Gert-Jan de Vreede
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Groupware: Design, Implementation, and Use

10th International Workshop, CRIWG 2004
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Preface

This volume constitutes the proceedings of the 10th International Workshop on Groupware (CRIWG 2004). The conference was held in San Carlos, Costa Rica, and followed the traditional CRIWG spirit: a relatively small number of attendees, lively discussions and participation during and between paper presentations, and a constructive and friendly environment, which promoted a high level of learning and collaboration.

The previous nine CRIWG workshops were organized in Lisbon, Portugal (1995), Puerto Varas, Chile (1996), El Escorial, Spain (1997), Buzios, Brazil (1998), Cancun, Mexico (1999), Madeira, Portugal (2000), Darmstadt, Germany (2001), La Serena, Chile (2002), and Autrans, France (2003).

This 10th anniversary CRIWG exemplified the continuing interest in the groupware research area. Groupware researchers from 14 different countries submitted a total of 71 papers. Each of the 71 papers was reviewed by two to three members of an international Program Committee, using a double-blind reviewing process. Reviewers were carefully matched to paper submissions as much as possible to ensure expert assessments of the submitted research while avoiding potential conflicts of interest. Reviews were usually extensive and contained many constructive suggestions for improvement. Based on the reviewers' recommendations 29 papers were finally accepted: 16 long papers presenting mature work, and 13 short papers describing work in progress. The accepted papers were grouped into seven themes that represent current pockets of interest in groupware research: knowledge management, awareness, support for collaboration processes, collaborative applications, groupware infrastructure, computer-supported collaborative learning, and mobile collaborative work.

CRIWG 2004 would not have been possible without the work and support of a great number of people. First of all we extend our sincere appreciation for the reviewers' efforts that enabled both a strong selection of papers for the conference as well as provided useful and actionable feedback for the large majority of the submissions, even if they were rejected. We were grateful for the advice and support provided by the CRIWG Steering Committee. Last but not least we thank Alan Calderón and Gwendolyn Kolfschoten for their enthusiastic support.

We especially wish to acknowledge our sponsoring organizations: Universidad de Costa Rica, Grupo GBM de Costa Rica, and Universidad de Chile.

September 2004

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On Theory-Driven Design of Collaboration Technology and Process

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Abstract. The design and deployment of collaboration technology has, until lately been more of an art than a science, but it has produced some solid successes. Commercial groupware products now support millions of collaborations per year. Under certain circumstances teams that use Group Support Systems perform far better than groups that do not. However, as impressive as the achievements are in this field, we can do better. A rigorous theoretical approach to the design of collaboration technology and process can lead us to non-intuitive design choices that produce successes beyond those possible with a seat-of-the-pants approach. This paper explains the simple structure of a rigorous scientific theory and offers examples of theory-driven design choices that produced substantial benefits. It then differentiates rigorous theory from several classes of theory that have intuitive appeal, but cannot inform design choices. It then argues that the logic of the theory-driven design approach suggests that the most useful focus for collaboration technology researchers would be the technology-supported work process, rather than just the technology.

1 Collaboration Technology Design as an Art

Designing collaboration technology has, until lately, been an art, founded on common sense and intelligence, guided by heuristics derived from inspiration tempered by hard experience. This approach has given rise to some solid long-term successes – consider, for example Lotus Notes, NetMeeting, and Webex, each of which now supports millions of collaborations per year. A robust body of literature shows that, under certain circumstances, people who use Group Support Systems (GSS) can be substantially more productive than people who do not (see Fjermestad and Hiltz, 1999, 2001 for compendia of GSS lab and field research). In 1999, we surveyed 127 organizations that used GSS. They reported an average cost saving of $1.7 million per year on an average technology investment of $75,000 USD. A year-long field study of more than 60 groups of GSS users at Boeing (Post, 1992) showed an ROI of 689% on an investment of approximately $100,000. It is rare in any field to find returns at that level.

Such results are nothing short of spectacular, yet as good as they are, we can do better; much better. Brilliant, intuitive minds and seat-of-the-pants reasoning can only carry us so far.

As many successes as there have been in this field, there have been many more failures. Remember The Coordinator? In the early 1990's, this system was heavily funded and highly touted. It was one of the first attempts at an integrated virtual

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workspace, including team calendaring, document repository, and a handful of other seemingly useful technologies. Yet users hated the system. Some disparaged it as Nazi-ware because of the draconian patterns of collaboration it enforced (e.g. every inbound message shall receive a reply before other work could be continued in the system).

The Boeing GSS case was so successful that it was written up in the February, 1992 issue of Fortune Magazine. And yet, the same week the article appeared, Boeing disbanded their GSS facility and reassigned all its personnel to other projects. This pattern of significant success followed by sudden cessation has been repeated by many organizations that adopt GSS (Agres, Vreede and Briggs, 2004, Briggs, Vreede and Nunamaker, 2003).

In light of these examples, consider these questions:

- How can we account for the dramatic success of some collaboration technologies?
- More importantly, how can we repeat those successes elsewhere?
- As successful as some collaboration technologies have been, are they as successful as they could be?
- How would we know?
- What else could we try that has never been considered that would be all but guaranteed to work?
- How can we account for stunning failures of other collaboration technologies?
- More importantly, how can we avoid them elsewhere?
- Do we have to wait for inspiration to strike some genius in our field before we attain our next leap forward?

Good theory can address all these questions.

2 There Is Nothing So Useful as a Good Theory

There is nothing as useful as a good theory. This assertion may draw snorts of derision from skeptics who may regard theory as an excuse for not doing anything useful. Yet, a good theory can put people on the moon and return them safely to earth on the first try. What one theory can do for space travel, others can do and have done for collaboration technology. Rigorous theory can lead to designs for collaboration technology process that far surpass those produced by a good mind and a gut feel. This paper explains what is meant by *good theory*, and present several cases to illustrate how a good theory can drive the design and deployment of collaboration technology in non-intuitive ways to yield unexpected success. It also discusses several classes of theory that seem tantalizingly useful at first, but which cannot lead to useful results. It concludes by discussing implications for ongoing collaboration technology research.

2.1 Good Theory: Always a Causal Model

A good scientific theory is a *model* of *cause-and-effect* to explain some *phenomenon of interest*.

Every technology presumes a cause-and-effect. Every technology is built to improve some outcome. By definition, this presumes that mechanisms exist to cause changes in the outcome of interest, and that technology can be used to invoke those mechanisms. A theory is a model of those causal mechanisms. The theory gives us a basis for understanding how we might use technology to attain the outcomes we want. If we have not taken the time to rigorously articulate the mechanisms that cause the outcome of interest, our technologies and our processes may miss the mark.

2.2 Phenomenon-of-Interest: Always the Effect; Never the Cause

In a good theory, the phenomenon-of-interest is *always* the effect; the outcome. The phenomenon of interest is the unchanging focus of a theory. The first step to successful theory-driven design is to explicitly identify, and then define the phenomenon of interest. It is not always obvious at first what outcomes a technology is meant to improve. For collaboration researchers, the possibilities are many – productivity, creativity, satisfaction, and so on. Suppose a technology designer wanted to improve satisfaction with group processes and with group products among stakeholders who were negotiating requirements for a new software development project. The phenomenon of interest would be satisfaction. It would not be group process, not group product, not requirements negotiation, not software development, and not project management. The research question would be, "What causes people to feel satisfied?"

However, labeling the phenomenon of interest is not sufficient. It must be explicitly defined. For example, the word, satisfaction, has many connotations in the English language. In one sense, satisfaction could be a *judgment* that goals have been attained or constraints have been met. In another sense, satisfaction could be an *emotional response* pertaining to goal attainment. These different satisfactions spring from different causes, and so have different theoretical explanations. Theory-driving design must therefore begin by not only identifying and labeling, but also by explicitly defining the phenomenon-of-interest.

Having identified and defined a phenomenon of interest, the next step is to challenge one's judgment, asking whether this outcome is truly the most useful or important target for improvement. If this outcome were improved, whose work might be more effective? Whose life might improve? Is there other outcome that could be improved instead to yield better results? When one can present an unbreakable case that a certain outcome is truly worthy of effort, it is then time to seek good theory.

2.3 Good Theory: Constructs Connected by Propositions

A good theory is a model of cause-and-effect that can account for variations in the outcome of interest. The logic of these models can be represented as collection of statements with a particular structure. These statements have only two components: axioms and propositions. For example:

If we assume that:

(Axiom 1) all individual actions are purposeful toward attaining goals,

Then it must be that:

(Proposition 1) the effort an individual expends toward attaining a group goal will be a function of goal congruence (the degree to which the group goal is compatible with the individual's private goals.)

An axiom is nothing more than an assumption about some mechanism that could affect the phenomenon of interest. An axiom doesn't assert Truth (with a capital T). It simply prompts one to ask, "If this assumption *were* true, would that be sufficient to explain how to get the outcome we want?"

A proposition is a functional statement of cause and effect. A proposition posits a causal relationship between two constructs. Constructs are different than variables. A variable is measurable. Productivity in the context of an automobile factory can be measured by the variable, "number-of-cars." Productivity in a brainstorming group can be measured in terms of the variable "number-of-ideas." But productivity itself is not a variable, it is an idea.

Propositions always posit that one construct causes another. A construct in a proposition is either a cause or an effect. In Proposition 1 above, the constructs are Effort and Goal Congruence.

There are a number of different ways a given proposition could be stated. The examples below express the same construct with different words:

- Individual effort toward a group goal is a function of goal congruence
- Goal congruence causes individual effort toward a group goal
- Individual Effort is determined by goal congruence
- The more goal congruence, the more effort.

All these phrasings can be summarized by a mathematical function like this:

$$E = f(G) \tag{1}$$

Where:
E = *Individual Effort*
G = *Goal Congruence*

Notice that this very simple expression is not specific about the nature of the function; it does not specify whether it linear, curvilinear, or discontiguous; it does not specify whether the function is bounded or infinite; whether it has constant or variable parameters. Such a young, incomplete theory would no doubt acquire more nuance and complexity as research progressed. Nonetheless, simple though it is, it is still useful to the collaboration technology designer. It suggests that E is a positive function of G, which means if you can figure a way to use technology to increase G, you should get more E as a result.

Theoretical propositions can also be illustrated as simple box-and-arrow diagrams. Figure 1 illustrates three propositions in a simple theory of group productivity. Each box-arrow-box combination constitutes a proposition. The direction of the arrow indicates the direction of causation.

In Figure 1, notice that Proposition 2, the Distraction proposition, posits an inverse relationship rather than a positive relationship. It could be interpreted, "The more distraction a group experiences, the less effort it will make toward a goal." Thus, if you could find a way to use technology to reduce distraction, effort toward the goal should increase, which should in turn increase productivity.

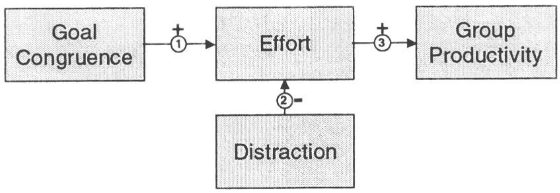

Fig. 1. A box and arrow diagram of several theoretical propositions to explain group productivity. The model posits Productivity as a positive function of goal-directed Effort. It posits Effort as a positive function of goal congruence, and as a negative function of distraction.

Box-and-arrow diagrams provide a way to run the Absurdity Test, a quick, useful way to smoke-test the basic logic of a proposition. Box-arrow-box combinations for improperly framed propositions will yield absurd statements when they are interpreted in the following form:

"The more of <Box X> we have, the more of <Box Y> will result."

For example, consider the two propositions in Figure 2.

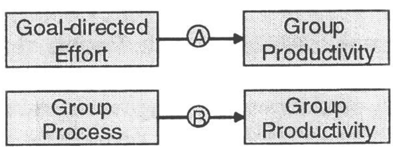

Fig. 2. Two Theoretical Propositions. Proposition A passes the Absurdity Test. Proposition B fails the test.

Proposition A yields a sensible statement when put in the form, "The more goal-directed effort group members make, the more productive the group will be." On the other hand, Proposition B, which has some intuitive appeal, (Group productivity must surely be a function of group process), nonetheless yields an absurd statement when put into the form, "The more process a group has, the more productive the group will be." The Absurdity Test quickly reveals a logical flaw in the proposition, signaling the need for additional attention.

Notice also that the axioms do not appear in the box and arrow diagram. Nonetheless, every proposition is based on one or more assumptions, whether or not they have been articulated. Until the axioms have been teased out and explicitly articulated, their validity cannot be judged, and so the model does not yet fully explain the phenomenon of interest, and the theory is not yet complete.

To summarize, then, a causal theory is a collection of statements that propose mechanisms that could cause a phenomenon of interest. These statements are composed of axioms (assumptions) and propositions (functional statements of cause and effect). They combine to form the logic of a causal theory, making arguments that take the form, "If we assume X, then it must be that Y is a function of Z. The propositions of a causal theory can be illustrated with a box-and-arrow diagram. Each box-arrow-box combination can be interpreted as some variation on the theme, "The more Z you have, the more Y will result."

3 Good Theories – Better Technologies

This section presents three examples that illustrate how a good theory can drive non-intuitive design choices that improve group outcomes.

3.1 Focus Theory and the Brainstorming Feedback Graph

The first example began with work started more than 50 years ago. In 1953, Osborn proposed a new group ideation technique that he called brainstorming. He conjectured that ideation could be improved if people followed a four-rule protocol:

- Do not criticize other people's ideas.
- Be open to wild or unusual ideas.
- Generate as many ideas as you can.
- Build and expand on other people's ideas.

Osborn's reasoning seemed sound, yet twenty subsequent studies were not able to demonstrate that people using the brainstorming protocol produced more ideas than nominal groups (Diehl & Stroebe, 1987; Valacich, Dennis, & Connolly, 1994).

Diehl and Stroebe (1987, 1991) unraveled the mystery by demonstrating that brainstorming groups suffer from production blocking, evaluation apprehension, and free riding. A number of subsequent ideation studies demonstrated that production blocking and evaluation apprehension could be overcome by using Group Support Systems (GSS) that allowed participants to contribute their ideas simultaneously and anonymously over a computer network. People using GSS could all contribute to a brainstorm simultaneously, which eliminated production blocking. People using GSS could also contribute to a brainstorm anonymously, which eliminated evaluation apprehension. The results were dramatic; under certain circumstances, people using GSS produced thirty to fifty percent more unique ideas than did people using nominal group technique (e.g., Dennis and Valacich, 1993; Gallupe, Bastianutti, & Cooper, 1991; Gallupe, Dennis, Cooper, Valacich, & Bastianutti, 1992; Valacich, Dennis, & Connolly, 1994). As remarkable as those results appeared to be, the question remained whether they were as good as they could be.

More than one hundred years of social loafing research showed unequivocally that, regardless of task, people who were working anonymously tended to make less effort than people whose contributions were individually identifiable (e.g. Harkins and Jackson, 1985, Kerr and Braun, 1981, 1983). GSS users were working anonymously, which meant social loafing had to be occurring. The question was whether anything could be done about it.

The electronic brainstorming system we used in our research included a feedback graph (Figure 3 (left)). It plotted the cumulative number of contributions the team made to the brainstorm over time. However, research had not shown that use of the graph had any impact on brainstorming productivity. The Focus Theory of group productivity (Briggs, 1994) suggests that effort toward the group goal is a function of goal congruence (the degree to which the private goals of individual members are compatible with the public goal of the group). Social Comparison Theory (Goethels and Darley, 1987) suggested a goal congruence hook that could be invoked by modifying the feedback graph. The theory posited that, all else being equal, people want

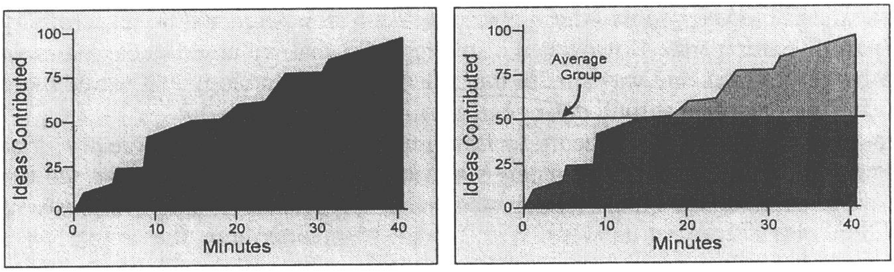

Fig. 3. Left: A feedback graph that provides no basis for social comparison in brainstorming groups. Right: A feedback graph that provides a way to invoke social comparison. Teams that viewed the right-hand graph during brainstorming produced approximately 60% more unique ideas than did teams using the other graph.

the status that accrues from being perceived as contributing fully to a group effort. They want to be seen as stars; they don't want to seem below average. They therefore tend to increase their efforts to at least match the performance of others.

We reasoned that we could add a single horizontal line to the middle of this graph (Figure 3 (Right)), and then tell people, "The average group produces about this many ideas during a brainstorming session…You don't to be below average, do you?" This, we reasoned, should invoke social comparison, causing anonymous brainstorming groups to make more effort, reducing the effects of social loafing. An experiment with 56 groups showed that the groups using the social comparison graph produced about 60% more unique ideas than did the groups using the groups using the standard graph. This was on top of the 50% gain they had already attained by moving from paper to electronic brainstorming. Thus, a good theory led us to a counter-intuitive design choice – the addition of a single horizontal line, which produced a significant improvement in group performance.

3.2 Cognitive Network Model and Creative Problem Solving Techniques

For many years, creativity researchers described creative people, creative environments, creative processes, and creative ideas. This research hinted at, but did not explain what caused creative ideas to emerge in the minds of people working together toward goals. It was not, therefore, possible to predict with confidence whether a new creative problem solving technique or technology might improve creativity. Creativity bordered on a mystical art.

Recently the Cognitive Network Model of Creativity (Santanen, Briggs, and Vreede, 2000) suggested mechanisms of the mind that could give rise to creative ideas. The model drew together standard axioms of cognitive psychology – long-term memory as a web of related concepts , limited working memory, and so on -- to argue that the creative solutions must emerge from novel juxtapositions in working memory of concepts from previously distant parts of the cognitive web. It further argued the number of novel juxtapositions was, among other things, a function of the variety of external stimuli. This theory was consistent with findings that teams using electronic brainstorming technologies could, under certain circumstances, produce substantially more ideas of greater creativity (e.g. Hender, Dean, Rodgers, and Nunamaker, 2002).