Using Sternberg's (1999) view, the knowledge creation can happen in the GCSS during evaluation when the participants view the knowledge in a new light, reconstruct it, redirect it, transfer it, extend it to a new domain, migrate it and so extend the borders of the domain, or radically redefine it to a new domain.

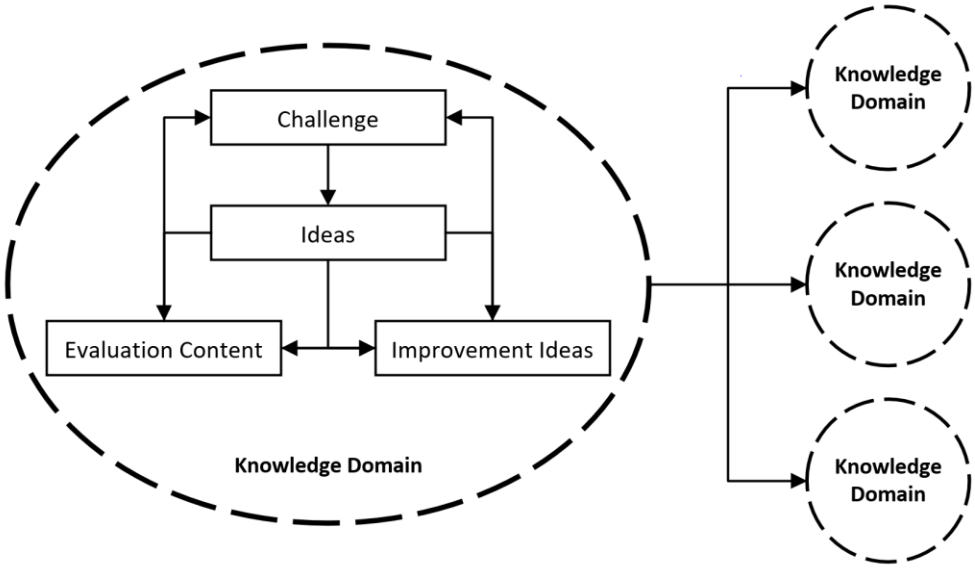

Figure 8. The Knowledge-creation Process in the GCSS Prototype

5.4 The Evaluation Approach is Iterative and Formative

The GCSS prototype helps individuals to formatively and iteratively evaluate ideas during creative production. As Figure 5 shows, the participants can click on the "evaluate and improve" button when they create a new idea. They can take the same actions when they click on an existing idea, which opens a drop-down menu with new options. This button leads them to the evaluation module (see Figure 6 and 7) where they can continuously evaluate the idea, improve it, or be inspired to create novel alternatives. Hence, the evaluation process is formative because the design of the prototype inserts idea evaluation directly into the creative process and uses the evaluation to iteratively facilitate the creative production. This design also facilitates easy transitions between evaluation and creative production.

5.5 The Evaluation Strategy is Informal and Ad Hoc

The GCSS prototype facilitates an evaluation strategy that guides negotiations between the participants (see Ulrich et al., 2015). Hence, the prototype does not use quantitative evaluation parameters that can

measure specific qualities such as rating scales for novelty and usefulness (e.g., Dean et al., 2006; Riedl et al., 2010). Instead, idea evaluation in the prototype is informal in that it uses evaluation parameters that collect open-ended qualitative information. Such parameters can be benefits and problems (e.g., Couger, 1996) that can provide a range of information about the ideas including knowledge about their novelty and usefulness (see the “benefits block” and “problems block” in Figures 6 or 7). To compare the qualitative evaluation with quantitative ratings, I tested a simple quantitative voting system in the WOZ version of the prototype. However, this voting system tended to reduce the participant's exploratory abilities because they would focus their attention on ideas with a higher score. Hence, I removed the scoring system.

Figures 5, 6 and 7 exemplify this evaluation strategy. When a participant adds a new idea (see “add new idea” in Figure 5), other participants can activate the evaluation module by clicking on the idea and then the “evaluate and improve” button in Figure 5. When clicking on this button, the participant opens the evaluation module (see Figure 6 and 7). From the evaluation module, the participants can evaluate the idea by adding comments and suggesting potential benefits and problems (see the “idea comment block”, the “benefits block”, and the “problems block” in Figure 6). Moreover, the participants can comment on those submitted benefits and problems to provide additional knowledge to enable other participants to create new improvements for the evaluated idea or proposed challenges and ideas (see the “add new comment” button in benefits or problems block in Figure 6). In both benefits and problems, the participants can propose improvement ideas to problems or ideas that expand the listed benefits (see the “add new improvement” button in benefits or problems block in Figure 6). The participants can also supplement the added content with word tags (see “user-defined tags” in Figure 6).

6 Exploring Dynamic Idea Evaluation in the GCSS Prototype

In this section, I analyze the results from using the GCSS prototype. I explore dynamic idea evaluation in relation to divergent and convergent thinking and relate it to the existing literature on knowledge creation. As a result, I produce a set of four design requirements and a process for facilitating dynamic idea evaluation in GCSS.

6.1 Results from Using the GCSS Prototype

During the five iterations, I added 64 ideas and ten improvement ideas over 12 challenges to the prototype. I added three challenges and one idea to facilitate the study. Moreover, the 15 participants 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, I extracted 26 improvement ideas during the post-analysis of the data. In total, the participants added 294 entries to the prototype over the five iterations.

6.2 Divergent and Convergent Production in the Travel of Knowledge

Figure 9 illustrate the workings of divergent and convergent production (Guilford, 1967, 1977) and the travel of knowledge in or between domains (Sternberg, 1999). The figure shows the relationships between challenges and ideas that the participants created during the five iterations. The numbers list the individual challenges and ideas with reference to Appendix B. The challenges (blue circles with dashed borders) contain an outer border of their knowledge domain (blue circles with straight borders). These domains include the ideas for each challenge and evaluation content for the challenges themselves (green circles at the edge of the blue circles). The ideas (white circles) have their knowledge domain concerning evaluation content (green circles in the white circles) and improvement ideas (yellow and purple circles).

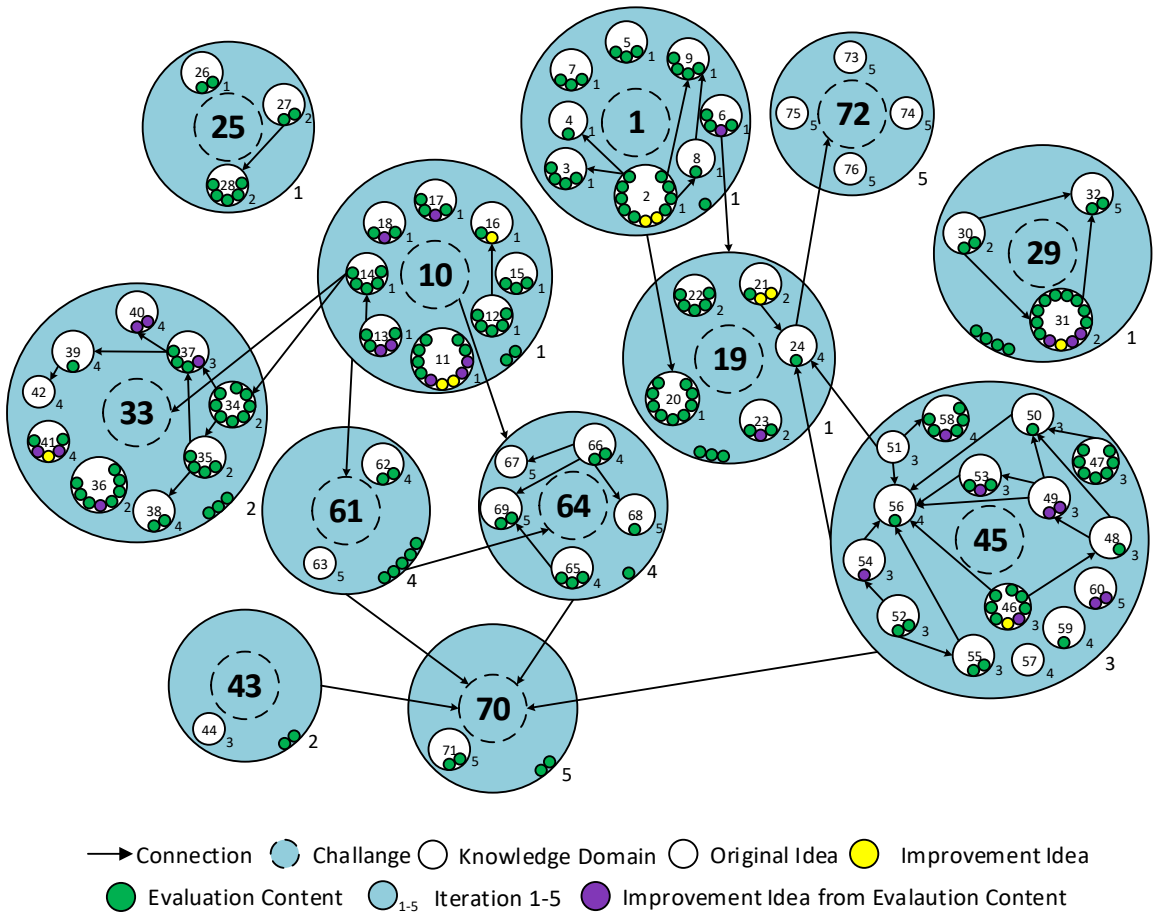

Figure 9. Context Map Showing Connections Between Knowledge Items and Domains

6.2.1 The Extension of Borders

Extracted from Figure 9 and Sternberg's (1999) view on knowledge, the participants' divergent production extended the borders of each knowledge domain surrounding the challenges. This divergent production occurs when participants act on a specific challenge by adding novel ideas. For example, one participant 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 experiences and practice and the challenge at hand. In the same challenge, another participant created two ideas in the third iteration. The participants identified knowledge embedded in a discussion on efficiency in an existing idea (52), which triggered him to reflect on his practice and enabled him to generate two novel ideas (54 and 55) that could make the travel expense system more efficient.

6.2.2 The Extension of Knowledge Domains

The participants' divergent production would also extend a domain by applying missing information. For example, one participant scanned the added ideas in the challenges of the travel expense system (45). Evaluating these ideas helped him to place value the current knowledge he was experiencing. This process enabled him to reflect on his practice and propose a new idea (56) that was missing in the domain. Also, another participant 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. Guilford (1977) considers the production divergent when one provides novel alternatives from the available knowledge. Hence, the participants used divergent production when they evaluated existing content according to their personal experiences and desire for change and alternative practices.

6.2.3 The Transfer of Knowledge From one Domain to Another

The participants' 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 participant 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 sports clubs at the university. Hence, he created an idea for a website for the university sports clubs (24).

6.2.4 The Creation of New Knowledge Domains

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). In 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 the evaluation and his practice as a former student enabled him to create a new challenge about a way to improve campus life for students (19).

6.2.5 Maintaining the Borders of the Domain

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

I deliberately inserted two participants into the study because they did not share day-to-day duties with the other participants. The first participant left the study after the first iteration. The second participant added a challenge and an idea on improving an administrative system that only she used (43 and 44). The other participants mostly ignored the content this second participant added because they could not correlate that content to their practice.

Overall, the prototype had the capability to support both divergent and convergent production despite including idea evaluation in the creative process. The findings concur with Sternberg's (1999) view on knowledge and Guilford's (1967, 1977) conceptualization of divergent and convergent production.

6.3 Design Requirements for a GCSS Facilitating Dynamic Idea Evaluation

Design requirements or meta-requirements "describe the class of goals to which the theory applies" (Walls, Widmeyer, & El Sawy, 1992, p. 42). The purpose of design requirements are, as Gregor and Jones (2007, p. 325) explain them, to describe a "whole class of systems" that can be created within the boundaries of the selected theory. These design requirements differ from the initial design manifestation listed in Table 2 by providing generalized requirements for future initiations of this class of artifacts. Hence, to guide future design of GCSS's supporting dynamic idea evaluation, I analyze the findings from using the GCSS prototype in comparison with the existing literature and list them as four design requirements.

6.3.1 Design Requirement 1: Use Evaluation to Acquire New Knowledge about Submitted Ideas

The participants used information gathering for different purposes. During the first iterations, some participants relied on their memory storage (practices and experiences) (see Guilford, 1977) to add information to other ideas by adding evaluation content (benefits, problems, and comments). This activity provided them with a safe starting point to participate in this study. Later, they became more confident with idea development and added ideas on their own. Other participants used the evaluation process to elaborate on their ideas by adding evaluation content. In one example, this ability to self-evaluate provided a participant enough insight into his idea to enable him to refine it before presenting it to the others. The participant who self-evaluated also wanted to link different ideas together. As Cropley (2006) and

Sternberg (1999) exemplify, knowledge can spark creativity in various ways (for example, by transferring ideas between different domains). Ideas are "textual, aural, or visual" representations (Lindic, Baloh, Ribiere, & Desouza, 2011, p. 183), and characterized by recombining and applying knowledge in novel ways through new discoveries (Burt, 2004; Hesmer, Hribernik, Hauge, & Thoben, 2011; Weitzman, 1998). As such, novel ideas depend on expert knowledge and problem-solving skills (Amabile, 1998). Luckily, idea evaluation is a knowledge-generating activity that can identify key issues in ideas and communicate those issues to others (Lindic et al., 2011; Weitzman, 1998). Consequently, I recommend the following design requirement:

DR1: Use evaluation to acquire new knowledge about submitted ideas. In a GCSS that facilitates dynamic idea evaluation, collect the knowledge embedded in the participants' memory storage. Such knowledge can be known problems, benefits, and other key issues connected to the evaluated idea.

6.3.2 Design Requirement 2: Deploy Idea Evaluation in the Early Stages of Idea Development to Facilitate Idea Bifurcation from the Collected Knowledge

From the first iteration, the participants connected knowledge embedded in evaluation content to existing ideas and their own memory storage. They used this knowledge to create improvement ideas (convergent production) and original ideas with entirely new properties (divergent production). During the five iterations, I identified five different processes of divergent or convergent production:

1. Divergent production of novel ideas by evaluating and connect knowledge in existing ideas to their memory storage: the participant would continuously evaluate existing ideas, connect the knowledge to their memory storage, and create novel ideas—even for unrelated challenges. For example, one participant proposed an idea about road pricing after recently completing her income tax forms (see idea 39 in Appendix B). By connecting these two knowledge items and the knowledge from the challenge, she used divergent production to transfer the idea of road pricing to an idea on tax-free bike rides (idea 42).
2. Divergent production of novel ideas by scanning for requirements: the participants would scan all existing ideas in a specific challenge and suggest a missing novel idea in that context. For example, one participant continuously evaluated the titles of ideas under existing challenges to identify missing ideas. She then added those missing ideas.
3. Divergent production of novel ideas by identifying loose and vague structures in existing evaluation content (comments and problems and benefits). In several instances, the participants would use existing evaluation content to create novel ideas and new challenges. In the first iteration, an improvement idea embedded in a comment on the idea of having "ice cream stands for each zip code" (idea 6) inspired a participant to create a new challenge for "engaging students out of classroom activities". From this challenge, other participants created five new ideas (idea 20-24). Over the remaining four iterations, these ideas worked similarly as an inspiration for new challenges and ideas.
4. Convergent production by establishing narrow searches for requirements: during all the iterations, the participants added in total 36 improvement ideas during the idea evaluation. Participants produced all these ideas from evaluating ideas by reviewing comments and identifying benefits and problems for specific ideas. Moreover, every improvement idea was incremental and, hence, convergent because the participants created small changes to existing ideas and, thereby, identified narrow knowledge patterns from their memory storage. For example, one participant created a novel idea on "usability testing of the travel expense system", while another participant expanded this idea with an improvement idea of "including user testing in the usability evaluation".
5. Divergent production by forming large quantities of alternative ideas: the participants would use their knowledge storage to add specific ideas to the suggested challenges without using the evaluation content. For example, one participant immediately created a new idea grounded in his experiences, while another participant never participated in evaluation activities. Instead, he relied on his practice and the knowledge embedded in the initial challenges to create novel ideas. Thus, the placement of idea evaluation in the creative process never became an obstacle for facilitating traditional divergent production.

These five different processes of divergent or convergent production include bifurcation. Bifurcation is well known in the organizational literature (Dhillon & Fabian, 2005; Fitzgerald, 2002; Guo, Vogel, Zhou, Zhang, & Chen, 2009; Hung & Tu, 2011; McBride, 2005; Samoilenko, 2008; Schuldberg, 1999; Thiétart & Forgues, 1995). It explains how systems (e.g., ideas) changes from one state into another; for example, from stability to instability (Schuldberg, 1999). When fresh knowledge leads to new insights (Clark, 1996), the outcome can be overwhelming (Dhillon & Ward, 2002; McBride, 2005) and trigger bifurcation and divergent production. As such, bifurcation can be the tipping point where novel input spins the system out of control if not countered by stabilizing actions that counter the introduced changes (McBride, 2005; Schuldberg, 1999). Hence, bifurcation explains the creative activities that occur during dynamic idea evaluation. The purpose of dynamic idea evaluation is to identify the value of existing ideas to facilitate creative production and a working solution over time. Moreover, creative systems are foremost chaotic as the outcomes are often unknown (Stacey, 1996). They are considered unpredictable, but they also encompass "stages of generativity and consolidation, incubation, and elaboration" (Schuldberg 1999, p. 186). Thus, when facilitating creative production, instability is a positive effect. When ideas bifurcate during dynamic idea evaluation, it does create instability in the ideas through continuous generativity. However, it also helps to consolidate, incubate, and elaborate on them. As the five presented processes show, such bifurcation can occur when the participants create novel ideas that originate from or are a combination of existing ideas, the participants' memory storage, evaluation content, or the presented challenges. Consequently, I recommend the following design requirement:

DR2: Deploy idea evaluation in the early stages of idea development to facilitate idea bifurcation from the collected knowledge. In a GCSS, that facilitates dynamic idea evaluation, include evaluation in the early stages of idea development. Early access to idea evaluation may introduce instability from the acquired knowledge, which may trigger early bifurcation of the submitted ideas.

6.3.3 Design Requirement 3: Deploy Specialized Creativity Techniques to Enhance the Novelty of the Creative Output

I implemented three creativity techniques in the prototype: two standard creativity techniques (word and image stimuli) and one creativity technique specifically developed for idea evaluation (force field analysis). Observations during the five iterations and the post-interviews showed that a GCSS facilitating dynamic idea evaluation requires creativity techniques developed specifically for this type of evaluation. Even though word and image stimuli worked to motivate divergent production for some participants, the majority never used these techniques despite their training in them during the first two iterations. However, the participants used the force-feedback technique frequently throughout the five iterations. An explanation for why participants used the specialized force field analysis technique may be its integration into the value-creation process of idea evaluation. The participants simply needed the technique to add value to the ideas they evaluated.

However, even small changes in structuring or configuring creativity techniques in a digitalized form can have profound effects on the creative outcome (Dennis et al., 1999; Hender et al., 2002; Malaga, 2000). For example, Aiken, Vanjani, and Paolillo, (1996) compared two electronic brainstorming techniques and found scant differences in the creative outcome between the two techniques. As the use of the GCSS prototype shows, digitalization of specialized creativity techniques for idea evaluation is key to motivate divergent and convergent production. These techniques should be easily intergraded in the IS design and be able to simultaneously facilitate idea evaluation and creativity production. Consequently, I recommend the following design requirement:

DR3: Deploy specialized creativity techniques to enhance the novelty of the creative output. In a GCSS that facilitates dynamic idea evaluation, include specialized creativity techniques that can facilitate divergent and convergent production while supporting idea evaluation.

6.3.4 Design Requirement 4: Design Iterative Evaluation Processes that can Switch between Divergent and Convergent Production

I constructed the GCSS prototype to support divergent and convergent production during the value creation in idea evaluation. However, during the last part of the study, some participants experienced a lack of purpose in the different ideas and needed a better way to select ideas and create solutions. Their observations indicated a flaw in the design through the absence of possibilities to use their convergent production abilities. In his seminal defense of convergent production, Cropley (2006) explains that

divergent and convergent production needs to coexist to be effective. Divergent production transforms and reinterprets while convergent production prefers simplicity and rules. Thus, divergent production can result in overconfident breakthroughs and worst-case disastrous changes. Convergent production used alone can equally lead to missed opportunities and stagnation. Hence, convergent and divergent production need to coexist in a healthy environment to produce both novel and effective solutions.

Agile software development researchers widely recognize that iterative work allows one to continuously improve software products (Rose, 2011). More recently, Aaen (2008) proposed a different alternative for software development called ESSENCE (essence.dk) in which creativity is part of every aspect of software development and not constrained to the initial creation of product specifications. You (1993) raised similar critique by questioning the linearity of evaluation. Instead, he proposed that creative and evaluative processes should be 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 & Mead, 1990; You, 1993), whereas the discovery of new information can trigger bifurcation where divergent production introduce instability and pull the idea toward new novelty (Richards, 2001; Schuldberg, 1999; Stacey, 1996; You, 1993). Hence, iterative balancing of divergent and convergent production is imperative during value creation in idea evaluation. Moreover, better integration of iterative evaluation process and balance divergent and convergent production in the GCSS design and may help to improve the creation of idea portfolios over time. Consequently, I recommend the following design requirement:

DR4: Design iterative evaluation processes that can switch between divergent and convergent production. In a GCSS that facilitates dynamic idea evaluation, include iterative processes that can facilitate a healthy environment for divergent and convergent production.

6.4 A GCSS Process Architecture for Dynamic Idea Evaluation

Next, I translate the design requirements into a process architecture that a GCSS for dynamic idea evaluation should contain (see Gregor & Jones, 2007; Müller-Wienbergen et al., 2011). The result is an IS artifact that facilitates divergent and convergent production by including creativity-enabling events in the architecture. In the following paragraphs, I explain an approach to the "blueprint" of the IS artifact (Gregor & Jones, 2007, p. 326).

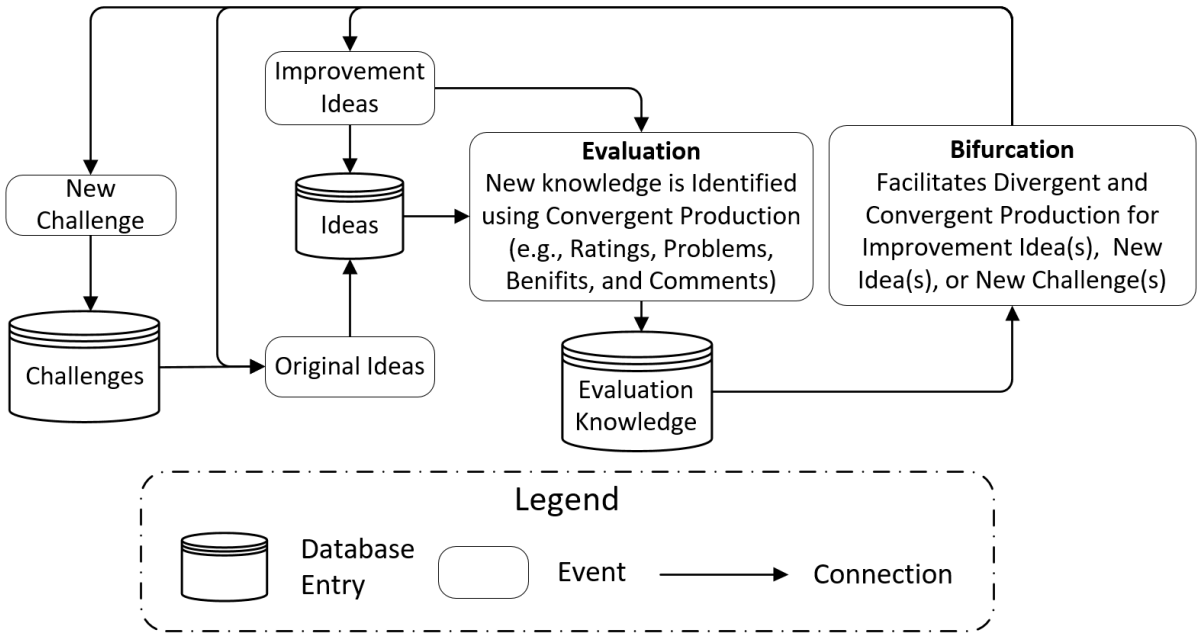

Figure 10. The GCSS Process Architecture

Figure 10 demonstrates the suggested architecture for a GCSS that facilitates dynamic idea evaluation system that facilitates divergent and convergent production through an iterative process (DR4). 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. Depending on the entry point of the participant, their starting point in the iterative process can be a challenge, an idea or improvement idea, or some of the evaluation content.

The proposed process architecture helps one identify overall challenges and create novel and improvement ideas. The system stores novel ideas and their improvements in a database. Moreover, the process architecture can include digitalized creativity techniques that can bifurcate existing knowledge and facilitate divergent and convergent production (DR3).

When a participant develops a novel idea, the GCSS aids the evaluation process by collecting participant input (e.g., ratings, comments, and identified problems and benefits). Moreover, the participant can add new information to the existing knowledge by, for example, commenting on problems and benefits associated with a given idea (DR1).

The evaluation process focuses on creating a state of bifurcation using creativity techniques (DR2). In the suggested process architecture, the creativity techniques can help participants' convergent production by, for example, solving problems or strengthening benefits in the initial idea (DR3). Similarly, the bifurcation of ideas created through this creative process can inspire further divergent production (e.g., when they identify transfer knowledge to a different domain by creating new challenges).

7 Discussion

To answer this study's research question (i.e., "How can a dynamic and iterative idea evaluation process be designed into a group creativity support system (GCSS) to facilitate creative production?"), I initially theorized dynamic idea evaluation and deployed a DSR approach to materialize theory into a GCSS prototype. Subsequently, I conducted an exploratory study to demonstrate the GCSS in a practical setting and interpretively analyzed it. Finally, I translated the results from exploring the prototype into four design requirements and a process architecture. Throughout the explorative study, I identified patterns of divergent and convergent production.

The results from the explorative study concur with Sternberg's (1999) view on knowledge. First, divergent production occurred when the participants extended the borders of each knowledge domain that surrounded a challenge. In this situation, divergent production occurred when the participants created ideas for challenges from the knowledge they identified in another challenge. Second, the ideas apparently shifted context and branched out by deploying existing knowledge in novel ways. Moreover, ideas expanded the knowledge domain of the challenge. Supported by Cropley (2006), such production is divergent when it crosses boundaries. Third, participants transferred knowledge from one domain to another by creating novel ideas from one challenge using knowledge identified in another. The activity was divergent when participants crossed these boundaries. In addition, the participants produced 64 unique ideas during the five iterations. Guilford (1967) defines this ability to generate multiple novel ideas for a specific domain as fluency—a clear sign of divergent production.

During the field study, I identified several signs of convergent production (e.g., when the participants suggested improvements to existing ideas). According to Cropley (2006), convergent production applies what is known and stays within borders. The results concur with Cropley's (2006) and Sternberg's (1999) views because the participants' production was convergent when they remained within the domain of the idea and only applied incremental changes. The study demonstrates that supporting divergent production is not enough. In his seminal defense of convergent production, Cropley (2006) explains that convergent and divergent production must support each other to produce novel and effective solutions. Overall, the field study demonstrated that it is possible to create a GCSS that use dynamic idea evaluation to enable the participant's divergent production. Facilitating divergent production is especially plausible if designers insert idea evaluation into an iterative creative group process and support it with specialized creativity techniques.

This paper raises some fundamental question about how current evaluation processes are structured. Osborn (1953) has argued that evaluation should be excluded from the creative process whereas Guilford (1977) has argued that formal evaluation may reduce information retrieval from memory storage and should not be included in divergent production. Even though these claims are not empirically supported, researchers such as Elam and Mead (1990) and practitioners such as Osterwalder and Pigneur (2010)

have taken Osborn's and Guilford's views even further and suggested that idea evaluation can only support convergent production due to its emphasis on deduction and decision making. Even though recent studies using ethnographic research have challenged this view (Moeran & Christensen, 2013), we have limited empirical backing for excluding or including evaluation in creative activities. Without claiming exhaustiveness, current research may have overlooked an important connection between the knowledge-creation processes of idea evaluation and divergent production. This study 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 resulted in their divergent production of novel ideas. Moreover, the study demonstrates the potential of structuring an iterative creative and evaluative process, which is transferable to a GCSS.

These findings entail several recommendations for future branches of studies and practice. GCSS researchers and practitioners can use the results and lessons learned from the study to rethink how they deploy idea evaluation in their creative process. Using design science research (Gregor & Jones, 2007; March & Smith, 1995), others can extend this paper's results into additional design requirements, constructs, and principals of form and function for this class of systems. Moreover, I adopted the applied DSR approach with inspiration from Sein's et al.'s (2011) and Baskerville and Pries-Heje's (2010) seminal contributions to build the design artifact and iterate findings from practice back to theory building. Without calming exhaustiveness, this applied DSR approach shows that one can use DSR beyond applied science by inductively using the artifact design to support theory building and identify new theoretical discoveries during the artifacts demonstration in practice. Hopefully, this paper can inspire future DSR research on theory-building and explanatory-design practices.

Finally, this study features a range of uncertainties that future research can address. For example, I show that specialized creativity and evaluation techniques benefitted creative production when used in the GCSS design. However, the overall influence of human-computer interaction on the creative output remains unexplored. Moreover, observing the participants using the GCSS prototype showed how participants would create idea portfolios within a specific challenge. Researchers and practitioners should use this finding to shift their focus from pursuing one great idea (e.g., Girotra et al., 2010; Kudrowitz & Wallace, 2013) 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 truly use the power of the crowd by building novel solutions from extensive knowledge-creation processes.

8 Conclusion

Existing research in idea evaluation and GCSS has not approached idea evaluation as a divergent process that could create new novel concepts. Instead, it has focused on supporting evaluation schemes that only included convergent production. In this paper, I provide a shift from this traditional view on idea evaluation by presenting an alternative view that integrates idea evaluation directly into the creative process. I demonstrate that the GCSS prototype can use the knowledge collected through a dynamic idea evaluation approach, which triggers participants' memory storage and facilitate their divergent and convergent production. Moreover, the findings resulted in four design requirements and process architecture that can improve this class of systems. These results encompass several implications for future research, including rethinking the current views about idea evaluation and suggestions for conducting future empirical research to guide further development of dynamic idea evaluation. Overall, this paper presents an interesting shift in research in that researchers can embed GCSS-driven idea evaluation into the creative process. Hence, the design theory and findings from this paper can initiate and guide future research and practice in GCSS and idea evaluation. I encourage researchers 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 novel state-of-the-art systems.

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Appendix A: Feature List of the Evaluation Module in the GCSS Prototype

Table A1. Feature List of the Evaluation Module

Feature	Purpose	Listed (Figure 5)
Header	The header of the prototype, displaying a menu across multiple pages.	(Header block)
Challenges and ideas button	Brings the user back to the front page.	Challenges and ideas button
User statistics button	Displays the amount of content the users have posted.	User statistics button
Sign out button	Enables the users to exit the session.	Sign out button
Search field	Type-in field where the users can type keywords when searching for content in the database (not functional).	[Search field]
Search button	Enables a search in the database after the after keywords have been typed in the search field (not functional).	Search button
Idea title	Displays the title of the idea.	[Idea title]
Idea description	Displays the description of the idea.	[Idea description]
Username	Unique identifier for the user posting the content.	(Username)
Date	Unique identifier for date of posted content.	(Date)
User-defined tags	Displays user-defined tags.	(User-defined tags)
Tag cloud	Facilitates divergent production using text and image stimuli by (a) generating a random tag cloud from the content displayed in the evaluation module and (b) transforming the tags into links for a Google image search (see also Malaga, 2000).	[Tag cloud block]
Add benefit button	Opens an input form where the user can type in a benefit related to the idea being evaluated and add tags to the benefit. After completion, the benefit is displayed in the [Benefits block].	Add benefit button
Add problem button	Opens an input form where the user can type in a problem related to the idea being evaluated and add tags to the problem. After completion, the problem is displayed in the [Problems block].	Add problem button
Comment on idea button	Opens an input form where the user can type in a comment related to the idea being evaluated and add tags to the comment. After completion, the comment is displayed in the [Idea comment block].	Comment on idea button
Add new idea button	Opens an input form where the user can type in a new idea.	Add new idea button
Force field analysis	1. Facilitates evaluation by listing benefits and problems side-by-side (see also Couger, 1996). 2. Facilitates convergent production when the participant can generate improvement ideas that enhance a benefit or solve a problem (see also Couger, 1996). 3. Facilitates divergent production by structuring evaluation content and using it as textual stimuli (see also Malaga, 2000).	Figure 5. [Benefit block] and [problem block]
Benefits	Displays the listed benefits for the idea.	[Benefits block]
Benefit title	Displays the title of the benefit.	(Benefit title)
Benefit description	Displays the description of the benefit.	(Benefit description)
Problems	Displays the listed problems with the idea.	[Problems block]
Problem title	Displays the title of the problem.	(Problem title)

Table A1. Feature List of the Evaluation Module

Problem description	Displays the description of the problem.	(Problem description)
Improvements in benefits and problems	Displays improvement ideas for benefits or problems.	[Benefits improvement block] and [problem improvement block]
Improvement title	Displays the title of the improvement.	(Benefit improvement title) in [benefits improvement block] and (problem improvement title) in [problem improvement block]
Improvement description	Displays the description of the improvement.	(BF improvement description) in [benefits improvement block] and (PB improvement description) in [problem improvement block]
Comments for benefits and problems	Displays the listed user comments for either benefits or problems.	[Benefits comment block] and [problem comment block]
Comments title for benefits and problems	Displays the comment title for either benefits or problems.	(Benefit comment title) in [benefits comment block] and (problem comment title) [problem comment block]
Comments description of benefits and problems	Displays the comment description for either benefits or problems.	(BF comment description) in [benefits comment block] and (PB comment description) in [problem comment block]
Idea comments	Displays the listed comments for the idea.	[Idea comment block]
Comments title	Displays the comment title.	(Comment title)
Comments description	Displays the comment description.	(Comment description)

Appendix B: Collected Ideas in the Study[1]

Table B1. Collected Ideas in the Study

Nr.	Title	Iteration	Improvement ideas	Evaluation items	Connected to
1	We are looking for new business opportunities within the ice cream market (inserted)	1	NA	1	NA
2	Liquorice ice cream (inserted)	1	2	9	1
3	“Giant Eskimo” in liter bulks	1	0	4	1, 2
4	Ice cream with different textures	1	0	1	1, 2
5	DIY ice cream mixes sold in super markets	1	0	3	1
6	Ice cream stand for each zip code	1	0(1)	4	1
7	Delivery by messenger	1	0	3	1
8	Nordic food and ice cream	1	0	1	1, 2
9	Paleo/low carb high fat ice cream	1	0	4	1, 2, 8
10	How do we improve the working conditions at the university? (inserted)	1	NA	2	NA
11	New, covered smoking place needed at the department	1	2(4)	9	10
12	Friday afternoon bar for staff	1	0	5	10
13	More variety in available food options	1	0(2)	5	10
14	Common area for staff from all clusters	1	0	6	10, 13
15	Reinventing teaching	2	0	3	10
16	After work organized sports or hobby events	2	1	1	10,12
17	Assigning a mentor to all new PhD students	3	0(1)	4	10
18	Talks and seminars with a flavor of social activity	4	0(1)	3	10
19	How can we engage students in out of class activities?	1	NA	3	6
20	A cheap bar	1	0	9	19, 2
21	More sports clubs for the students	2	2	1	19
22	Cool coffee shop	2	0	5	19
23	Campus mall	2	0(1)	3	19
24	Improve the university website and provide clear data on the clubs at the university	4	0	1	19, 21, 45, 51
25	Who would you like to visit our August department meeting?	1	NA	0	
26	The guys who claimed to have beaten the Turing Test	1	0	2	25
27	Time management	2	0	2	25
28	Using social media in lectures	2	0	5	25, 27
29	What will be the next “smart device”?	1	NA	4	
30	Wearables—the new black	2	0	2	29
31	Technology forecasting as a path to new smart devices	2	1(3)	12	29, 30
32	A truly smart toaster	5	0	0	29, 30, 31
33	How can we reduce the amount of traffic on the roads?	2	NA	3	14
34	Car Pooling	2	0	7	33, 14
35	"Highways" for alternative forms of transportation	2	0	4	33, 34

[1] I joined some ideas and challenges with their description after the data collection to increase their readability. I added ideas and challenges tagged with “(inserted)” to the prototype to facilitate the study.

Table B1. Collected Ideas in the Study

36	Facilitate homeworking	2	0(1)	8	33
37	Cultural change	3	0(1)	3	33, 34, 35
38	Mini buses	4	0	2	33, 35
39	Road pricing	4	0	1	33, 37
40	Cabin bike	4	0(2)	2	33, 37
41	Car trains	4	1(2)	4	33
42	Tax free bike rides	5	0	0	33, 39
43	How to improve our administration database?	2	NA	2	
44	New System	3	0	0	43
45	How can we make a better travel expense system? (inserted)	3	NA	0	NA
46	Usability testing	3	1(1)	7	45
47	Combine application, travel reporting and reimbursement	3	0	7	45
48	Remove subpages from the system	3	0	1	45, 46
49	Adjust the fields according to the user role	3	0(2)	2	45, 48
50	Survey other systems	3	0	1	45, 47, 48, 49
51	Usability is the key	3	0	0	45
52	Make the system more efficient	3	0	2	45
53	Use meaningful names for accounting rather than account numbers	3	0(1)	3	45, 49
54	My calendar knows where I've been—use that in the system	3	0(1)	1	45, 52
55	Email upload of travel documents picture taken with a smart phone	3	0	2	45, 52
56	Include the funding application in the system	4	0	1	45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55
57	Look how other organizations have solved this problem	4	0	0	45
58	Make admin people do the travel reporting	4	0(1)	6	45, 51
59	Integrate with the IOS Passport app and similar	4	0	1	45
60	Use TripIt and similar	5	0(2)	2	45
61	How do we ensure timely holiday registration?	4	NA	5	10
62	Understanding why registration of held and planned holidays is important	4	0	2	61
63	Holiday registration system	5	0	0	61
64	How do we manage the competing demands of teaching additional students, higher requirements to publish, and general administration tasks?	4	NA	1	10, 61
65	Strike!	4	0	3	64
66	Teach worse	4	0	2	64
67	Do your research worse	5	0	0	64, 66
68	Establish clear goals	5	0	1	64, 66
69	Manage your time better	5	0	2	64, 65, 66
70	How do we have a Christmas Party in 2014 with no money?	5	NA	2	43, 45, 61, 64
71	Book a place	5	0	2	70
72	What would you like to have included on a future department website?	5	NA	0	24

Table B1. Collected Ideas in the Study

73	Accessing the website at university.dk and not only at www.university.dk	5	0	0	72
74	Updated event and news section	5	0	0	72
75	Section for new potential students	5	0	0	72
76	Not only which information, but also how	5	0	0	72

About the Authors

Frank Ulrich received his PhD in Information Systems from Aalborg University and is currently employed as a post doc at the Department of Technology and Innovation Management and DTU Management Engineering in Denmark. His current research interests include evolutionary perspectives on creativity and organizational complexity. Moreover, he has previously published research addressing group creativity support systems, idea evaluation, and creative culture in hacker communities.