Supporting Creative Processes with IT: A literature review

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Abstract. Over the last decades, advances in IT have changed markets and businesses. Companies that were unable to adopt have vanished. In most businesses, the best strategy for keeping a competitive advantage is to innovate at a faster pace than rival organizations. This requires a systematic approach to innovation that is tailored to the individual situation of a company. In order to improve the speed and quality of their innovation process on an organizational level, companies can incorporate IT solutions such as electronic brainstorming that support the creativity of their employees on a group and individual level. The aim of this study is to investigate the current state of research in the IS literature regarding technology supported creativity. We have conceptualized the topic into individual research strands. For each research strand, we present theoretical models, their alignment with empirical findings and an agenda for future research.

Keywords: creativity, support systems, literature review, creativity techniques

1 Introduction

The starting point of every innovation is an idea. However, initial ideas rarely emerge fully formed from an innovative employee's head. Usually it needs to be shaped and modified significantly in order to be fleshed out into a successful business plan [1]. Therefore, working in a team on challenges with no obvious solution is very common in organizations that innovate. Ideas about products, practices, services, or procedures are considered creative when they are (a) novel or original and (b) potentially useful to the organization [2].

Many innovation methods and frameworks such as Design Thinking or Lean Startup promote interdisciplinary team collaboration and have become popular over the last years [3]. They make use of creativity techniques such as brainstorming or De Bono's six thinking hats. However, most of these approaches rely on hand written interactions techniques such as post-its and collaborating in face to face (f2f) sessions and make little use of technology for communication or stimulating group creativity.

Group work on topics with high uncertainty can be classified into divergent phases, in which ideas are generated and convergent phases that are focused on making

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decisions. Typically, divergent and convergent phases are used iteratively to first generate and then select the best ideas [4].

Many information systems exist that hold the potential for supporting groups in these phases, such as group support systems (GSS), creativity support systems (CSS), decision support systems (DSS) or knowledge management systems (KMS) [5–8].

Although many such tools are already available on the market, a significant gap still exists between those products and the creative process that they are supposed to support [9]. Therefore, Gabriel et al call for a an re-examination of the entire creative process to understand and fulfill real needs [10].

In order to start this endeavor we have conducted a literature review focused on theoretical and empirical findings within this field. Our research contributes to theory by providing an overview of existing theoretical knowledge on supporting creativity with technology in form of a conceptual framework. Furthermore, we identify several research gaps and lay out a research agenda for future research.

Our literature review is structured in the following manner: Within the next section, we describe the design of our literature review, focusing on selection of appropriate journals, conferences and articles. Then we describe our procedure of coding the selected articles and identification of main research themes. Next, we provide an overview of each theme and develop a conceptual framework integrating the themes. Finally, our review gives a short conclusion and implications for future work.

2 Design of the literature review

The intention of this study is to investigate the current state of research in the IS literature regarding technology for support of creative work and to identify research gaps.

Table 1. Review Scope

Characteristic		*Categories*			
1	focus	research outcomes	research methods	theories	applications
2	goal	integration	criticism	central issue	
3	organization	historical	conceptual	methodological	
4	perspective	neutral representation	espousal of position		
5	audience	specialized scholars	general scholars	practictioners	general public
6	coverage	exhaustive	exhaustive & selective	representative	central/pivotal

We therefore conducted a systematic literature review following the five steps of vom Brocke et al. [11]: Definition of the Review Scope (1), Conceptualization of the Topic

(2), Literature Search (3), Literature Analysis and Synthesis (4) and Derivation of a Research Agenda (5). To increase the comprehensiveness of our literature review, we discuss the Research Agenda directly within each result section as described by Müller-Bloch et al. [12].

In the first step, we clarified the scope (1) of our research according to Cooper's [13] taxonomy (depicted in Table 1): We decided to carry out a conceptual literature review, taking a neutral perspective, in order to integrate research outcomes and theories of how technology can support creativity by reviewing journals from high quality IS journals. The paper is intended for specialized scholars and may be considered representative for the IS domain.

Secondly, we conceptualized the topic (2) following Rowley and Slack's method [14]. We started by conducting a brief search for relevant literature in leading journals and books. Therefore, we read several books about creativity techniques and related topics such as design thinking, lean startup and innovation management to get a general understanding of the topic and to derive relevant search terms. Next, we started conceptualizing the topic and decided which concepts from it were relevant to our research topic. The result of the conceptualization is our conceptual framework, which is described in-depth in the next section. Throughout the process of forming the conceptual framework, we iteratively reviewed literature and developed a list of search terms we found relevant to our topic.

Thirdly, we conducted the literature review (3) as described by vom Brocke [11]. We chose to include only articles from peer-reviewed high-quality IS-journals. Therefore we searched in all journals ranked B or higher in the vhb-jourqual3. In order to find relevant articles we used the Scopus database. We limited the search to the ISSNs of the selected journals and included all articles that contained one of following search terms in the title or abstract:

"triz", "brainstorming", "creativity technique", "creativity techniques", "disney method", "six thinking hats", "creativity support system", "brain writing", "creative problem solving", "group decision support system", "collaborative creativity", "mind mapping", "quality function development", "axiomatic design", "lateral thinking", "kansei engineering", "open innovation", "group support system".

In order to find current research gaps, we limited the search to articles published from the 1st of January 2006 until the 2nd of April 2017. Our search yielded 140 hits. Next we determined which articles were relevant to our review. We only included articles that reported research on a) how a group of people could be supported in the process of generating, refining or documenting ideas by the use of information technology. Moreover, the reported research needed to be b) focused on the individual or group level and not on an organizational level. Finally, c) we excluded articles that were limited to an application domain and thus not appropriate to contribute to theory. We screened title, abstract and if necessary full text of the articles in order to identify all articles relevant to our topic. As a result of the screening for relevance 36 articles remained in the further process of the literature review.

3 Findings

In this section we describe our conceptual framework (Table 2) and discuss existing research, theoretical knowledge and research gaps within each theme.

Table 2. Conceptual Framework

	Concept					*Type*	
Citation	***Idea Evaluation***	***Creativity Interventions***	***Communication***	***Knowledge***	***Anonymity***	***Converging***	***Diverging***
(Ackermann et al. 2016) [15]					x	x	
(Althuizen/Reichel 2016) [8]		x		x			x
(Wong et al. 2016) [16]			x			x	x
(Tegarden et al. 2016) [17]			x		x	x	x
(Figl/Recker 2016) [18]				x			x
(Álvarez Carrillo et al. 2015) [6]			x			x	
(Ducassé/Cellier 2014) [19]				x		x	
(Jongsawat/Premchaiswadi 2014)			x				x
(Chen et al. 2014) [22]			x		x	x	
(Althuizen/Wierenga 2014) [4]		x		x		x	x
(Eden/Ackermann 2014) [23]					x	x	x
(Marett/George 2013) [24]			x			x	
(Dennis et al. 2013) [25]		x					x
(Bartelt et al. 2013) [26]		x				x	
(Javadi et al. 2013) [27]				x			x
(Kolfschoten/Brazier 2013) [28]				x		x	
(Reinig/Briggs 2013) [29]	x			x	x		x
(Voigt et al. 2013) [30]		x				x	x
(Müller-Wienbergen et al. 2011) [31]				x		x	x
(Ackermann/Eden 2011) [32]			x		x	x	x
(Ferreira et al. 2011) [33]				x			x
(Kuo/Yin 2011) [7]			x		x	x	x
(Barkhi/Kao 2011) [5]		x				x	
(Haines/Cheney Mann 2011) [34]			x		x	x	
(Alnuaimi et al. 2010) [35]			x				x
(Barkhi/Kao 2010) [36]			x			x	
(Briggs/Reinig 2010) [37]	x	x	x		x		x
(Paul/Nazareth 2010) [38]			x	x		x	
(Hahn/Wang 2009) [39]				x		x	x
(Cooper/Haines 2008) [40]			x		x	x	
(Lim/Guo 2008) [41]					x	x	
(Reinig/Briggs 2008) [42]	x						x
(Chen et al. 2007) [43]		x				x	x
(Reinig et al. 2007) [44]	x						x
(Shirani 2006) [45]			x	x		x	
(Heninger et al. 2006) [46]			x				
Σ	4	8	16	12	11	24	21

3.1 Evaluation of ideas

Since our study focuses on creative problem solving contexts with high uncertainty, the main unit of analysis for group and individual performance is the ideas that emerge from a creative problem solving session. Several metrics for idea evaluation are in use, such as idea-count, sum-of-quality, average-quality, and good-idea-count [29]. Researchers use these metrics to evaluate the efficacy of interventions targeted at improving the creativity of proposed solutions to a given problem. Despite the central role idea evaluation methods pose for creativity research, we identified very little discussion on the validity of the mentioned metrics. Only four studies evaluated the quality of idea evaluation methods and were all written by Reinig & Briggs. Moreover, their research is focused on ideas that stem from diverging phases.

Throughout their research, Reinig & Briggs theorize that only idea quality is a reliable measure to evaluate ideas. Moreover, they find that idea quantity is a poor surrogate for idea quality [29]. They also present theoretical reasoning which questions Osborn's conjecture that quantity of ideas will lead to high quality ideas [37]. They argue, that there may only be a limited amount of good solutions to a problem (limited solution space) and that humans are subject to cognitive inertia. Cognitive inertia occurs when people focus on a subset of concepts and have difficulties activating additional concepts from their long-term memory, making new ideas more and more similar to previous ideas.

Discussion and future research

So far, no standard metric has emerged to evaluate the outcome of creative problem solving sessions. The studies in our literature review used a variety of dependent variables, making it difficult to compare their findings. Quantity of ideas is far easier to measure than idea quality. Therefore, many studies include it as a dependent variable. Reinig & Briggs and Osborn provide contradictory theoretical arguments on the validity of idea quantity as a quality measure, whereas idea quality is an accepted measure within the research community. Empirical future research is needed to answer, whether quantity leads to quality. Another area for future research is to develop more efficient and robust methods to evaluate idea quality and decision quality.

3.2 Creativity improving interventions

In total, we found eight studies that tested interventions, which influenced the creativity of groups or individuals. The main contributors to theory on this topic are Reinig & Briggs and Althuizen et al. [4, 8, 29, 37, 42, 44, 47].

On a group level, Reinig & Briggs propose their own theory called Bounded Ideation Theory (BIT) [37]. BIT states that ideation team member's ability, understanding of the task, scarcity of attention resources, mental and physical exhaustion, goal congruence and the openness of the solution space predict the ratio of good ideas to total ideas. Findings from Barkhi et al.'s support BIT's proposition that understanding of the task improves group decision-making performance. On the other hand, they found that psychological safety leads to better performance, which is not modeled by BIT [5].

Althuizen et al. focus more on how the creativity of individuals can be increased [4, 8]. They found stimuli providers helped individuals create more novel and useful ideas than mind mappers or process guides [8]. To explicate their findings they draw upon the dual pathway to creativity theory [8]. This theory posits, that in order to find more novel solutions to a problem, individuals need to be stimulated either to be more persistent in the exploration of their knowledge base (persistence) or to search within a broader range of categories (flexibility).

However, creativity support systems are only effective if they take the creative ability of the individual into account and provide a sufficiently large and diverse set of cases that are closely linked to the problem at hand [8]. Moreover, creativity support systems are not likely to help highly creative individuals [4]. Achievement priming and creative problem solving training was successfully employed to generate a higher quantity and quality of ideas of groups [26, 43], whereas priming techniques which were known to be effective for idea generation were not effective in the same form for decision making [26].

Discussion and future research

Important topics for future research would be to explicate what factors influence the creative performance on a group level. BIT proposes several moderating constructs. An empirical measurement of their effect size could help to direct future research. Moreover, research is needed to explain how priming, creativity techniques and stimuli providers on the individual level effect outcomes on a team level. Further investigation of the optimal level of remoteness of stimuli to the target problem could help to effectively stimulate creativity. Finally, future research could develop and test other priming techniques to achieve better outcomes in decision processes.

3.3 Group communication

We differentiate three types of communication that can occur in the context of technology supported creativity: Face to face (f2f), distributed-synchronous and asynchronous communication [22]. In total, sixteen studies investigated the influence of communication on the creative process.

Asynchronous communication helps users to respond in a more measured and thoughtful way if they have time to process statements [15]. Users typically perform the same tasks in asynchronous communication as in f2f meetings. E.g. people that usually summarized contributions of others continue to do so in Computer Mediated Communication (CMC) [32]. Furthermore, individuals that usually dominated f2f meetings through rhetoric and charisma have less influence in CMC.

Text-based asynchronous interaction benefits those that have high levels of computer literacy [21, 32]. Furthermore, participants in synchronous text-based meetings typically wish to express their own point of view before focusing on the contributions of other group members [32]. Moreover, individuals often fail to process information they receive in text communication while concentrating on contributing to the discussion, due to an effect called dual-task interference [7, 46]. The resulting text from asynchronous communication can provide a group memory that can be revisited

at a later point in time [21]. The presence of such documentation can lead to enhanced decision making, project awareness, collaboration and decision consent [22].

F2f groups tend to discuss information that is known to all members of the group before focusing on unshared information, whereas unshared information is discussed earlier in asynchronous text-based communication [45]. F2f communication via video conferencing or co-location is more efficient than distributed asynchronous communication for decision making [6, 21, 22, 36, 48, 49]. Moreover, individual decision-making performance depends on individual group member's perceived level of psychological safety, psychological meaningfulness and their understanding of the decision goal [5].

The motives underlying individual group member behaviors (insight awareness) are key to increasing decision quality and consensus. Greater insight awareness is obtained when individuals are able to track and characterize other individual's behaviors (behavior awareness). Behavior awareness depends on an individual's ability to identify and distinguish among the different individuals within the group [34, 40]. On the other hand, behavior awareness increases individual's conformity and perception of dispensability. This in turn decreases participation and perceived consensus in teams [34]. Interestingly, these findings seem to align with Alnunaimi's theoretical model of social loafing [35]. Furthermore, Jongsawat & Premchaiswadi found that group awareness information had a positive influence on the work effort on a given task and the quality of collaborative work [21].

Lies and deceptive statements occur more often in (CMC) than in f2f meetings. However, lies and deceptions have significantly more success in influencing group decisions in f2f meetings [24]. Finally, social loafing and free riding occur more often in CMC than in f2f meetings and hinder team productivity [35, 37].

Several theories have been used to explicate findings on group communications. Focus Theory assumes that communication, information access and deliberation are needed for groups to be productive. If individuals need to allocate more attention resources to one of the three processes, the other two are neglected [22]. This theory would explain the dual task-interference described by Heninger et al. Alnuaimi et al. build on the theory of moral disengagement to explain social loafing and its effects in on team productivity [35]. They found that social loafing occurs more often in big and dispersed teams. In bigger teams members feel less responsible for outcomes, attribute blame on other team members more often and dehumanize team members. Team dispersion also strongly contributes to the dehumanization of team members. The result is increased social loafing and less team productivity.

Discussion and future research

Future research could develop frameworks that help decide under which circumstances which type of communication is optimal for group creativity. Moreover, research on how dehumanization, diffusion of responsibility and attribution of blame in large distributed teams can be prevented is needed. Since dual-task interference during group communication negatively influences decision quality, future research could develop and test counteractive measures and research if dual-task interference also occurs in diverging phases. Many articles mention the advantages the use of mobile ICT could have for group communication [16]. However, none of the articles in our

study report scenarios in which mobile ICT has been tested for creative problem solving.

There has been very little research focused on the behavior and speech of participants in technology supported creative processes. Interesting topics for research could include the analysis of cognitive load, stress level or body language. Knowing under which circumstances individuals experience cognitive load could help to empirically evaluate theories such as BIT, Focus Theory or idea integration.

Finally, since the findings of Haines et al. on behavioral awareness resemble those of Alnuaimi's findings on moral disengagement and social loafing future research could investigate whether those two theories are taking two perspectives on the same phenomenon.

3.4 The role of knowledge

We found twelve studies that discussed the role or representation of knowledge in technology supported creative processes. According to the dual pathway to creativity theory, creativity is tightly intertwined with knowledge, since ideas stem from the knowledge base of individuals [8, 31]. Therefore, measures that support individuals to search their knowledge base can be helpful. However, providing knowledge that is too remote to the problem at hand may be counterproductive [4]. Furthermore, knowledge should be presented differently in convergent and divergent phases. In convergent phases Knowledge Management Systems (KMS) that connect information seekers and specific answer providers are more efficient, whereas in divergent phases it is more important to bring together individuals with similar interests [39]. Moreover, when large amounts of information need to be processed, the team perceives time pressure, the information is complex or multiple criteria need to be considered, information overload can occur during decision making [19, 28, 38]. Regarding the representation of knowledge, Figl & Recker found that visual models helped participants to generate more appropriate ideas than text [18].

Information overload can also occur during idea integration in diverging phases when ideas need to be clustered or combined. Idea integration and existing knowledge can also limit the original creativity due to cognitive bias [27, 29, 31, 33]. On the other hand idea integration is a central mechanism for the inclusion of knowledge from other team members [27].

Discussion and future research

Future research could investigate methods of reducing cognitive load while searching the own knowledge base or integrating knowledge from other sources. Moreover, since too much knowledge can also have a detrimental effect on creativity, further investigation of the right amount and scope of knowledge necessary for sparking creative solutions is important.

3.5 Role of Anonymity

We found eleven studies that theorized on the use of anonymity in creative processes supported by ICT. Anonymity generally separates a person from their contribution,

such that contributions can be evaluated by their merit and not by who voiced them [15, 32, 41]. Moreover, anonymity allows things to be said that could not be said otherwise [15], leads to blunter statements [23] and more controversial ideas like "tattoo AIDS victims to ID them" [29]. Anonymous brainstorming groups generate a larger quantity of unique ideas but of the same quality as non-anonymous ones [29].

Furthermore, Briggs & Reinig found that anonymity decreases evaluation apprehension [37]. Evaluation apprehension is the fear of receiving retribution from peers or superiors for submitting an unpopular idea. Anonymity also reduces the uncertainty of minorities and helps them voice unpopular opinions [41]. Therefore, it can be used to flatten hierarchies and to develop ideas in a non-power based manner, which also works for a more objective evaluation of ideas [17].

Finally, anonymity can be provided with or without the use of nicknames. Not being able to differentiate which individual voiced a comment can be confusing for users [22, 34] and can lead to coordination problems during consensus tasks, because users do not know who holds which opinion. This effect decreases group influence, whereas when nicknames are provided and users can identify which individual holds which opinion, the group influence is increased [34].

Discussion and future research

The advantages and limitations of anonymity and the different forms of group communication have been researched to a certain degree. However, no theory has been tested or developed to explain the findings. A framework that explains under which circumstances anonymity is beneficial would be helpful.

4 Conclusion

In this article, we investigated the current state of the scientific literature about technology for supporting creative processes in the IS literature. We find that the IS field has focused on supporting creativity via group support systems, creativity support systems, decision support systems and knowledge management systems.

We have identified several research strands in the literature about these systems: Quick and correct assessment of ideas, measures that improve the creativity of groups and individuals, the influence of the different types of group communication, the role of knowledge and how it is presented to groups and individuals, the behavior of team members and the effects of anonymous communication. Future work in the field of technology supported creativity could target the research gaps we have identified within the individual research strands.

Even though an abundance creativity techniques such as de bono's six thinking hats, mind mapping or TRIZ have been used for more than 20 years, very few of the articles in our literature review reported scenarios in which technology supported versions of such techniques were employed. Brainstorming seems to be the only creativity technique of major interest in the IS literature.

Finally, research on creativity is vast and scattered among many disciplines such as neuroscience, cognitive science, sociology or economics. Our study is only limited to

what has been researched in the field of Information Systems. Comparing the findings from other disciplines with ours could lead to a fruitful discussion.

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