NOVEL IDEA GENERATION, COLLABORATIVE FILTERING, AND GROUP INNOVATION PROCESSES

Completed Research Paper

Tracy A. Jenkin
Queen's University
School of Business
Kingston, Ontario, Canada
tjenkin@business.queensu.ca

David B. Skillicorn
Queen's University
School of Computing
Kingston, Ontario, Canada
skill@cs.queensu.ca

Yolande E. Chan
Queen's University
School of Business
Kingston, Ontario, Canada
ychan@business.queensu.ca

Abstract

Organizations that innovate encounter challenges due to the complexity and ambiguity of generating and making sense of novel ideas. Exacerbated in group settings, we describe these challenges and propose potential solutions. Specifically, we design group processes to support novel idea generation and selection, including use of a novel-information discovery (NID) tool to support creativity and brainstorming, as well as group support system and collaborative-filtering tools to support evaluation and decision making. Results indicate that the NID tool increases efficiency and effectiveness in creative tasks and that the collaborative-filtering tool can support the decision-making process by focusing the group's attention on ideas that might otherwise be neglected. Combining these two novel tools with group processes provides valuable contributions to both research and practice.

Keywords: Knowledge creation, data mining, innovation, creativity, brainstorming, group decision making, information systems

Introduction

Organizations seeking a competitive advantage often pursue innovative and creative paths when charting their strategic direction. For example, Miles and Snow's (1978) prospectors and Bierly and Chakrabarti's (1996) innovators and explorers actively seek ways to create new markets, products or services. This may require "creative destruction" (the creation of something new while at the same time destroying something else) (Schumpeter 1976), radical learning (questioning and changing basic assumptions), external learning (learning from external sources of knowledge) (Bierly and Chakrabarti 1996), or technology brokering (recombining existing technologies in new ways to create new products or services) (Hargadon 2002; Hargadon and Sutton 1997). The novelty of the ideas being generated can lead to innovation and competitive advantages. However, this novelty also creates challenges for organizations.

Although "novelty" tends to suggest the creation of something entirely new (Encinar and Muñoz 2006), novel ideas that are completely unrelated to existing knowledge are rare. Instead, innovating often involves combining existing elements together in new ways (Hargadon 2002; Hargadon and Sutton 1997). Making these connections is challenging. It often involves bringing together knowledge from disparate domains and discovering how such unrelated areas can be connected in relevant and important ways (Hargadon 2002; Hargadon and Sutton 1997). Thus, knowledge creation, sharing and learning are involved. Despite potential benefits, there are several challenges associated with generating novel ideas.

In an organizational context, the challenges associated with novelty are exacerbated because assessments and decisions are made by groups, not individuals. Although groups bring benefits (e.g., interparticipant synergies), there are a number of challenges that inhibit the process, such as process losses (McGrath 1984; Potter and Balthazard 2004; Steiner 1972), social complexity (Weick 2006), biases towards ideas in which members have knowledge "at stake" (Carlile 2004; Hargadon and Fanelli 2002), and interpretational differences due to diverse knowledge bases (Carlile 2004). As a result, developing a shared understanding of novel ideas and reaching a consensus is challenging for groups. Further, social complexity often results in groups developing less creative ideas (Weick 2006).

Although past research has examined the group idea-generation and decision-making processes, there is less research on highly creative tasks (Fjermestad and Hiltz 1999). Of this research, most studies examine the cognitive processes and associated group support system (GSS) functionality that promote creativity (Hender et al. 2002; Li et al. 2009; Ocker et al. 1996), while other studies examine GSS use in an innovation context (Elfvengren et al. 2009a; Elfvengren et al. 2009b). We seek to address an important gap by examining the challenges associated with idea generation and decision-making when innovation and novelty are the goals. To understand how to solve these challenges, we conduct a field study to explore techniques and processes for idea generation and decision making when there is a high degree of novelty. The processes and tools introduced in this paper not only address the group challenges associated with novelty, but also offer new ways to enhance these group processes in terms of effectiveness and efficiency. We introduce two new tools in this research. The first, a novel-information discovery (NID) tool, highlights non-obvious connections to an individual in order to stimulate thinking and support the generation of novel ideas. Our results show that an NID tool can improve the efficiency and effectiveness of individual brainstorming, reduce the "stake" individuals have in their own ideas and provide highly creative results. The second, a collaborative-filtering tool, provides an alternative way of analyzing the opinions of group members by favoring the most competent evaluators. Results indicate that a collaborative-filtering tool can help improve the effectiveness of the group decision-making process by highlighting important ideas that may be overlooked during the discussion due to cognitive complexity amongst other issues.

This paper is organized as follows. We begin by examining the problems associated with novel idea generation and evaluation in groups, suggesting how processes and tools can alleviate these problems. Next, we review our research method, describe the results and conclude with a discussion of key insights.

Group Challenges with Novelty

Of the group tasks commonly studied, creativity and decision-making are those most relevant for this research. We examine these below and identify the challenges for groups when dealing with novelty.

Creative Group Tasks

Creativity has been defined as an "act, idea or product that changes an existing domain or that transforms an existing domain into a new one" (Csikszentmihalyi 1996 p. 28). Creativity tasks, which involve the generation of ideas or alternatives, often utilize techniques to increase the number and novelty of ideas generated. For example, brainstorming involves individuals within a group attempting to generate as many ideas as possible by thinking creatively and building on each other's ideas (Osborn 1953). Although groups have the advantage of creating unique hybrid ideas due to interparticipant synergies, past research has found that individuals generate more, as well as more creative, ideas than groups. Groups may suffer from process losses such as production blocking (Diehl and Stroebe 1987; Diehl and Stroebe 1991; Lamm and Trommsdorff 1973; Steiner 1972), which refers to the inability of a group member to contribute an idea while another is speaking. While not unique to novelty, the cognitive complexity associated with generating novel ideas exacerbates this issue (*challenge 1*). To address this issue, past research has recommended a multi-phase approach for idea generation, including a phase where individuals conduct brainstorming to generate ideas separately, followed by group discussion (Potter and Balthazard 2004).

The cognitive processes involved in brainstorming and techniques to stimulate cognitive processes, have previously been examined (e.g., Hender et al. 2002; Li et al. 2009; Potter and Balthazard 2004). This research suggests that, during idea generation, individuals search through familiar categories and associations in their memory (Anderson 1987; Anderson 1992; Barsalou 1983; Hintzman 1988) and mental models (Piaget 1954; Piaget and Inhelder 1969) – frameworks to help simplify and organize information (Crossan et al. 1999; Hedberg 1981). Brainstorming productivity can be improved by providing individuals with cues or stimuli to help with this memory search and the generation of ideas (Hoffman 1959; Nagasundaram and Dennis 1993; Potter and Balthazard 2004). The creativity of the ideas generated is affected by the degree to which the stimuli are related to the problem (VanGundy 1988) and individuals' existing mental models. When individuals are provided with stimuli that are related to the problem, they tend to search narrowly, accessing familiar associations in their mental models. As a result, these techniques are less cognitively complex and more efficient than those involving unrelated stimuli because familiar associations are triggered (Barsalou 1983; Hender et al. 2002; Nagasundaram and Dennis 1993; Potter and Balthazard 2004). However, existing mental models constrain creativity and, thus, ideas tend to be lower in creativity (Hender et al. 2002; Nagasundaram and Bostrom 1995) (*challenge 2*). Alternatively, when individuals are provided with stimuli unrelated to the problem, the act of forcing a relationship back to the problem (VanGundy 1988) requires the individual to make unfamiliar and non-obvious connections, reframing their existing mental models (Hender et al. 2002; Li et al. 2009). Although this process is more cognitively complex and time consuming, the result is highly creative ideas (Hender et al. 2002; Nagasundaram and Bostrom 1995; Nagasundaram and Dennis 1993).

Technology brokering (Hargadon 2002; Hargadon and Sutton 1997) can facilitate novel idea generation. Having a broad range of organizational perspectives and knowledge is important to generate novel combinations of existing technologies and concepts and assess the potential relevance of novel ideas (Schulz 2001). However, groups composed of individuals with a breadth of perspectives and knowledge makes understanding how knowledge in one domain is relevant in another difficult (*challenge 3*).

Increased social complexity, due to the coordination required for group tasks, affects the overall creativity and imagination of the group. To coordinate, group members tend to rely on their common knowledge and shared mental models rather than imagining novel possibilities (Weick 2006). As a result, highly novel ideas may be discarded in favor of less radical ones. In addition, new ideas created by the group as a result of group brainstorming synergies will tend to be no more novel than individual ideas (*challenge 4*).

Decision-Making Tasks

The generation of ideas is often followed by a decision-making process in which one or more ideas are chosen to pursue. Groups have several advantages over individuals in completing decision tasks, which involve choosing an alternative when there is no "correct" answer and consensus is required (McGrath 1984). These advantages include a broader range of knowledge and experience upon which to draw, increased legitimacy of the final decision, and the ability to share the workload (McGrath 1984). There are also a number of challenges, such as the influence of high-status individuals, uneven participation, and difficulties associated with the diversity of group members' knowledge and experience (Cartwright and

Zander 1968; Desanctis and Gallupe 1987; McGrath 1984). Group challenges specific to dealing with novel ideas are discussed below.

Groups may have interpretive differences in how they ascribe meaning to the novel ideas generated (*challenge 5*). Some common knowledge between group members is required in order to communicate effectively and leverage the specialized knowledge of each group member (Carlile 2002; Carlile 2004; Cohen and Levinthal 1990; Grant 1996). However, when dealing with novel ideas, this common knowledge may no longer be effective to understand and communicate how specialized knowledge applies to the novel idea (*challenge 6*). Thus, while one member of the group may understand a novel idea and how it could be valuable to the organization, others may have difficulty sharing this understanding.

Another challenge for groups is the knowledge that each individual has “at stake”. Each member of the group has his or her own acquired expertise and interests and views this as “at stake” due to the costs of discarding existing knowledge (Hargadon and Fanelli 2002). Novel ideas may be particularly costly to certain group members whose knowledge is “at stake” (Carlile 2004) (*challenge 7*).

Research has found that groups, after discussing the alternatives, tend to shift their original preferences to either a riskier or more conservative one (e.g. Stoner 1968; Vinokur 1969; Vinokur and Burnstein 1974). The direction of the choice shift depends on the degree to which partially-shared persuasive arguments (i.e., important information not known by all group members) are made during the discussion and the riskiness of the alternative these arguments support (Vinokur 1969; Vinokur and Burnstein 1974). When alternatives are ambiguous or persuasive arguments not given, individuals tend to conform to the group majority, according to social comparison theory (McGrath 1984; Vinokur 1969). Thus, groups tend to shift their preferences towards popular ideas or more extreme ideas (McGrath 1984; Vinokur 1969; Vinokur and Burnstein 1974) (*challenge 8*). Although a choice shift needs to occur for the group to reach a consensus, partially-shared persuasive arguments can unduly promote riskier or more conservative ideas.

Solutions to Group Challenges: Tools, Techniques and Processes

We now explore different processes and techniques for addressing the challenges associated with group tasks and novel ideas (see Table 1), starting with a description of two new tools: one designed to support creative tasks (a novel-information discovery (NID) tool) and another designed for decision making (a collaborative-filtering tool). Further, we discuss group support systems (GSS), focusing on their support for decision making, yet recognizing they can support both types of tasks.

Table 1. Group Challenges Associated with Novel Ideas

Group Task	Challenges	Possible Solutions		
		NID	GSS	Collab Filter
Creative	1. Individuals generate more, as well as more creative, ideas than groups due to process losses such as production blocking (McGrath 1984; Potter and Balthazard 2004; Steiner 1972).	X	X	
	2. Existing mental models constrain creativity (Li et al. 2009; Nagasundaram and Bostrom 1995). Use of unrelated stimuli can help, but requires the individual to make unfamiliar connections and is more cognitively complex and time consuming (Hender et al. 2002).	X		
	3. Difficult to understand when knowledge in one domain is relevant in another in order to identify novel combinations of existing concepts.	X		
	4. Increased social complexity for group tasks affects the creativity and imagination of the group. So, group members tend to rely on their common knowledge and existing relationships in their shared mental models rather than imagining novel possibilities (Weick 2006).	X	X	X
Decision Making	5. Group members with a broad range of perspectives and knowledge will have interpretive differences regarding how they ascribe meaning		X	

	to novel ideas (Carlile 2004).			
	6. Common knowledge may not be sufficient to understand and communicate how specialized knowledge applies to the novel idea (Carlile 2002; Carlile 2004; Cohen and Levinthal 1990; Grant 1996).		X	
	7. Novel ideas may be particularly costly to certain group members whose knowledge is "at stake" (Carlile 2004).	X		X
	8. Groups have a tendency to shift preferences towards popular ideas or more extreme ideas (i.e., riskier or more conservative) (McGrath 1984; Vinokur 1969; Vinokur and Burnstein 1974).			X

Tools for Creative Tasks

To increase the novelty and, thus, radicalness of the ideas generated, past studies suggest the use of unrelated stimuli (Hender et al. 2002; Nagasundaram and Bostrom 1995; Nagasundaram and Dennis 1993) and external sources (Bierly and Chakrabarti 1996; Li et al. 2009). Juxtaposing existing knowledge with unrelated stimuli (Hender et al. 2002; Nagasundaram and Bostrom 1995; VanGundy 1988) or peripheral cases (Gogan 2006; Li et al. 2009) can help "shake up" the individual's thinking and allow them to challenge their existing mental models. However, this is also more cognitively challenging and, therefore, more time consuming because it extends thinking beyond existing mental models.

External sources can support technology brokering and the generation of novel ideas by, for example, providing information on existing technologies, which can then be combined together in new ways. Locating these non-obvious connections is typically facilitated by social networks (Hargadon 2002; Hargadon and Sutton 1997). Although there are no known tools to support this process, the Web is a valuable source of external information and potentially rich repository for novel idea generation. For example, the Web has been used in previous studies within the brainstorming context to assist with grouping (Roussinov and Zhao 2003) and generating ideas (Li et al. 2009). Despite its potential, the Web is challenging to use because of information overload (e.g. Chung et al. 2005). Further, the results of a typical search engine are highly related to the search terms (Beccerra-Fernandez et al. 2004). Thus, locating non-obvious connections is challenging. Assessing the relevance of these connections is difficult because it is outside individual mental models (e.g., Hargadon and Douglas 2001).

We propose that a novel-information discovery (NID) tool, recently developed in other studies (Jenkin 2008; Jenkin et al. 2007; Skillicorn and Vats 2007), can help users overcome the challenges associated with generating novel ideas using the Web and unrelated stimuli (specifically challenges 1, 2 and 3). This NID tool, called Athens, uses an iterative clustering technique to support the discovery of novel information on the Web, or other information repositories. Athens accepts several parameters, including keywords, and returns information that is indirectly related to the search terms, yet contextually appropriate, and this becomes the desired stimuli. This is done by using the results of the initial search (i.e., highly related) to identify directly related concepts and searching "outwards" by pairing newly discovered terms with terms from the previous step. This is repeated twice, so that the resulting information is unlikely to be directly associated with the initial search terms, but very likely to be "just over the horizon" with respect to them. The results, Web pages, are clustered according to similarity. The end result is a set of novel clusters that contain concepts indirectly related to the original search terms. Each novel cluster is described using the most important descriptive terms found in the associated Web pages. Additional technical details can be found in Skillicorn and Vats (2007).

As individuals review the novel results, they uncover content (key words, URLs, and document content) that is indirectly related to their original search term, which spurs them to generate novel ideas. The indirect connections are a middle ground between the high cognitive complexity of completely unrelated knowledge and the potential staleness of existing mental models.

Tools for Decision-Making Tasks

Idea-generation and especially decision-making processes at the group-level are supported by group support systems (GSS) (Desanctis and Gallupe 1987; Sambamurthy and Poole 1992). Three levels of GSS tools have been identified, ranked by the level of structure and intervention into the natural group process. Three different types of structure are provided in varying degrees, including communication support (e.g., anonymity and parallelism), information-processing support (e.g., decision modeling), and process support (e.g., facilitation, agendas, restrictive software) (Dennis et al. 2001; Desanctis and Gallupe 1987; Sambamurthy and Poole 1992; Watson et al. 1988; Zigurs and Buckland 1998). Although GSS have proven to be helpful for brainstorming in groups by reducing process losses (*challenge 1*) (e.g., Hender et al. 2002; Potter and Balthazard 2004), they are not specifically designed to address highly creative tasks nor the Web issues describe above.

In addition to the anonymous rating and democratic tabulation of votes supported by GSS, we propose an alternative method of analyzing the opinions of group members – a collaborative-filtering tool – which may help groups when dealing with high degrees of novelty and broad organizational perspectives and knowledge. Using data-mining techniques to combine the opinions or judgments of multiple individuals, the collaborative-filtering tool evaluates and weights each individual's ability to judge, and provides a "global" recommendation (Skillicorn 2001; Skillicorn 2007). Google uses a similar approach for Web page ranking – a Web page's relevance is assessed by the number of pages that link to it, weighted by the quality of those pages (Chen 2001). Collaborative filtering applies ensemble-learning principles, where collections of individual classifiers that are diverse and accurate are constructed (Dietterich 2000). Each individual classifier votes for the decision they deem best, resulting in a highly accurate global classification decision (Dietterich 2000).

In contrast to a democratic voting system, collaborative filtering discounts the opinions of individuals who appear to be "weak" assessors and emphasizes the opinions of individuals who appear to be "strong" assessors. The quality of an individual assessment is based on the degree to which an individual's opinions are in agreement with the opinions of other individuals with better judgment skills (Skillicorn 2001). Collaborative filtering resolves this circular relationship to provide a collective recommendation that retains the variance in opinions across the group and develops a bias towards strong assessors. One can think of a strong assessor as a "discerning" evaluator. Movie ratings provide a useful example. On a continuum of best to worst movies, the best are known as "blockbusters". These movies are universally popular – most people like the movie, but often only weakly. The worst movies are also universally viewed as bad – otherwise known as "B" movies. However, it is often more interesting to look at movies that are liked by a relatively smaller number of discerning movie critics. These movies do not appeal to everyone, but are viewed as great by a small number of individuals with high-quality movie-rating skills. Thus, the collaborative-filtering tool distinguishes between these two types of raters: 1) raters who show an ability to discern different "grades" of movies, similar to other "high quality" raters, and 2) raters who like or dislike most things. The "high quality" raters are assigned more weight so that the global recommendation is skewed towards the movies, or ideas in this case, that these raters evaluate highly. The bias incorporated into collaborative filtering is supported by McGrath (1984), who suggests favoring more competent participants may be more appropriate. In theory, the results from a collaborative-filtering tool will differ from a democratic vote and bring unique, and perhaps less commonly understood, ideas to the forefront of the decision-making process, rather than only the most popular ideas (*challenges 4, 7, 8*).

The collaborative-filtering tool in this study uses matrix decomposition – specifically singular value decomposition (SVD)[1] – scripted in Matlab (www.mathworks.com). Using idea ratings from multiple assessors as input, the tool computes a global assessment of idea ratings, weighted by each assessor's ability to evaluate. The raw output consists of three matrices, referred to as U, S, and V, which are then transformed into a series of two- and three-dimensional graphs to facilitate interpretation and analysis of the results.

To determine the ranking of ideas, the output of the collaborative-filtering tool is interpreted by first analyzing the most prominent singular values. Singular values represent underlying factors or dimensions in the data (Skillicorn 2007) and can be interpreted in a similar fashion to eigenvalues in factor analysis. A review of the values in the S matrix reveals the approximate number of prominent singular values or dimensions. These dimensions are then interpreted by reviewing the graphical output of the tool, including both the global ratings of ideas and ratings of individuals.

1 Singular value decomposition is an unsupervised data-mining approach that rotates a multi-dimensional dataset (matrix) so that variance is maximized on the first axis and remaining variance is subsequently maximized on the other axes. For further information on SVD, please refer to Skillicorn (2007).

Once meaningful dimensions are identified, the collaborative-filtering tool is used to draw a line that best represents these two dimensions (ideas and raters) simultaneously and project the ideas onto this line. The output of this processing is a list of the ideas and values indicating positioning on the line. The position of each idea on the line represents a "rank" order of ideas. Some interpretation is required to determine the most appropriate sort direction (i.e., descending vs. ascending).

We now describe how combining these three tools with individual and group processes alleviates the eight challenges outlined above. First, we describe the outcomes under consideration.

Outcomes

Outcomes of creative processes such as the ones examined here have typically been evaluated using criteria such as novelty and value (Amabile 1983; Couger and Dengate 1992; Newell et al. 1962). Thus, we focus on: 1) the radicalness of the idea, and 2) the benefit of the idea to the organization. These outcomes also reflect the quality of the decision made. Satisfaction and confidence are also examined.

Radical ideas and innovations have been described as controversial, and potentially disruptive (Hall and Martin 2005); involving new processes or materials (Barnett 1953; Hill and Rothaermel 2003); and, having new technological content (Barnett 1953; Dahlin and Behrens 2005). The changes or improvements are discontinuous (Leifer et al. 2000), resulting in a product or service that differs substantially from the alternatives (Barnett 1953; Zaltman et al. 1973).

The potential benefit of an idea is often viewed as benefit less cost. Three types have been identified in the literature and included here: 1) tangible – costs and benefits that are directly measurable (e.g., increased variable costs); 2) quasi-tangible – costs and benefits that have some directly measurable aspects and other aspects that are difficult to quantify (e.g., improved shipment accuracy may lower costs and improve customer satisfaction); and 3) intangible – costs and benefits that are indirectly measurable and require a subjective assessment (e.g., improved morale) (Parker et al. 1988; Ryan and Harrison 2000).

Processes

During the creative phase (i.e., idea generation), the NID tool provides individuals with apparently "unrelated stimuli" (though, in fact, it is logically proximate) to support the individual in discovering non-obvious connections (*addresses challenge 2*), which may also help to reduce the "stake" the individual has in his or her ideas (*addresses challenge 7*). Due to the complexity, each individual can produce a relatively small number of ideas as opposed to the large numbers typical in brainstorming activities (Osborn 1953).

Outcomes are limited by the individual's interpretation of both the problem and relevance of the results. Accordingly, during the decision making phase (i.e., evaluation) the relevance of new information is best assessed by multiple individuals with diverse domain knowledge (Schulz 2001) (*addresses challenge 3*). Thus, to include multiple perspectives, we propose that each group member use the NID tool to generate ideas individually (*addresses challenges 1, 4*) and then examine the combined list.

Using a GSS, anonymous group evaluation of the combined list of ideas prior to group discussion creates a useful baseline for analyzing initial individual viewpoints, unbiased by group discussion, and subsequent choice shifts. Feeding the ratings from this process to the collaborative-filtering tool could help highlight ideas that are not widely popular, but viewed as important by "discerning" evaluators (*addresses challenge 8*). Although a high level of agreement is unlikely, strong assessors will tend to be in agreement regarding the "good ideas" (high on both radicalness and benefit) and the "bad ideas" (low on benefit). The bias towards the strong assessors will tend to favor ideas high on both radicalness and benefit.

Following the initial vote, a facilitated group discussion leveraging the GSS tool features will facilitate consensus-building. Debate, discussion and persuasive arguments will reduce variation in the group, creating a shared understanding and high level of agreement (*addresses challenges 5, 6*). The final democratic and anonymous vote "eliminates" any biases. Group discussion will facilitate consensus on a final decision. Partially-shared perspectives will result in choice shifts from the group's initial position. Group discussion will tend to increase satisfaction with the process and confidence in the final decision.

Although social complexity and coordination issues are addressed by GSS tools through features such as voting and agendas (*addresses challenge 4*), the group discussion and debate may result in coordination issues that move the group away from controversial and radical ideas (Weick 2006). Using the output from the collaborative-filtering tool during the discussion could help ensure potentially important ideas are not forgotten (*addresses challenge 8*).

Research Method

Given the complexity and ambiguity of generating and evaluating novel ideas within groups, as well as the novelty of the tools we are examining (i.e., NID and collaborative-filtering tools) we chose to employ a field study, useful for examining behaviours in a natural setting (Scandura and Williams 2000). The objective was to facilitate idea-generation and decision-making processes, using the processes and tools described above to alleviate the eight challenges (see Table 1) and see where and if other issues arise.

The participating organization, referred to here as High Tech (pseudonym), was a Canadian subsidiary of a large Fortune 500 organization in the high-tech industry. Initially, a group consisting of eight individuals was formed. We advised the sponsor that a group including a range of roles and domains was ideal. Due to conflicts, the final group consisted of six members representing a range of roles (from business analyst to senior director) and departments (from market intelligence to user design).

The initial site visit included an introduction to the study for the participants and training on the NID tool. During this visit, participants were provided the study task, determined by the organizational sponsor in collaboration with the researchers. The task was phrased as follows: *"How can High Tech generate business value from virtual worlds such as Second Life? The goal is to generate novel ideas that might lead to the creation of business value from virtual worlds for High Tech."* Participants were also told that as a group, they must choose two ideas for the organization to pursue.

Given the nature of the NID tool, participants were asked to submit their keywords to the researchers prior to the start of the main study, which was conducted in the organization's group decision lab (using GroupSystems). At the start of the main study, participants were provided with their NID results, generated by the researchers beforehand. After brief instructions, they were asked to generate up to five novel ideas to address the task using their NID results to help reuse, modify or create new ideas. The number of ideas was limited to 5 due to the complexity and novelty of the task. Participants were asked to document their ideas and the Web link that spurred this idea (i.e., stimulus) using the Web form provided. Documenting the stimulus helped ensure participants were leveraging the NID results. This phase of the process represented idea generation. The evaluation of the ideas progressed sequentially from individual assessments to final group consensus so that we could examine choice shifts in depth.

Participants were asked to evaluate ideas three separate times, following the process described above and depicted in Figure 1 below. Evaluation phases 1 through 3 included rating the radicalness and potential benefit of each idea, as well as how well the idea addressed the task overall. Specifically, participants evaluated ideas using the GSS tool's rating functionality. GSS rating instructions (see Table 2) were based on the definitions of radicalness and benefit discussed above in the outcomes section. Using a Web survey, participants were asked to indicate their level of satisfaction with the process and confidence in their decisions and provided the opportunity to submit comments regarding the process at the end of each phase. To facilitate the group discussion (phase 3), tabulated scores were displayed in the form of a decision model, including means and standard deviations of scores for each idea. Results were color-coded to highlight top scores, large standard deviations and large differences between radical and benefit scores. Decision models have been shown to help reduce information overload in the GSS context (Paul and Nazareth 2010). After the final consensus was reached, a debriefing session was held with the participants to discuss their experiences. The entire process, including breaks, lasted 4 hours.

Table 2. Decision-Making Task: Instructions for Idea Rating
Radicalness: The radicalness of an idea is defined as the extent to which the technical content of the idea is new to the organization, based on what the organization does now. Technical content refers to products, services, processes, materials, technologies. On a scale of 1 to 10, please indicate how radical this idea is to High Tech, where 1 represents "Not new to High Tech" and 10 represents "Radically new to High Tech".
Benefit: The overall benefit of an idea is defined as the potential benefits less potential costs, including

tangible and intangible benefits and costs. On a scale of 1 to 10, please indicate how beneficial this idea is to High Tech, where 1 represents "Not beneficial to High Tech" and 10 represents "Extremely beneficial to High Tech".
Overall: In this activity, you will be asked to provide an overall rating for each of your ideas. On a scale of 1 to 10, please indicate how well this idea addresses the search task, where 1 represents "Not well at all" and 10 represents "Extremely well".

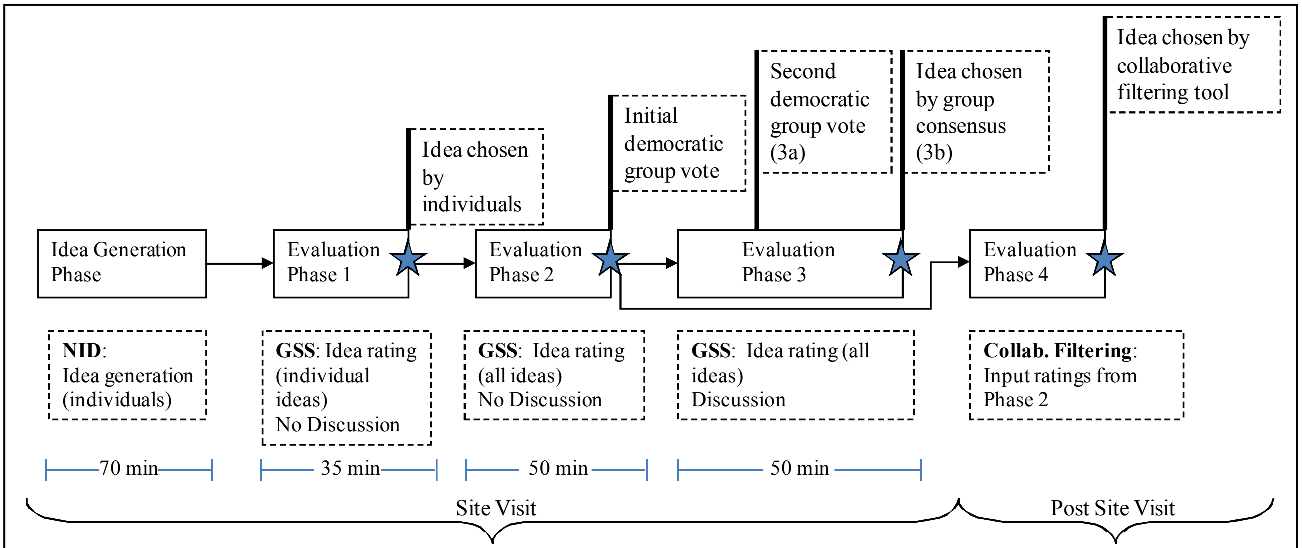

Figure 1. Idea Generation and Evaluation Phases

After the site visit, scores from phase 2 (ideas evaluated using a GSS without group interaction) were provided to a collaborative-filtering tool to identify the top-ranked ideas chosen by the tool (phase 4) and compare these to the other phases. Other data analysis included assessing choice shifts (i.e., changes in the scores assigned to an idea) at the individual and group level. Satisfaction and confidence were also compared across evaluation phases 1 through 3. A broader qualitative analysis was performed to deepen our understanding of the challenges and how the tools and processes used here addressed them. This included reviewing and coding transcripts from the group discussion and debriefing session, and reviewing the comments from the surveys. We did not specify a coding schema a priori, but allowed the codes to emerge from the analysis. For example, in the group discussion transcripts we coded comments that related to persuasive arguments, reaching a shared understanding, the process, and measurement.

Results

The results of the field study are discussed below, beginning with an overview of the results of the idea-generation and evaluation processes.

Creative Task: Idea-Generation Processes

Insights into the effectiveness and efficiency of the NID tool, Athens, for idea generation were derived from the comments made during the debriefing session. Comments suggest that individuals used the tool in different ways to generate novel ideas. One participant found that the ongoing process of reviewing and progressing through the NID tool results helped her to generate ideas, rather than just the reviews of each individual Web page encountered. Another participant depended less on the specific results, but used the results as a jumping off point to think more creatively. One participant commented,

> *"Does seem to be very individual. Some people liked to look at the result set, which by itself spurs off ideas. Then there are people like <name removed> who wanders off on his own, who is naturally curious. All depends on how we use it. I used it as a tool to assist versus a tool that is going to give you results."*

Another found the descriptive terms helped stimulate ideas. Thus, scanning high-level results, without going into detail, can help spur ideas. This participant felt a tool like Athens could be useful in her job. In addition to these comments, which highlight the effectiveness of the NID tool for idea generation, participants also noted issues with the tool, such as some irrelevant or redundant Web pages and challenges with the novelty of the results. Two participants commented:

> *"We're supposed to get novel stuff. But some of it was ridiculously novel...The topic is important. I worried about our topic in that there wasn't much about it period. And as a result we got really novel connections. There just wasn't enough content for Athens work on."*
> *"I couldn't make the leap."*

Thus, the novelty of the topic itself may influence the overall effectiveness of the tool. However, the participants agreed that having more "trial runs" using the tool would help and indicated an interest in using the tool more after the study.

Comments made also suggest that an NID tool could help groups with brainstorming tasks, making the process more efficient. One participant commented on the speed with which the group came up with several innovative ideas for consideration. In this participant's experience, this type of process typically lasts for days, rather than half a day in this case (both used the decision lab and GSS software). Another indicated that they found the limited amount of time to generate ideas using the tool helpful. She noted that it usually takes her a long time to generate ideas and find information on the Web. Thus, she found that the tool and process helped speed this process up and facilitate information foraging (i.e., searching for information based on the expected value and cost of the search; Pirolli and Card 1995; 1999), idea generation and stimulate thinking. For these two participants, an NID tool helped increase brainstorming efficiency. It is plausible that the indirectly-related results helped stimulate creativity, a finding supported by the group-creativity literature (Hender et al. 2002; Nagasundaram and Bostrom 1995).

In addition, two participants commented that the usefulness and interpretation of the results depended on individual knowledge. Differences in interpretation also affected idea evaluation.

Decision-Making Task: Idea-Evaluation Processes

We now discuss the differences between the distinct evaluation and voting phases. First, we describe how the group interacted (using the GSS, phase 3) and then compare the outcomes of the four evaluation phases (see Figure 1).

The qualitative analysis of the group discussion (phases 3a and b) provided insights into the content and progression of the discussion. The emergent codes identified in this analysis, number of comments, and illustrative quotes are provided in Table 3. Facilitated by the lead researcher, participants reviewed the phase 2 scores presented in a structured decision model and discussed the content of the ideas in an effort to come to a shared understanding. Participants often discussed why they felt an idea was beneficial or radical or why it was problematic. In some cases, this involved a lengthy discussion including explanations of technical complexities so that others could understand the idea. After arguments were presented, participants would agree and move on to the next idea. Interestingly, there were very few "ownership" comments made throughout the discussion, suggesting participants had less "stake" in the ideas they contributed. During this time, participants discussed 12 out of the 21 ideas and began clustering certain ideas that represented a common theme. Thus, not all ideas were actively discussed.

Table 3. Analysis of Comments in Group Discussion

Code	Definition	Count by Phase 3a	Count by Phase 3b	Illustrative Quote Example
Process	The way in which ideas are evaluated and discussed.	6	0	*I almost feel like I would like to rate them 1 through 21 or 1 through 10.*
Measure	The meaning and definition of evaluation criteria.	10	0	*But when I looked at benefit, I said "would High Tech be a leader in this versus a supplier or is collaboration required". So separate how we benefit from it visibly versus internally.*
Knowledge	The importance of knowledge in interpreting and evaluating the ideas.	4	0	*Doesn't it also depend on our background? We all come from the lab. But people from sales might think that what we call not radical they think is uber radical.*
Cluster	Grouping similar ideas together.	7	8	*There were some that I thought were somewhat related and you could almost group it into one. Even the banks related to the virtual exchange idea.*
Argument	Rationale provided for the evaluation or importance of an idea.	11	17	*I liked that idea, but gave it low on cost-benefit because of the cost involved. Seems right up our alley and new. I think that is why there is a big standard deviation in benefit.*
Ownership	Person identifies an idea as their contribution.	3	1	*It's a volume thing too. I actually generated that one. But I was thinking you could sell it for 10 or 30 dollars. But how many and how much time would you have to devote to just making these things just to make a million dollars. So it wouldn't be worth it.*
Question	Poses a question to the group.	1	3	*So the second one, what's the business value?*
Agreement	Indicates agreement or shared understanding.	9	7	*Yes those two as one. We're going to do this, right?*
Comment	General statement.	1	1	*And platform is up there (idea 9).*

After the initial group discussion and subsequent rating using the GSS (phase 3a), the updated decision model was presented to the participants. A facilitated discussion was held so that a consensus could be reached regarding the top two ideas to pursue (phase 3b). As shown in Table 3, during this phase participants also discussed the rationale for idea evaluations in order to reach agreement. Participants clustered ideas together (9, 7, 6, 18) to form one of their top ideas. This cluster of ideas was viewed as large in scale and costly to implement. However, the group felt this idea would be beneficial to the company. The idea was a natural progression for the organization and not viewed as particularly radical. One participant commented, *"I don't see it as that innovative. Is that a problem?"* Another responded, *"No. These are things we do well."* The other idea chosen (4) was viewed as smaller in scale than the first idea, but much more innovative. One participant commented, *"I think it's (the idea) critical to the future of virtual worlds"*.

We compared the results from the GSS processes – democratic votes (phases 2 and 3a) and consensus based on group discussion (phase 3b) – with those from collaborative filtering (phase 4) to determine whether the collaborative-filtering tool could help alleviate some of the group challenges. The phase 4 idea rankings were determined using the collaborative-filtering tool. Votes from phase 2 (GSS democratic vote) served as input in the form of a matrix (idea ratings (row) by individual rater (column)). The collaborative-filtering tool produced global-idea rankings (ideas 9, 18, 13, 16, 4) that differed from the democratic-vote rankings and the ideas chosen by group consensus (see Table 4).

Table 4. Collaborative Filtering Scores and Comparative Ranking					
	Collab. Filtering Rank*		Democratic Vote & Consensus Rank (GSS)		
Idea	Score	Phase 4	Phase 2	Phase 3a	Phase 3b
9	4.2	1	2	3	1=
18	3.07	2		5	1=
13	2.73	3	1	4	
16	2.65	4			
4	1.71	5	3	1	5
12	1.15		4		
10	0.77				
7	0.57				1=
21	0.53				
6	0.49		5	2	1=
11	0.4				

*Low ranked ideas not reported; = Ideas grouped to form a cluster.

Despite choosing different ideas, with some overlap, the results (see Table 5) suggest that the average radicalness and benefit scores of ideas chosen in each phase did not vary (see Table 6). For comparability and to eliminate any confounding effect of choice shift, the collective ratings from phase 2 are reported for each group of ideas in Tables 5 and 6. It is important to note that Phase 4 was automated and required much less work than phase 3 and, thus, given the similarity in scores between phase 3 (both phases 3a and 3b) and 4, efficiency was an important factor to consider. Further, the ideas chosen in phase 4 are similar to those in 3a (overlap of 4) and phase 3b (overlap of 3). Interestingly in phase 3, participants appeared to shy away from purely beneficial ideas. For example, idea 13 was originally the top idea in the initial decision model (democratic votes – phase 2). However, after the group discussion, this idea was rated lower overall and had a much higher standard deviation (i.e., less agreement).

Table 5. Summary of Top Ideas across Phases			
Phase	Description	Radicalness	Benefit
Phase 2 (ideas 13,9,4,12,6)	Democratic (tally) vote (GSS)	7.30	7.80
Phase 3a (ideas 4,6,9,13,18)	Democratic (tally) vote (GSS)	7.33	7.77
Phase 3b (ideas 9,7,6,18,4)	Consensus by discussion (GSS)	7.53	7.57
Phase 4 (ideas 9,18,13,16,4)	Collaborative filter	7.57	7.53

Table 6. Differences between Processes - Radicalness and Benefit						
		Phase 2	**Phase 3a**	**Phase 3b**	**Phase 4**	**Test Statistics**
Radical	Mean (Std Dev)	7.30 (0.59)	7.33 (0.56)	7.53 (0.43)	7.57 (0.70)	
	Kruskal-Wallis (mean rank)	9.20	9.60	11.40	11.80	χ^2=0.732; p=0.866
Benefit	Mean (Std Dev)	7.80 (0.57)	7.77 (0.60)	7.57 (0.32)	7.53 (0.83)	
	Kruskal-Wallis (mean rank)	11.70	11.30	9.80	9.20	χ^2=0.626; p=0.890

Choice Shift

To examine shifts in preferences, choice shifts were analyzed at the individual and group levels across evaluation phases 1 through 3a (see Figure 1). Analysis of individual choice shifts indicated that participants shifted their scores between phases 1 and 2, tending more towards positive shifts (i.e., score increase) than negative shifts. In contrast, shifts between phases 2 and 3a were mostly negative and appeared to be much larger. Significant differences were found between the shifts in phases 1 and 2, and phases 2 and 3a for all three dimensions (α 0.01 and 0.05 levels) (see Table 7). The shifts from phase 2 to phase 3a were negative on average, whereas the shifts from phase 1 to phase 2 were positive on average.

Table 7. Differences between Choice Shifts – Individual Average Shift

		First shift (Phases 1-2)	Second shift (Phases 2-3a)	Test Statistics
Overall	Mean (Std Dev)	1.27 (0.79)	-0.94 (1.80)	
	Kruskal-Wallis (mean rank)	9.17	3.83	χ^2=6.587; p=0.010**
Radical	Mean (Std Dev)	0.79 (1.25)	-1.58 (1.64)	
	Kruskal-Wallis (mean rank)	9.00	4.00	χ^2=5.789; p=0.016*
Benefit	Mean (Std Dev)	0.38 (1.23)	-1.57 (0.96)	
	Kruskal-Wallis (mean rank)	9.17	3.83	χ^2=6.564; p=0.010**

** significant at the 0.01 level; * significant at the 0.05 level

At the group level, choice shifts between phases 2 and 3a were analyzed (changes in the average score for each idea). Partially-shared persuasive arguments should result in more similar idea ratings after the discussion. For example, participants discussed the rating criteria in an effort to develop a shared understanding of it (coded as *"measure"* in Table 3). Participants recognized that they viewed radicalness slightly differently and noted that the definition is relative to each individual's risk perceptions and level of knowledge. Before the next round of evaluations, participants agreed to define radicalness as "innovativeness to the organization". Any differences in ratings due to variation in the interpretation of rating criteria are assumed to have been reduced or eliminated. Further, the rationale shared for liking or disliking a particular idea are possibly partially-shared persuasive arguments. An example of such a dialogue follows:

> *"I figured the combination of radical and high business value was good. So new opportunity different from what anybody is doing, but would actually generate cash. I liked idea 13 – had business value and was most elegant. There were lots of great ideas about what to do in virtual worlds, but in terms of generating cash…"*
> *"I found that one the hardest to rate."*
> *"It's just a good idea about what might happen in virtual worlds. But we don't have any stake in it so there may be no benefit to High Tech."*

Participants also commented that the discussion helped develop shared understandings of ideas and rating criteria. This should have led to a greater degree of agreement on ratings. However, the standard deviation in scores for each idea increased from phase 2 to 3a, signaling lack of consensus and shared understanding (α 0.05 level for overall dimension, α 0.001 for benefit and radical dimensions).

On average, group members decreased their ratings of ideas from phase 2 to 3a (α 0.01 level for overall dimension, α 0.001 for benefit and radical dimensions), suggesting members took a more critical view. One participant commented prior to the final vote, *"I also feel strongly that I can go radical on my voting. I'm going low and high. I feel that I'm eliminating the bottom 80%."* To better understand how the discussion had shaped the group's rating of ideas, we compared choice shifts between the ideas the group chose and those that were not chosen in the final group consensus. There were significant differences between the chosen and non-chosen ideas across all dimensions (α 0.01 through 0.10 levels) (see Table 8). The chosen ideas had, on average, an increase in overall scores whereas the non-chosen ideas had a decrease (α 0.01 level). The overall-score standard deviation decreased for the chosen ideas, signifying consensus, compared to the increased standard deviation for non-chosen ideas (α 0.05 level).

This result suggests that the ideas that were chosen at the end of phase 3 showed more consensus and favorable overall scores than the non-chosen ideas.

Table 8. Differences between Group Choice Shifts

		Non-chosen Ideas	Chosen Ideas	Test Statistics
Overall Shift	Mean (Std Dev)	-1.36 (1.06)	0.43 (0.53)	
	Kruskal-Wallis (mean rank)	8.69	18.40	χ^2=9.364; p=0.002**
Overall Std Dev Shift	Mean (Std Dev)	0.67 (0.91)	-0.30 (0.68)	
	Kruskal-Wallis (mean rank)	12.56	6.00	χ^2=4.261; p=0.039*
Radical Shift	Mean (Std Dev)	-1.79 (0.88)	-0.90 (0.69)	
	Kruskal-Wallis (mean rank)	9.56	15.60	χ^2=3.626; p=0.057†
Radical Std Dev Shift	Mean (Std Dev)	0.50 (0.70)	1.07 (0.70)	
	Kruskal-Wallis (mean rank)	9.75	15.00	χ^2=2.727; p=0.099†
Benefit Shift	Mean (Std Dev)	-1.73 (0.94)	-1.07 (0.72)	
	Kruskal-Wallis (mean rank)	9.75	15.00	χ^2=2.743; p=0.098†
Benefit Std Dev Shift	Mean (Std Dev)	0.49 (0.50)	1.40 (0.69)	
	Kruskal-Wallis (mean rank)	9.38	16.20	χ^2=4.609; p=0.032*

** significant at the 0.01 level; * significant at the 0.05 level; † significant at the 0.10 level

Satisfaction and confidence were also analyzed. Since participants were not involved in reviewing the phase 4 results, only phases 1 through 3 were analyzed. Significant differences were found between phases for satisfaction with the process (α 0.05 level) (see Table 9). As predicted, participants were more satisfied with the process in phase 3 than phase 1 (α 0.05 level). Of the six participants, five indicated they preferred phase 3. Comments made by participants in the final end-of-phase survey and debriefing session further supported this preference. Thus, the quantitative and qualitative data provided support for higher satisfaction with phase 3. Participants commented on phase 3:

> *"Taking the group input and honing it into a synthesized result was most useful as well as seeing the bounds on the ratings using the standard deviations."*
> *"I thought the collaboration aspect was the critical one, where we discussed pros and cons of each idea, and then came to consensus."*
> *"I thought the last phase was most critical for me. I liked the face-to-face collaboration that the tool didn't provide at all. It was nice to go over all our thoughts and flush out some of the ideas and rescore. It just seems more valuable that way."*
> *"There's a difference between doing something purely individually vs. online (in a group). Where we discovered – for example – the term radically was being used radically differently. You either continue that confusion all the way through or you get it clarified or even the description of items."*

Significant differences were also found between phases for confidence with the decision made (α 0.10 level). Participants were more confident in decisions made in phase 3 than phase 1 (α 0.05 level).

Table 9. Evaluation of Differences between Voting Phases – Satisfaction and Confidence

		Phase 1	Phase 2	Phase 3	Test Statistics
Satisfaction	Mean (Std Dev)	5.00 (0.63)	6.00 (0.89)	6.17 (0.75)	
	Kruskal-Wallis (mean rank)	5.42	11.00	12.08	χ^2=6.016; p=0.049*
	Mann-Whitney (mean rank)	4.67	8.33		p=0.058†
	Mann-Whitney (mean rank)	4.25		8.75	p=0.022*
	Mann-Whitney (mean rank)		6.17	6.83	p=0.733

Table 9. Evaluation of Differences between Voting Phases – Satisfaction and Confidence					
		Phase 1	Phase 2	Phase 3	Test Statistics
Confidence	Mean (Std Dev)	5.00 (0.89)	6.00 (1.10)	6.33 (0.82)	
	Kruskal-Wallis (mean rank)	5.67	10.67	12.17	χ^2=5.340; p=0.069†
	Mann-Whitney (mean rank)	4.83	8.17		p=0.093†
	Mann-Whitney (mean rank)	4.33		8.67	p=0.031*
	Mann-Whitney (mean rank)		6.00	7.00	p=0.604

* significant at the 0.05 level; † significant at the 0.10 level

Discussion

To address the eight challenges associated with generating and evaluating highly novel ideas in groups, we examined idea generation and decision-making processes and tools. From our field study, we gained insights into how both tools and processes can address these eight challenges as well as improve the effectiveness and efficiency of novel idea generation for the purposes of innovation.

For the creativity task (i.e., idea generation), we found that an NID tool can be particularly useful for brainstorming. The tool provides a number of benefits, primarily helping to alleviate the challenges associated with generating novel ideas. Leveraging the Web, the NID tool provided a wider array of external stimuli indirectly related to the subject matter (in this case, virtual worlds). It helped individuals notice potentially important connections between known concepts they may not have considered otherwise (*addressing challenges 2, 3, and 4*). The output of the tool helped stimulate thinking, enabling individuals to generate novel ideas to address the task. For one participant, simply reviewing the descriptive terms helped her make the "leap" and generate novel ideas. For another, it was the ongoing review and exploration of the results. Thus, the tool helped make brainstorming more effective for novel idea generation (*addressing challenge 2*). Comments made by participants regarding the speed of brainstorming using the NID tool and process for idea generation suggest efficiency gains as well (*addressing challenge 1*). Further, using external stimuli during idea generation makes individuals less "invested" in the ideas they generate. This is useful during idea evaluation, supplementing the anonymity benefits of the GSS, and resulting in less ego and stake in one's own ideas (*addressing challenge 7*). Rather than defending ideas, individuals appeared to be more inclined to consider and filter ideas during the evaluation phase.

For the decision-making task, our field study comprised four evaluation phases, three of which involved active voting and one the use of a collaborative-filtering tool. Despite similarity in radical and benefit scores across phases, a comparison of the chosen ideas shows that the top ideas selected in each phase differs. The collaborative-filtering tool (phase 4) produced results that differed from those of the GSS – democratic vote (tally of votes: phases 2 and 3a) and the final group consensus (phase 3b), with some overlap (e.g., overlap of 3 ideas with phase 3b). This moderate overlap suggests some possible synergies between collaborative-filtering tools and group discussion. Rather than using it as a standalone tool, a collaborative-filtering tool could be used in conjunction with group discussion. For example, using a collaborative-filtering tool as a decision model and comparing it to a democratic vote may help highlight ideas that may not have come out in the discussion, but are worth discussing further in the group discussion phase (*addressing challenges 4 and 8*). For example idea 13, chosen by the collaborative-filtering tool, appeared to be a good idea, but was silently dropped from the discussion. Comments made about idea 13 suggest that it was liked by some and not well-understood by others. Reviewing the collaborative filtering results during the discussion could have reintroduced idea 13 to the group as something they should discuss further. Combining the efficiencies of the collaborative-filtering tool with the satisfaction and confidence derived from a facilitated group discussion could not only help address a broader array of group challenges, but also provide both increased efficiency and effectiveness for group decision making when considering novel ideas.

Comments made by participants reveal that group discussion is critical for developing a shared understanding of novel ideas (*addressing challenges 5 and 6*). An analysis of the choice shifts between voting phases provided insights into the impact of group discussion and interaction. Between phases 1 and 2, individuals rated ideas more favorably. However, once group interaction was introduced – between phases 2 and 3 – choice shift was negative, resulting in less favorable ratings on average. Thus, the group discussion influenced how individuals perceived the ideas and resulted in participants taking a more critical view. Some individuals were more critical than others as indicated by the increase in standard deviations (i.e., less agreement) between phases 2 and 3. Thus, group members continued to have different interpretations of the ideas. Interestingly, the ideas that were chosen after the final vote actually had a positive shift (i.e., more favorable ratings) and lower standard deviations in scores (i.e., more agreement). Thus, the group had come to a shared understanding of these ideas and was able to reach a consensus on choosing these ideas. However, the group showed definite shift tendencies (*challenge 8*), discussed in more detail below.

The limited number of ideas (5 out of 21) in which a shared understanding (i.e., high agreement in ratings) was gained in process 3 is an interesting finding and challenge. Boland and Tenkasi (1995) suggest that a groupware voting system, where finding a consensus is promoted, can hamper "the team members from first strengthening and representing their own perspectives and then engaging in a dialogue of perspective taking with each other" (Boland and Tenkasi 1995 p. 360). The emphasis on consensus and time restrictions, as well as the novelty of ideas and associated cognitive complexity, could explain why the group reached a shared understanding on so few ideas. For example, ideas that involved high levels of specialized knowledge could have been ignored due to a lack of common knowledge and language to facilitate a discussion (e.g., Carlile 2002; Carlile 2004). Or complex ideas that were discussed could have resulted in fatigue due to the lengthy explanations required, leading to less discussion of other ideas. It is also possible that the number and complexity of ideas under consideration created information overload (Paul and Nazareth 2010), limiting the number of ideas that could be reasonably discussed and processed. Further, the pressure to contribute to the discussion may have resulted in dual task interference, a phenomenon similar to production blocking where the need to perform two tasks reduces the performance level of both (Heninger et al. 2006). Thus, the group discussion itself may have diverted individual cognition and attention from processing more ideas. However, another explanation is that the group developed a bias towards these ideas during their discussion and, as a result, ignored all other ideas. Group interaction can give rise to cognitive passivity, where the discussion is restricted to a small subset of ideas without deviation (Lamm and Trommsdorff 1973). Although related to challenge 8, this issue is of a slightly different nature. Group choice shift based on partially-shared persuasive arguments describes how opinions change based on "rationale" thinking processes. Cognitive passivity, on the other hand, shows a mindlessness and bias towards a certain ideas in order to minimize effort. To avoid premature convergence in the evaluation process, a collaborative-filtering tool may be helpful in pointing out interesting, yet not necessarily universally popular ideas.

Conclusion

Using a field study, we explored how different processes and tools can address the challenges associated with novel idea generation and evaluation in groups. Specifically, we have identified two new tools and an overall process that helps address eight distinct challenges and improves both the efficiency and effectiveness of innovation processes involving creativity and decision-making tasks. The NID tool promises to make the brainstorming process faster and is, therefore, most beneficial in the idea generation phase. By stimulating thinking using non-obvious connections, the NID tool helps make novel idea generation more effective and not just the result of serendipity. The collaborative-filtering tool, used as a decision model, can support groups in making better decisions by helping them consider interesting ideas that may not otherwise be discussed because they are not universally popular. Combined with group discussion, the collaborative-filtering tool can be used for process support, making the entire group decision-making process more efficient and effective.

Although the findings of this field study are promising, there are limitations. First, we employed an exploratory field study in order to develop deeper insights into how the tools and processes helped address group challenges. As a result, our sample size was low. In addition, we did not directly compare the proposed process and tools to other approaches. Thus, we relied primarily on the subjective comments of the participants to conclude the proposed process and tools are superiors. This said, as discussed by Ackermann (2011), it is difficult to use control groups when using real organizational groups. Using student subjects to increase sample size, future research should compare different processes and tools to quantify differences in effectiveness and efficiency for novel idea generation and evaluation in groups.

This research makes contributions to both research and practice. A new decision model for group decision-making was presented and evaluated in this research. The collaborative-filtering tool, which uses singular value decomposition, produced different results from the typical decision-making techniques (e.g., consensus building and democratic voting). Although there was some overlap, the tool also highlighted potentially valuable ideas (e.g., idea 13) that were not fully addressed in the group discussion, but deemed as important ideas by discerning evaluators. Future research should examine the active use of collaborative filtering results in conjunction with other decision models during group decision-making to further assess its effectiveness. Shown to be useful in an innovation context, collaborative filtering may also be useful in other decision-making contexts and should be examined in greater depth in future research.

This research also contributes to the GSS literature. The need for research that examines more realistic and natural usage of GSS (Fjermestad and Hiltz 1999) was addressed by this study. In addition, the call for "more emphasis on the use of larger groups of nonstudent subjects, using more complex tasks over a longer period of time than has been typical" (Fjermestad and Hiltz 1999 p. 27) was addressed. For instance, in this study an organizational group, composed of individuals with diverse knowledge and experience, performed a complex task involving novel idea generation and decision making over a four-hour time period. The complexity of the task was increased by the cognitive demands required to generate novel ideas using indirectly connected concepts and translating different group member interpretations of these novel ideas to reach a consensus. Thus, our study contributes to this particular call for research in almost all areas. Further, we examined the creativity of the group-decision outcome – an area in which more research is needed (Fjermestad and Hiltz 1999) – and analyzed the challenges associated with group creativity and decision-making tasks when dealing with high degrees of novelty. This research also extends past GSS research that examines the use of external stimuli, specifically the Web, to support brainstorming. Rather than using external stimuli to supplement idea generation performed primarily by individuals (Li et al. 2009), our study used external stimuli from the Web as the primary source of brainstorming. Lastly, participants in this study commented on the efficiencies gained by using an NID tool in the idea-generation process. This is a promising finding and suggests that using an NID tool in conjunction with a GSS for decision making may result in process gains. Past research has provided discouraging results regarding the process gains associated with GSS in comparison to face-to-face decision processes (Fjermestad and Hiltz 1999). Thus, the results of this research are encouraging.

Researchers and managers interested in studying or developing NID tools further can review the NID design theory, developed elsewhere (Jenkin et al. 2007). The NID design theory describes high-level design characteristics meant to support the development of NID tools in general.

Summarizing the challenges associated with generating and selecting a novel idea in a group setting and identifying solutions (tools and processes) will help managers interested in facilitating innovation better understand the outcomes and implications of these processes. Use of an NID tool for brainstorming can result in process efficiencies and more creative outcomes. Although learning effects could have negatively influenced the results, we found that despite the novelty of the tool, participants commented on how efficient the process was and how the tool stimulated thinking. Further use and training should enhance these benefits. Involving multiple individuals with different knowledge and experience in the use of the NID tool to generate ideas separately, provides diverse input into both idea-generation and the decision-making processes. Using multiple decision models, such as a collaborative-filtering tool and a democratic-voting model, can help groups develop a shared understanding of a greater number of novel ideas and improve decision-making outcomes for their organizations.

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