2009

Exploring the Effects of a Convergance Intervention on Ideation Artifacts: A Multi-Group Field Study

Victoria R. Badura
Chadron State College, vbadura@csc.edu

Aaron S. Read
University of Nebraska at Omaha, aread@mail.unomaha.edu

Robert O. Briggs
University of Nebraska at Omaha, robriggs@mail.unomaha.edu

Gert-Jan de Vreede
Delft University of Technology, gdevreede@usf.edu

Exploring the Effects of a Convergence Intervention on Ideation Artifacts: A Multi-Group Field Study

Victoria R. Badura
Chadron State College,
Center for Collaboration Science
University of Nebraska at Omaha
vbadura@csc.edu

Aaron S. Read
Center for Collaboration Science
University of Nebraska at Omaha
aread@mail.unomaha.edu

Robert O Briggs
Center for Collaboration Science
University of Nebraska at Omaha
robriggs@mail.unomaha.edu

Gert-Jan de Vreede
Center for Collaboration Science
University of Nebraska at Omaha &
Delft University of Technology
gdevreede@mail.unomaha.edu

ABTRACT

Information technology professionals frequently need to reduce and clarify ideas. The convergence patterns of collaboration-reduce and clarify are key in helping a group focus effort on issues that are worthy of further attention. This study furthers understanding convergence patterns by exploring and characterizing the effects of a FastFocus intervention on an ideation artifact. Researchers conducted an observational case study of executives and staff addressing a real task within a large it intensive organization. Three sets of artifacts were analyzed from three groups. Analysis of the problem statements generated during a problem identification and clarification session revealed several implications about convergence interventions. The FastFocus thinkLet reduced the number of concepts from 620 down to 145, a reduction of 76%. Ambiguity dropped from 55% in the ideation artifact to 6% in the converged artifact. Implications for brainstorming instructions were identified that may contribute to reduced ambiguity in ideation artifacts.

Keywords: collaboration, convergence, group support systems, cognitive load.

INTRODUCTION

IS/IT professionals and the decision makers they serve face a continuing need to solve problems. Researchers have proposed systematic frameworks that characterize decision-making and problem-solving processes (e.g. Ackoff 1970; Brightman 1980; Bross 1953; Dewey 1933; Dunker 1945; Simon 1977). These models begin with one or more phases where actors attempt to make sense of their problem(s). Ackoff (1970) for example, includes a phase for formulating objectives, while Brightman (1980) include a diagnosis phase. Weick (1993) describes sensemaking as creating order and making retrospective sense of events. In this work, we use the term, *sensemaking* as a label for activities a group executes to identify unacceptable conditions, to understand what may have caused those conditions to exist, and to understand which of those causes can be influenced by the group.

Collaboration Engineering researchers identified six patterns of collaboration that manifest as groups work through a problem solving process, and characterize how groups move through their activities (Kolfschoten, Briggs, Vreede and Appleman 2006): Generate, Reduce, Clarify, Organize, Evaluate, and Build Consensus. Some authors combine the *reduce* and *clarify* patterns under the more general heading, *convergence* (Davis, Vreede and Briggs 2007).

Work has also been undertaken to understand consensus building, e.g. (Dunlop 1984; Innes and Booher 1999; Rosenau 1962). A great deal of research has pursued the idea generation pattern by groups (e.g. Diehl and Strobe 1987; Diehl and Stroebe 1991; Fjermestad and Hiltz 1998-1999; Fjermestad and Hiltz 2001; Graham 1977; Kolfschoten and Santanen 2007; Lindgren 1967; Osborn 1963). Ideation activities, however, often generate more ideas than a group will find useful. In the knowledge economy, however, attention may be an organization's scarcest resource (Davenport and Beck 2001). To reduce cognitive load, therefore, convergence interventions follow idea generation activities. Researchers have recently begun to focus on convergence interventions: reduction activities

which move a group from having many ideas to a focus on fewer that they deem worthy of more attention, and clarification activities which move the group from less to more shared understanding of the concepts in their shared set (e.g. Davis, Badura and Vreede 2008; Davis et al. 2007).

Group members sometimes find convergence interventions to be painful and time consuming (Chen, Hsu, Orwig, Hoopes and Nunamaker 1994; Easton, George, Nunamaker Jr. and Pendergast 1990). Facilitators report that leading a convergence process requires more facilitation skills than any other pattern of collaboration (Hengst-Bruggeling and Adkins 2007). A better understanding of convergence might provide a conceptual foundation for creating new convergence methods that require less time and effort to execute, and that produce superior results. Better understanding of convergence might also lead to better understanding of the other patterns that often precede and follow convergence activities. It may be, for example, that observed variations in the artifacts of ideation activities would correlate with the ease and effectiveness of subsequent convergence interventions. Such insights could lead to better understanding of ideation. Observed variations in converged artifacts may also be discovered to correlate with variations in the organizing, evaluating, and consensus building activities that follow a convergence, and so lead to better understandings of those patterns.

This paper makes two key contributions to the convergence literature: a) it provides reliable, repeatable approaches to measuring and comparing the effects of convergence interventions on the artifacts of ideation sessions; and b) it characterizes those effects in detail for a particular ideation technique and a particular convergence technique as they were used by stakeholders for a real sensemaking task in a real workplace. For the purposes of this study a convergence intervention is any activity within a collaborative work process that is implemented with the intent of moving the group from a large number of ideas to a smaller number of ideas deemed worthy of further attention.

In this paper, we report an exploratory study to address the research question, "What is the effect of a convergence intervention on the artifacts of an ideation activity?" Such exploratory studies may help clarify the phenomena of interest for theory building and experimentation in future convergence research. In the next section we summarize recent literature on convergence activities. We then report a field study where we observed senior executives for a multi-national financial institution as they generated a set of possible barriers to achieving the organization's strategic goals, and then converged on a set of problem statements that they would use as the basis for action planning. We next analyze and compare the artifacts of the ideation activity and the artifacts of the convergence intervention to characterize the effects the convergence intervention had on the artifact of the ideation session. We discuss the implications of our exploration for research and practice, and conclude by outlining directions for future research.

BACKGROUND

Convergence

As mentioned above, convergence is one of six patterns of collaboration used in collaboration engineering. Two sub-patterns comprise the convergence pattern of collaboration: *Reduce,* which means moving from having many ideas to a focus on fewer the group deems worthy of more attention, and *Clarify,* which means moving from less to more shared understanding of the concepts (Vreede, Kolfschoten, & and Briggs, 2006).

Previous research on convergence patterns has developed a set of performance metrics for the thinkLets which fall under the convergence pattern of group behavior (Davis et al. 2007) . They identified five Results Oriented Success Criteria; *Speed, Comprehensiveness, Shared Understanding, Reduction and Refinement.* They also identified five Process Oriented Criteria; *Acceptance by Participants, Ease of Use for Facilitator, Ease of Use for Participants, Satisfaction with the thinkLet by the Facilitator, and Satisfaction with the thinkLet by the Participant.*

Davis and colleagues (2007) propose that one of the main purposes of convergence is to reduce the cognitive load of follow-on activities. Theories of cognitive load focus on the effective utilization of working memory (Barrouillet, Bernardin, Portrat, Vergauwe and Camos 2007; Sweller, van Merrienboer and Paas 1998). An important concept in these theories is working memory. Working memory refers to a limited cognitive resource used in reasoning and learning (Baddeley). , Approximately seven items of information can be held in working memory at any given moment (Miller 1956). When groups reduce the amount of information they have to process at a time therefore, working memory is freed, allowing the group to devote this resource to reasoning and decision making.Another important goal of convergence is to create shared understanding amongst group members (Valacich and Junh 2006).

Shared understanding allows individuals with differing expertise and information to create new ideas (Arias, Eden, Fischer, Gorman and Scharff 2001). Pendergast and Haynes (1995) conceptualize shared understanding as a shared context model which puts bounds around a group's focus. Groups that do not have shared understanding may devolve into unproductive conflict. Nunamker, Reinig, and Briggs (Nunamaker, Reinig and Briggs), for example, cited a case where a group negotiating requirements for a new online bookstore reached an impasse over system rights that should be granted to "affiliates." It turned out that there were five orthogonal meanings for the word, "affiliate" in that group. Until they reached clarity on those five concepts, they could not move forward with decisions about access rights.

The next section presents our approach to measuring the effectiveness of a convergence intervention in achieving reduction and clarification.

METHODS

The Research Venue

This study took place in the headquarters of a large Financial Services organization headquartered in the Midwestern United States. The company is more than 100 years old, and has more than 2,000 employees.

Participants

Twenty-five senior executives from across the organization participated in the work practice we observed. Participants came from both the headquarters (Office) and from the sales force (Field). They represented several different departments from customer service and underwriting to information technology. Participants ranged in age from 27 to 55 years of age, with an average age of 42 years. On average, participants had 23 years of experience in this industry. Twenty-three of the executives were female; two were male. All were born in the U.S.A., and all were U.S. citizens who spoke English as their first language. All had lived in the U.S. for their entire lives except for two who had lived 20 and 24 years overseas.

The Task

The executives met at the world headquarters to identify barriers that prevented the organization from achieving its strategic objectives. The company hired an outside paid facilitator to design and conduct the workshop. The workshop design took participants through several activities to create a list of high-priority problem statements organized under key themes. The workshop was instantiated in multiple sessions, with each group meeting for half a day to go through the process. In total six groups completed the workshop. This study examines three of those groups. This is an extension of an earlier study that examined just one group.

In the first workshop activity, the group generated ideas for 15 minutes in response to the question, "What are the key problems that block us from obtaining our strategic objectives?" This activity was based on an idea generation technique called *Free Brainstorm* (Briggs, Vreede, Nunamaker and Tobey 2001).

The brainstorming technique allowed all participants to contribute simultaneously and anonymously. The first workshop yielded an artifact containing 124 comments, subsequent sessions yielded artifacts containing 124, and 77 comments respectively. Some of the comments contained a single problem. Some contained multiple problems. Some contained no problems. This artifact was referred to as the *Raw Data Set.*

The second workshop activity was based on a convergence technique called *FastFocus* (Briggs et al. 2001). During this activity, each participant held a different page from the brainstorming activity. At the beginning of the activity, the facilitator displayed an empty list on a public projection screen where all participants could read it. Each participant is given the opportunity to select or formulate an important idea from the list. The facilitator screens the idea for redundancy, relevance, clarity, and level of abstraction. After each participant has had the opportunity to participate, they switch brainstorming pages and repeat the process until each participant feels that all relevant ideas have been contributed. The FastFocus activity lasted 45 minutes for each session and yielded artifacts containing 29, 31, and 20 problem statements. This artifact we refer to as the *Reduced Data Set.*

The participants continued working with the facilitator on a number of subsequent activities. These, however, are outside the scope of this study.

Metrics

Davis and colleagues (2007) proposed five Results Oriented Success Criteria for comparing convergence techniques:

Speed – The time required to execute the convergence intervention for a given data set.

Comprehensiveness – The degree to which all useful ideas from the idea generation artifact are included in the converged artifact, and the degree to which less-useful ideas are excluded from the converged artifact.

Shared Understanding – The degree to which group members ascribe similar meanings to the concepts in the converged artifact.

Reduction – The degree to which the converged artifact contains fewer concepts than the idea generation artifact.

Refinement – the degree to which concepts are expressed parsimoniously and unambiguously.

Comprehensiveness, reduction, and refinement are all attributes of artifacts. This exploratory study focuses on these measures.

In order to measure the effects of the convergence intervention on the ideation artifact, we conducted a multi-step step analysis in three phases: a) characterizing the ideation artifact; b) characterizing converged artifact; and c) comparing the ideation artifact to the converged artifact.

Characterizing the Ideation Artifact

Several steps were required to characterize the Ideation artifact. We refer to the output from the ideation activity as the *Raw Data set*. First, two coders counted the number of comments contributed to the brainstorming activity. Next, in order to count the number of unique problem statements in the brainstorming artifact, the coders disaggregated the *Raw Data Set* into single unique problem statements. Two coders independently evaluated each contribution contained in the *Raw Data Set.* Coders extracted each unique noun/verb/object combination that identified a desired state or outcome. Coders marked a contribution as ambiguous if its wording allowed for two or more grammatically correct interpretations, which would lead to differences in the disaggregation. Coders demonstrated the ambiguity of a contribution by identifying at least two different grammatical interpretations of the comment.

Coders trained for 4 hours on a sample data set, until they were able to achieve concurrence that exceeded 90%. They then each independently disaggregated each data set with an inter-coder reliability of .93. Disaggregation required approximately 12 hours per coder, spread across the three Groups, a total of 36 man-hours. For the set of rules used by the coders, please contact the lead author.

The coders met to resolve their differences. In all cases where coders disagreed on the disaggregation of unambiguous comments, they were able to demonstrate a coder had broken a disaggregation rule. In those cases, they agreed to the disaggregation that met the constraints of the rules[1].

In some cases, the coders discovered that the statement upon which they disagreed was, in fact ambiguous, each coder having derived a different grammatically sound interpretation for the contribution. The coders marked those items as ambiguous. Coders reviewed the ambiguous statements together to determine the most plausible interpretation, given the context of the brainstorming problem. For statements where no single interpretation seemed more plausible than the others, coders did not disaggregate the statement. If two coders disagreed on the interpretation of an ambiguous contribution, a third coder resolved the issue. Comments were considered ambiguous if they contained a rhetorical question rather than a problem statement (e.g. Do we really know what our customers want?). Statements were deemed to be ambiguous if they offered a solution disguised as a problem or (e.g. "We should get a faster computer," implying that current computers are too slow), or a problem disguised as a solution (e.g. "We have not yet switched over to a service oriented architecture," offering a solution, but not implying any particular problem). Resolution of disagreements and ambiguities required 5 person hours per group. Finally, two coders worked together to identify redundant problem statements in the disaggregated set. If either coder found a contribution to be non-redundant, it was retained in the set. This activity yielded the *Disaggregated Raw Data Set* (R-D). Researchers then counted the number of unique problem statements included in the Ideation Artifact.

[1] For the rule set used by the coders, please contact the lead author.

Characterizing the Converged Artifact

Researchers followed the same protocol to characterize artifact of the convergence intervention. This data set contained 30, 28 and 19 items for Groups A. B & C respectively, of which both reviewers identified only five items as ambiguous. Refer to Table 1 for a breakdown of the individual group counts.

Comparing and contrasting the Ideation Artifacts

Three coders worked together to determine whether each of the unique disaggregated problem statements from the *Raw Data Set* were reflected in the text of the problem statements in the *Reduced Data Set*, and which were not. Researchers then counted how many unique problem statements from the Ideation Artifact were included in the reduced artifact.

ANALYSIS

Table 1 presents a collection of variables that characterize the Ideation Artifact. Participants contributed 325 comments, of which only 7 were deemed to be off-topic. One hundred and seventy of the comments (52%) were counted as ambiguous.

Description of Variable	*Variable Name*	*ID*	Value			
			A	**B**	**C**	**Total/ Mean**
Number of Raw Comments Contributed	*Raw Comments*	*RC*	124	124	77	325
Number of Raw Off Topic Comments (no problem statement disaggregated from the comment)	*Raw Off-Topic*	*RC-Off*	1	7	0	7
Number of Raw On-Topic Comments	*Raw On-Topic*	*RC- On*	123	117	77	317
Number of Raw Comments deemed unambiguous	*Raw Unambiguous*	*RCU*	70	54	23	147
Number of Raw Comments deemed to be ambiguous	*Raw Ambiguous*	*RCA*	56	63	54	170
Ratio of Ambiguous Comments to Raw comments (RCA / RC)	*Raw Ambiguity Ratio*	*A/RC*	0.45	.50	.70	.52
Number of Raw Disaggregated Problem Statements	*Raw Disaggregated Problems*	*RCD-Problems*	280	230	161	671
Number of Unique Raw Disaggregated Problem Statements	*Raw Disaggregated Unique*	*RCD-Unique*	246	220	154	620
Number of Redundant Raw Disaggregated Problem Statements	*Raw Disaggregated Redundant*	*RCD-Redundant*	29	31	20	52
Number of Raw Problem Statements disaggregated from unambiguous Raw Comments	*Raw Disaggregated Problems - From Unambiguous Comments*	*RCD-Unambig*	165	143	40	199
Number of Raw Problem Statements disaggregated from Raw Ambiguous Comments	*Raw Disaggregated Problems - From Ambiguous Comments*	*RCD-Ambig*	115	87	122	324
Average Number of Problem Statements Disaggregated from each Raw Comment (RCD-Unique / RC)	*RC Disaggregation Ratio*	*U/RC*	1.98	1.77	2	1.91
Average Number of Problem Statements Disaggregated from Each Unambiguous Raw Comment (RCD-Unambig / RCU)	*RC Disaggregation Ratio - unambiguous*	*U/RC-Unambig*	2.2	1.15	1.74	1.69

Table 1. Characteristics of the Ideation Artifact

One hundred and forty-seven of the comments (45%) were coded as unambiguous when independent coders produced disaggregations of identical content. The 325 comments disaggregated into 671 simple problem statements. Fifty-one of those were deemed to be redundant, yielding 620 unique disaggregated problem statements.

Description of Variable	*Variable Name*	*ID*	Value			
			A	**B**	**C**	**Mean/ Total**
Number of Reduced Problem Statements	*Reduced Problems*	*RD*	30	31	20	81
Number of Reduced Problem Statements deemed unambiguous by coders	*Reduced Problems - Unambiguous*	*RDU*	29	28	19	76
Number of Reduced Problem Statements deemed to be ambiguous by any coder	*Reduced Problems-Ambiguous*	*RDA*	1	3	1	5
Ratio of Ambiguous Reduced Problem Statements to Number of Reduced Problem Statements	*Reduced Ambiguity Ratio*	*A/RD*	.03	.096	.05	.06
Number of Reduced Disaggregated Problem Statements	*Reduced Disaggregated Problems*	*RDD-Problems*	59	50	36	145
Number of Unique Reduced Disaggregated Problem Statements	*Unique Reduced Disaggregated Problems*	*RDD-Unique*	58	44	35	137
Number of Redundant Reduced Disaggregated Problem Statements	*Redundant Reduced Disaggregated Problem Statements*	*RDD-Redundant*	1	6	1	8
Number of Reduced Problem Statements disaggregated from unambiguous Reduced Problem Statements	*Reduced Disaggregated Problems - Unambiguous*	*RDP-Unambig*	55	44	35	134
Number of Reduced Disaggregated Problem Statements from ambiguous Reduced Problem Statements	*Reduced Disaggregated Problems - Ambiguous*	*RDD-Ambig*	4	3	1	8
Average Number of Problem Statements Disaggregated from each Reduced Problem Statement (RDD-Unique / RD)	*RD Disaggregation Ratio*	*U/RD*	1.96	1.41	1.75	1.69
Average Number of Problem Statements Disaggregated from Each Unambiguous Raw Comment (RDD-Unambig / RDU)	*RD Disaggregation Ratio - unambiguous*	*U/RD-Unambig*	1.90	1.57	1.84	1.76
Average Number of Problem Statements Disaggregated from each Ambiguous Raw comment (RDD-Ambig / RDA)	*RD Disaggregation Ratio – ambiguous*	*U/RD-Ambig*	4.00	1	1	1.6

Table 2. Characteristics of the Converged Artifact

Approximately half the unique problem statements were disaggregated from unambiguous comments; the other half from ambiguous comments. On average, coders identified 1.69 problem statements per unambiguous contribution, and 1.91 unique problem statements per ambiguous contributions.

Table 2 presents a collection of variables that characterize the Converged Artifacts. This set contains 81 Reduced Problem Statements, of which only five were discovered to be ambiguous by the coders. Those 30 statements

disaggregated to 145 simple problem statements. Eight statements were found to be redundant. Eight of these items were disaggregated from ambiguous statements.

DISCUSSION

Davis and colleagues (2007) proposed the *Reduction,* and *Refinement* concepts as a means to compare convergence techniques. This paper contributes approaches for measuring those constructs. The Ideation artifacts contained 620 unique problem statements, while the Convergence Artifacts contained 145 unique problem statements, a 76% diminution. The FastFocus technique therefore produced a demonstrable reduction effect. Fifty-two percent of the contributions in the Ideation Artifact were ambiguous. Only six percent of the problem statements in the Convergence Artifact were discovered to be ambiguous. The *FastFocus* technique produced a demonstrable decrease in ambiguity. Given that ambiguity in problem statements would increase the likelihood that different people in a group would ascribe different meanings to the same problem statements, a reduction in ambiguity is likely to correspond to an increase in shared meaning. Therefore, the *FastFocus* technique may also have produced a clarification effect.

Davis and colleagues (2007) also advanced *Comprehensiveness* as a way to compare convergence techniques. Comprehensiveness is the degree to which important concepts from the Ideation Artifact are represented in the Convergence Artifact. Given the constraints of working with real groups on real tasks in the field, we did not anticipate gathering measures of comprehensiveness. However, a serendipitous event in the field, provided an opportunity. Two months after the initial workshops, two of the three groups of executives (A and B) combined their Convergence Artifacts and voted on the importance of the problem statements from both lists. Some of the items from group B did not appear in the Convergence Artifact of group A, and vice versa. All these ideas had, however appeared in the Ideation Artifacts of both groups. When the members of the first group rated the items they had excluded from their reduced artifact, they rated several of their excluded ideas higher than most of the ideas in their Converged set (See Table 3). This result has two possible explanations. First, it may be that the *FastFocus* technique is not fully comprehensive in the extent to which it extracts all useful ideas from the ideation set. A second possibility is that something transpired during the intervening two months that caused participants' priorities to change. Given that the FastFocus technique is often selected for its comprehensiveness, this aspect of the technique should be explored more fully in future research.

Group A's votes for Group B's FastFocus Items	**votes**	**rank**
There are insufficient human resources and training resources for the workforce	10	1
The delivery of our customer service is sub-standard	8	3
The bi-weekly cutoff detracts from customer service (also a work process consideration)	7	8
Group B's votes for Group A's FastFocus Items		
We are too reactive to problems and not proactive enough to solutions	9	1
There are insufficient human resources and training resources for the workforce	7	2
There is an understaffing challenge leading to burnout, low morale, which in turn results in poor customer service	6	3
The bi-weekly cutoff detracts from customer service (also a work process consideration)	6	4

Table 3. Examples of Ideas Eliminated from the Convergence Artifact Their Votes and Ranking Two Months Later

Implications for Brainstorming Techniques

The study provides several interesting implications for brainstorming techniques. Over half the contributions to the brainstorming activities were discovered to be ambiguous. Explicit brainstorming instructions may reduce the ambiguity of contributions, and so reduce the cognitive load of subsequent ideas. Many ambiguous contributions contained the word, "need." A statement like, "Need faster computers," could be interpreted as a problem (slow computers) or a solution (faster computers). Warnings against that type of ambiguity before work begins could improve the caliber of idea generation. Other contributions were rendered ambiguous when participants used long sentences with many dependent clauses or long chains-of-causation with multiple direct and indirect objects. Instructions to keep statements short and direct might have yielded less ambiguous. For example "There is too much

work, so people are working overtime, which results in reduced morale, leading to lower productivity" could be broken up by participants into several simpler causal statements like: "There is too much work so people are working overtime. Overtime results in reduced morale. Reduced morale leads to low productivity."

Limitations and Future Research

Although our data came from real executives and managers working on real problems in the workplace, we note that our dataset came from only three groups in a single organization. It would be useful to explore these phenomena further with other groups in other organizations using the same techniques for ideation and convergence. It would be useful to compare the effects of other convergence techniques on the same Ideation artifacts.

It would also be useful to conduct similar studies under conditions where participants could rate the merit of each contribution. This would allow for more-detailed explorations of the comprehensiveness of convergence techniques.

This research focused on the effects of a convergence technique on *artifacts.* Additional research will be required to gage the effects of convergence techniques on the shared understanding and cognitive load of the participants themselves.

Conclusion

This paper makes two key contributions to the convergence literature: a) it provides reliable, repeatable approaches to measuring and comparing the effects of convergence interventions on the artifacts of ideation sessions; and b) it characterizes those effects in detail for a particular ideation technique and a particular convergence technique as they were used by stakeholders for a real sensemaking task in a real workplace. Such exploratory studies may help clarify the phenomena of interest for theory building and experimentation in future convergence research.

REFERENCES

1. Ackoff, R.L. *A concept of corporate planning* Wiley-Interscience, New York, 1970.
2. Arias, E., Eden, H., Fischer, G., Gorman, A., and Scharff, E. "Transcending the individual human mind: Creating shared understanding through collaborative design," *ACM Transactions on Computer-Human Interaction* (7:1) 2001, pp 84-113.
3. Baddeley, A. "Working memory," *Science* (255:5044) 1992, pp 556-559
4. Barrouillet, P., Bernardin, S., Portrat, S., Vergauwe, E., and Camos, V. "Time and Cognitive Load in Working Memory," *Journal of Experimental Psychology: Learning, Memory, and Cognition* (33:3) 2007, pp 570-585.
5. Briggs, R., Vreede, G.J., de, Nunamaker, J., and Tobey, D. "ThinkLets: Achieving Predictable, Repeatable Patterns of Group Interaction with Group Support Systems (GSS)," IEEE Computer Society, 2001, p. 1057.
6. Brightman, H.J. *Problem solving: A logical and creative approach* Business Publishing Division, College of Business Administration, Georgia State University, Atlanta, 1980.
7. Bross, I.D.F. *Design for Decision* The Macmillan Company, New York, 1953.
8. Chen, H., Hsu, P., Orwig, R., Hoopes, L., and Nunamaker, J.F. "Automatic concept classification of text from electronic meetings," *Communications of the ACM* (37:10) 1994, pp 56-73.
9. Davenport, T.H., and Beck, J.C. "The Attention economy," *Ubiquity* (2:14) 2001, p Article 1.
10. Davis, A.J., Badura, V., and Vreede, G.J. de., "Understanding Methodological Differences to Study Convergence in Group Support Systems Sessions
11. " Proceedings of the 14th Collaboration Researchers' International Workshop on Groupware, Omaha, Nebraska, 2008.
12. Davis, A.J., Vreede, G.J., de., and Briggs, R.O. "Designing thinkLets for convergence," in: *Proceedings of the 13th Americas Conference on Information Systems (AMCIS-13), Keystone, Colorado*, 2007.
13. Dewey, J. *How We Think* Health, New York, 1933.
14. Diehl, M., and Strobe, W. "Productivity Loss in Brainstorming Groups: Towards the Solution of a Riddle," *Journal of Personality and Social Psychology* (53:3) 1987, pp 497-509.

15. Diehl, M., and Stroebe, W. "Productivity Loss in Idea-Generation Groups: Tracking Down the Blocking Effect," *Journal of Personality and Social Psychology* (61) 1991, pp 392-403.
16. Dunker, K. "On Problem Solving," *Psychological Monographs* (58:5) 1945, pp 47-90.
17. Dunlop, J.T. *Dispute Resolution: Negotiation and Consensus Building*, 1984.
18. Easton, G.K., George, J.F., Nunamaker Jr., J.F., and Pendergast, M.O. "Using two different electronic meeting system tools for the same task: An experimental comparison," *Journal of Management Information Systems* (7:1) 1990, pp 85-101.
19. Fjermestad, J., and Hiltz, S.R. "An Assessment of Group Support Systems Experimental Research: Methodology and Results," *Journal of Management Information Systems* (15:3) 1998-1999, pp 7-149.
20. Fjermestad, J., and Hiltz, S.R. "Group Support Systems: A Descriptive Evaluation of Case and Field Studies," *Journal of Management Information Systems* (17:3) 2001, pp 115-159.
21. Graham, W.K. "Acceptance of ideas generated through individual and group brainstorming," *Journal of Social Psychology* (101:2) 1977, pp 231-234.
22. Hengst-Bruggeling, M., and Adkins, M. "Which Collaboration Patterns are most Challenging: A Global Survey of Facilitators," Proceedings of the 40th Hawaii International Conference on System Sciences, IEEE, Big Island 2007, pp. 1-10.
23. Innes, J.E., and Booher, D.E. "Consensus Building and Complex Adaptive Systems," *Journal of the American Planning Association* (65:4) 1999, pp 412-423.
24. Kolfschoten, G.L., Briggs, R.O., Vreede, G.J.de., and Appleman, J.H. "Conceptual foundation of the ThinkLet Concept for Collaboration Engineering," *International Journal of Human-Computer Interaction* (64:7) 2006, pp 611-627.
25. Kolfschoten, G.L., and Santanen, E.L. "Reconceptualizing Generate thinkLets: the Role of the Modifier," in: *Proceedings of the 40th Annual Hawaii International Conference on System Sciences*, IEEE Computer Society, 2007, pp. 16-26.
26. Lindgren, H.C. "Brainstorming and the facilitation of creativity expressed in drawing," *Perceptual and Motor Skills* (24:2) 1967, p 350
27. Miller, G.A. "The magical number seven plus or minus two: some limits on our capacity for processing information," *Psychological Review* (63:2) 1956, pp 81-97
28. Nunamaker, J., Reinig, B.A., and Briggs, R.O. "Principles of Effective Virtual Teamwork," *Communications of the ACM* (52:4) 2009, pp 113-117.
29. Osborn, A. *Applied Imagination: Principles and Procedures of Creative Problem Solving* Scribner, New york, 1963.
30. Pendergast, M.O., and Hayne, S.C. "Alleviating convergence problems in group support systems: The shared context approach," *Computer Supported Cooperative Work* (3:1) 1995, pp 1-28.
31. Rosenau, J.N. "Consensus-Building in the American National Community: Some Hypotheses and Some Supporting Data," *The Journal of Politics* (24:4) 1962, pp 639-661.
32. Simon, H.A. *The New Science of Management Decision* Prentice-Hall, NJ, 1977.
33. Sweller, J., van Merrienboer, J., and Paas, F. "Cognitive Architecture and Instructional Design," *Educational Psychology Review* (10:3) 1998, pp 251-296.
34. Valacich, J.S., and Junh, J.H. "The effects of individual cognitive ability and idea stimulation on idea-generation," *Group Dynamics: Theory, Research, and Practice* (10:1) 2006, pp 1-15.
35. Weick, K.E. "The Collapse of Sensemaking in Organizations: The Mann Gulch Disaster," *Administrative Science Quarterly* (38:4) 1993, pp 628-652.