Exploring a human centered perspective on collaboration and knowledge management systems

Christopher M. Barlow
Stuart Graduate School of Business, Illinois Institute of Technology.
Chicago, Illinois

Abstract -- **The success of "Cyber" support systems for collaborative work, knowledge creation, and knowledge management occurs not within the system, but in the minds of those using them. This human centered learning focus brings relevance to lessons learned in areas such as deliberate creativity, general systems thinking, complexity, value engineering, and asynchronous learning networks.**

Index Terms -- **collaboration, cross-functional teams, team creativity, complex thinking, group decision support systems**

I. Introduction

As the infrastructure of telecommunications develops and expands, it's design gives a particular shape to the flow of technically transferred knowledge, whether it manifests as knowledge management systems, collaboration support systems, or the Asynchronous Learning Networks of distance learning. Not only do these knowledge-related systems share many elements and characteristics, but in their ultimate forms, they may be identical. Asynchronous Learning Networks serve as a link between students and a great variety of knowledge that needs some kind of management system, and may have their greatest contribution in the learning students gain from collaborative processing of the course knowledge. Knowledge management systems are successful to the degree they provide high speed, just-in-time learning, and can be seen not only as a collaborator with individuals, but as containing the breadth of organizational knowledge which would require a collaborative team to process and apply. Collaboration support systems should not only provide access to the relevant content of knowledge management systems, but may benefit from analysis of collaboration as a learning process.

While much progress has been made to date by considering these elements separately, a great deal of progress may be available in considering them as different perspectives on the same process. It also seems useful to suggest that while the systems that designers and researchers focus on have many challenging technical dynamics, the crucial events happen within people and social systems, not within the machines.

This human phenomena perspective seems to justify greater investigation of tools developed by practitioners for complex knowledge processing before telecommunicated computers were available. Many patterns of practice have been invented over the years in many different industries and domains of knowledge to enable collaboration, creativity, and learning of complex knowledge. Approaches with names like value engineering, creative problem solving, general systems thinking, and soft systems methodologies have emerged to guide complex collaborations, with various degrees of research into their effectiveness and dynamics. As with Fjermestad and Hiltz's [5] review of a broad array of studies of group support systems that found that few discovered positive contribution, the suspicion is not that the methods lack potential, but that research in these areas should be based on more comprehensive theory and use more complex and realistic problems.

This paper explores a few concepts that might simplify theory and guide productive research in this area, whether one is focusing on collaborative creativity, distance learning, or knowledge management.

barlow@stuart.iit.edu

II. Creativity: An Insight Model

Most research into creativity and innovation has focused on the production and implementation of ideas, with little clarification of how an idea is defined. Tracking specific explicit ideas as unchanging stable entities through the creative, innovative, and implementation processes can be quite difficult, especially when the process is working well and the ideas keep transforming, merging, stimulating better ideas, etc.

To investigate the creativity of cross-functional teams, Barlow [3] based part of the research design on an alternative perspective that focuses on the change in the "creator" rather than upon the idea. In this model the dynamics of discovering ideas new and more satisfying to the creator are isolated from the measure of the usefulness of that idea or perspective to some other context or field.

This alternative perspective has its roots in that most subjective and individualistic phenomenon of all, the "AHA" or "Eureka!" experience. Throughout history, various individuals have described this reaction a person has to getting an idea, such as Koestler [9]. Barlow suggests that this intensely physical, emotional, and intellectual experience marks our fundamental recognition that a profoundly advantageous change has taken place in our own thinking and proposes that this self-perceived advantageous shift in perspective or paradigm can be used as the essential and defining phenomenon of subjective creativity. The model is described in figure 1.

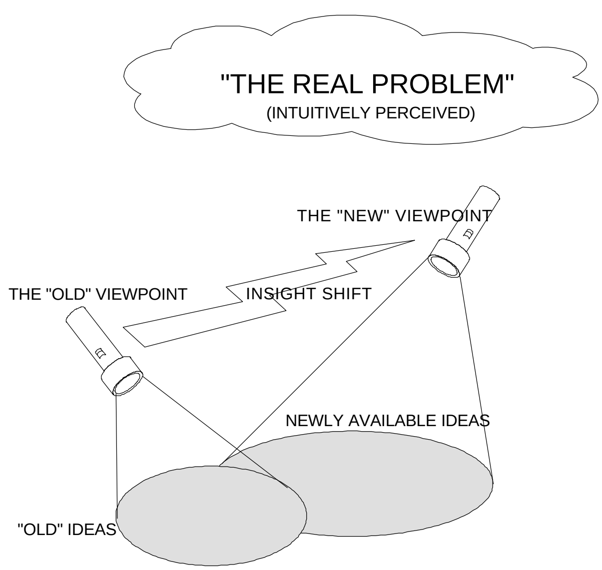

Figure 1. Shifted Insight Model

A flashlight was chosen for the model as an analogy for the perception of a problem. The surface below represents all the things anyone could ever do. The area of that surface illuminated by the flashlight represents the set of ideas that fit the problem statement. If the flashlight represents a problem statement or intention such as "raise the bridge," the illuminated circle represents all the various actions that might raise the bridge.

A second flashlight represents a new formulation of the problem, such as "increase the gap between the bridge and the water" or "get tall boats past the bridge." In successful creativity, some of the alternatives illuminated or made obvious by this new viewpoint are better than the best of the ideas made obvious by the old perspective.

The lightning bolt represents the shift to the new definition or perspective. Although getting such an insight might take years, when it happens, it seems as fast as that lightning bolt.

The cloud above represents the "real" problem, the complex interaction of wants, wishes, and reality that is only approximated by our viewpoints and problem statements. Locating the second flashlight of the new viewpoint closer to that cloud represents our subjective perception of a closer fit of the new perception to the total problem.

It is certainly true that problem redefinition as a technique for discovering ideas has been discussed in more places than it is possible to mention, but for research in some areas, it might be useful to treat that shift in definition as **the** creative event, and the resulting ideas as the aftereffect, not as the creativity. The structure and dynamics of this alternative model seem to have a better fit to some interesting issues about creativity and its reception, especially in cross-functional projects:

- **"Better Box Thinking"** From the perception of someone holding to the old flashlight or perspective, these new ideas are outside the limits of the problem. This matches the "box" people refer to when speaking of "out of the box" thinking. It is interesting that what makes these new ideas valuable is **not** that they are out of the old box, but their better fit to the ultimate problem, as represented by the new defining vision. Therefore, it might be more appropriate to refer to creativity as "**better box**" thinking.
- **Creative systems: groups, organizations, machines?** This model suggests that any thinking

system with a perspective mechanism and a mechanism for comparing the effectiveness of those perspectives or paradigms to its intentions and experience can be described as being creative, whether an individual, a group with its norms, an organization with its culture, or even a software system with its "schemas". This process may be identical to Argyris and Schon's [2] "double loop learning," providing an interesting link between the literatures of creativity and learning. In addition, it closely matches Brown and Duguid's [4] discussion of the difference between the changes in the knower as knowledge develops versus the inputs and implications of that knowledge which are exchanged explicitly, providing a bridge between knowledge management, learning, and creativity.

- **"Appreciative AHA"** In this model, when someone else's idea triggers an advantageous shift of perspective in you, you are being creative. This "**appreciative AHA**" is an essential aspect of team creativity. In a team situation, it is possible for a person to generate and state an idea that may give them only a mild AHA, but triggers an intense AHA reaction in someone else who can better see the potential. Other times, an idea will trigger a "team AHA" as each member reacts to its fit both to their perspective and to their understanding of the entire problem.
- **AHA subjectivity**. The AHA we feel when the shift happens is a very real experience, but it is proportional to the subjective advantage to the observer, not necessarily the long-term usefulness of the solution. Its strength seems to depend on how much we care about the problem, how "far" we have to shift, and how much better the insight seems. If we care a great deal about a problem (or the person with the problem) and/or if the insight seems especially profound, we feel a tremendous surge of excitement, joy, and satisfaction.
- **"Relevant AHA"** While ideas of great potential may be uttered by people of any background, only when the knowledge and values of the individuals or group reacting are closer to the "real problem" can we trust the response as a **"relevant AHA"**. The search for this "relevant AHA" can serve as an effective guide for the strategies and techniques of deliberate creativity, guiding our selection of team members, the sharing of knowledge across the team, and the social facilitation to achieve the needed flexibility of thinking in these individuals.
- **Insight before idea acceptance**. To a person or social system with the old viewpoint, the new ideas are outside their perspective and make no sense until they shift to a new perspective that fits the new idea. Many creative teams have unjust expectations of organizations and executives. After extensive and intensive work, the team comes to a new perspective on the problem that leads to a creative course of action. Then they present their plan, expecting the listeners to make the same shift of perspective and understanding instantaneously. This certainly relates to the reaction commonly labeled as "**resistance to change**."
- **Transformative effect**. It is useful to notice that as team members learn and shift their perspectives, not only do new ideas emerge, but the team members change in ways that make old ideas newly acceptable. This learning and transformation by team members is not a trivial issue for innovation, since AHA reactions by those with the resources to make the changes leads to almost instant implementation. This is interesting in the light of the philosophical perspective that all knowledge is about the development of belief. The insight model also fits very well to the most profound religious conversion experiences as well as to the concept of paradigm shifts. It may be that dynamics related to the formation of belief in various perspectives by various people are critical in these processes.

The insight model allows us to differentiate between creativity in different social systems and to see innovation and implementation processes in the dynamic fit between creative processes in various individuals, groups, organizations and other social systems. Separating the subjective creativity processes within the knowledge of a creator from the fit of that knowledge to some ultimate reality or goal supports the importance of relevant knowledge and experience which was devalued in perspectives focused only on "out of the box" responses. It also allows examination of conflicts between processes used for efficient knowledge acquisition (learning) and creative application of that knowledge.

III. Complicatedness and complexity

Distinctions have long been made in the nature of problems. We split knowledge (the problems whose solutions we just have to remember) from problem solving (the problems whose solutions we have to figure out). Problem solving is further split into well structured (problems for which we have algorithms and heuristics likely to discover a pretty good solution that fits a pretty clear goal) and ill-structured (problems for which no method is known and for which we probably have no clear idea of the goal). It is often pointed out that in the category of ill-structured, while some goal confusion results from the natural conflicts of sub-systems seeking the same overall goal, there are problems labeled "wicked" because even with all the analysis and problem solving possible, there are still profound disagreements among stakeholders about the goal, often basic conflicts of values. However, it may be useful to consider another way to look at problem complexity and to assess the impacts of that distinction on practice and research.

A. Separating cognitive complexity from complicatedness

It may be useful to consider that tools of team collaboration, knowledge management, and education address elements of knowledge that vary along two different dimensions of complexity, with different dynamics.

The term "cognitive complexity" is used in psychology for the ability to process information that is not well defined and internally consistent. The term complexity is also used commonly to discuss problems or systems which may be low in this cognitive complexity (i.e. well defined and internally consistent), but which consist of varying numbers of different conflicting elements and relationships, a dimension that we will label "complicated".

Some knowledge is low both in complicatedness and in cognitive complexity, and can be processed by most people. Some people are able to handle a great deal of complicatedness, as long as the cognitive complexity is low. Other people are adept at balancing multiple conflicting goals and constraints, while remaining lower in their ability to manage complicated systems. Very few people are able to excel at both complicated and cognitively complex tasks.

Problems that are merely complicated require a set of dynamics that are commensurable, able to be related in the same domain of knowledge. For example, once an airline has translated its various criteria and factors about different flights into measurable variables, techniques such as linear programming or artificial intelligence can help handle the complicatedness of the problem of scheduling flights, especially as dynamics such as weather and passenger load shift.

Getting those factors of profit and customer satisfaction and the relative importance of on-time service in different markets into that model is cognitively complex.

This "cognitive complexity" seems to have two major sources, conflicts in perspective and conflicts in values. In a company where everyone is working on the same goal of maximizing profits, different departments have different optimization strategies, which often conflict. Marketing effectiveness is best served by a production system that can deliver a "one of a kind" product by tomorrow morning, and a finance system that gives the customer 12 months to pay. Manufacturing efficiency is best served by receiving orders six months in advance and then making the same version continuously for three months. Accounting is most successful when cash is received before the sale is accepted, so they can purchase the raw materials well in advance for production. Finding the best positioning on manufacturing flexibility and credit flexibility is an extremely complex task. Ability to memorize theories and findings in finance, production, and marketing do not predict an ability to integrate these strategically.

The term wicked problems was coined to designate problems that are complicated by goal and values conflicts among the stakeholders. These can sometimes be reduced by relating decisions to ultimate goals on which the different parties agree, or by inventing detailed concrete solutions that leave all parties equally dissatisfied. Both of these strategies can benefit from participatory creative efforts, but even after the best rationality and creativity, goal conflict can remain. For example, when couples go shopping for a house, their preferences often conflict. This is the zone of negotiation, whether it is family members working out inheritance issues or union-management negotiations about who gets to take home the greatest part of the profits of their joint work. Even here, the insight model suggests that the effort of attempting problem solving together may transform the perspectives of the participants about the problem and about each other, opening new zones of possible solutions.

B. *Collapsing the Complexity*

Sometimes the way we think about problems makes them more complicated, and one result of creativity is to discover a simpler version of the knowledge. One example of this simplification is the old joke about someone asked to name the greatest invention ever, responding "the thermos bottle, because it keeps the hot stuff hot and the cold stuff cold". When asked what is so incredible about that, they answer: "But how does it know?"

To a person who thinks of the insulated bottle as keeping the hot stuff hot and the cold stuff cold, knowing and managing that process is obviously complicated. To a person who sees the device as a way to prevent heat from moving between the contents and the outside, it is a simple problem.

Another example is that when numbers are represented as Roman numerals, they are impossible to multiply, but when they are translated to a scheme like Arabic numbers where digit placement is meaningful, multiplication becomes simple, although tedious as the size of the numbers increases. Finding such simplifying models is a big part of effective work with complex systems like information technology, as well as science and its attempts to understand nature. Back when everyone believed (or was required to believe) that the sun and everything in the universe revolved around the earth, astronomers invented some amazing and complicated mathematics to calculate the movements of the Sun and the planets. Using the assumption that the Sun was the center of the solar system, Newton was able to predict the movement of the planets with math that was far simpler.

C. *The ability to handle complexity*

If a person is available who has all of the relevant knowledges and has adequate capacity for complicatedness and cognitive complexity, the best approach is to let that person solve the problem, reporting back with a plan and pattern of decision which will act together to achieve the goal.

Although many individuals believe that they possess the required knowledge and skills (because they are unaware of the missing knowledge and skills) the most common approaches to handling complexity are creating a bureaucratic organization that links together the required knowledges and cognitive capacities or creating cross-functional team projects.

We are all familiar with the ways that organizations bring together people who specialize in different kinds of knowledge, but the capacity for complex thinking is also a key design issue. Jaques [7] proposes that people differ in their ability to handle complexity, growing in the capacity throughout their lives and careers, although at different rates. Each level in an organization must provide a distinctly higher level of complexity for those in the level below, or there is no reason to have the reporting relationship. Properly constructed organizations assign people of increasing levels of cognitive complexity to handle increasing levels of problem complexity and to look further into the future.

Excelling with highly complicated tasks at one level does not imply effectiveness at the next higher level, nor does effective functioning at one level imply competence at lower levels. In sports, the best player is often the worst coach, and many coaches were mediocre players. Managers promoted to a level for which they lack the required thinking complexity can be recognized because the only way they can help guide their subordinates is to ask them to watch as the boss performs the lower level task for them.

In his current model, the first four levels of an organization are defined by how people decide on their actions and by their time line, the amount of time they pay attention to:

- The first level, direct action, with a timeline of 0-3 months, handles tasks like production and filing, which have clear procedures and templates. They have a mental process of "Declarative Processing" in which truth is black or white and can be determined from a single piece of evidence. For most tasks, there is a clear image available of what the output should look like.
- The second level, cumulative processing, with a time line of 3 - 12 months, is where most engineers and technical experts reside. The thinking here is based on accumulating multiple inputs over time to come to conclusions. For most work, there is a clear linear path of what the process should look like.
- The third level, serial processing, with a time line of 1-2 years, is where senior engineers and project managers tend to work. These people are required to consider and choose among multiple alternative linear paths to the goal, thinking strategically about what must be accomplished in order to accomplish the next step, and so on.

- The fourth level, parallel processing, with a time line of 2-5 years, is the realm of general managers and senior project managers, where simultaneously many different chains of events are happening and actions must be chosen that positively affect not one serial chain but the overall complex of parallel events.

Jaques has found that if a person's boss is not providing this higher level of thinking complexity, he or she will bypass that boss routinely to seek input from the level that actually provides that complexity. In addition, bosses that give inputs based on less complex thinking are seen as "micromanagers" and oppressive.

One interesting observation made by Jaques is that when a person starts attempting contributions that fit the higher level of complexity, we tend to label that as creative. This seems to align at least one kind of creativity with an increase in the complexity of thinking.

D. *Implications of complexity dimensions*

In any creative challenge, different subjects will provide different responses from different mixes of knowledge, paradigms, heuristic application, analysis, and creativity. Subjects can be expected to differ in their ability to handle complicatedness and cognitive complexity, and in their ability to discover perspectives that reduce the complicatedness or cognitive complexity. It is clear then that the subjective creativity of a particular idea or response will differ from subject to subject. It may only be the subject who can assess the factors that affect the creativity of a particular response.

IV. TEAMS AND COLLABORATION

Organizations handle complicatedness and complexity by routing problems to the individual with adequate cognitive capacity whose subordinates include all those with knowledge relevant to the goal. This individual transforms the complexity into sub-problems of reduced complexity and reduced knowledge breadth that can be assigned to available subordinates.

There is a hidden assumption in this approach that is invalidated where things change rapidly. In the past, the detailed knowledge picked up rotating assignments while rising through the organization gave a manger a good basis for considering most problems and subdividing them.

Today the realities of markets, technology, and organizational capacities are changing so fast for most organizations that the detailed knowledge and intuitive feel developed by managers is obsolete in some important ways. This leads to Nonaka's [11] suggestion that complex projects must be done by collaborations among those at the level with the relevant and current knowledge in a process he calls "up-down-middle management".

In addition, organizations attempt to take advantage of so many different possibilities that the organizations, which must be structured to handle the most common interactions and coordination, do not handle some of their most interesting opportunities. In the old logic, the only person in a position to handle multi national and multi technology objectives might be the company president.

Therefore, the ability to extract value from collaborative teams about complicated and cognitively complex problems is a major element of organizational potential. While some of the available writing and research about teamwork may provide useful insights, it is important to consider several critical differences in the structure and dynamics of cross-functional teams.

It is fairly obvious that there are differences in the dynamics of a production focused group (sports or factory) and a knowledge creating group, and that the shorter duration of teams in cross-functional collaboration has some affects on the dynamics. There is, however, a more critical difference. Cross-functional collaborations can be strongly distinguished from other kinds of teamwork because their very nature means that the collaboration process cannot work without trust in the contributions of their team members.

If a team project is assigned to a single discipline group, such as an MBA finance class project team or a C+ Coding group, each team member can be expected to have the ability to check the work of other team members in great detail. The issues of trust in these teams are around levels of effort and reliability of commitments.

In cross-functional projects, members contribute knowledge and processes that cannot be checked in detail by other team members. The marketer can't really check the engineering calculations and the engineer is rarely equipped to check the cost allocation decisions of the accountant. This reality strongly affects team performance and the earning of trust from each other is a critical team dynamic, one that requires time and process.

On the other hand, as the team shares information, ideas, insights, and judgements about the problem being considered, each team member begins to develop what might be called a "strategic" knowledge of the basic paradigms and dynamics of the other knowledge domains, which allows them to better understand the full value of their ideas and to seek new ideas which fit the strategic goals of the others, ideas which will only survive after intensive analysis by each of the different knowledge experts.

This same inability to check knowledge in detail is central to both educational systems and knowledge management systems, since, if you have the ability to check the validity of the knowledge, you do not need the education or knowledge management system. Processes related to the development of belief in knowledge and in the competence of others are critical aspects of all three types of systems, so it would seem useful to compare and share the trust processes across all three.

A. "Hypertext" Teams

There is another research assumption about teams that may need to be questioned: the idea that the work of teams is the sum of the work of its members. Nonaka [11] describes product development team processes and makes an interesting analogy, based on the idea of hypertext, the mechanism underlying the World Wide Web. A "normal" page contains what it contains. A "hypertext" page links to an entire spectrum of knowledge and resources.

Nonaka points out that in collaborative teams members are links to their home departments and disciplines, not just independent experts. Researchers often think of team members as limited to using their individual capacities, when it is their access to resources and ability to blend those inputs with those of others that defines their usefulness to the team. Seeing team members as portals to resources would seem to trigger significant shifts in the design of support systems and in the research into these teams.

In addition, it would seem that project related interactions of team members with their departments and colleagues may well trigger the growth of new perspectives, insight, and knowledge which will prepare them to comprehend and evaluate the outputs of the collaboration, a critical factor in implementation and eventual innovation success.

B. Summary of Teamwork implications

Cross-functional teams have important dynamics beyond the development of cohesiveness and shared norms. As teams mature, members gain more insight into the perspectives, values, and knowledge of other members while developing trust in the expertise which they can deliver from their own abilities and from the resources available to them. The changes in a team during its existence not only make possible better ideas, but also bring new knowledge and perspectives to others in the social environment of the project that ease the understanding and implementation of new possibilities.

V. TOOLS

Many tools have been selected, developed, and enhanced by managers, engineers, and other practitioners attempting to increase the effectiveness of their own thinking and the thinking of the groups and organizations they lead. These deliberate efforts to increase the creativity and complexity of design, problem solving, and knowledge creation operate in the same domain as "natural" processes of knowledge application, and creativity, but may have quite different approaches and processes of effect. It is important to note that on any particular task, individuals may be relying on different mixtures of talent and tools. Further, tools which multiply the effectiveness of individuals with less natural talent or skill, might reduce the performance of those with higher levels of talent or practice.

A. Tools of development or leverage?

In developing and researching facilitation tools, it seems critical to realize that tools may affect the outcomes in more ways than would result from using a tool to enhance physical labor, like a hydraulic jack to raise a car in order to change a tire. The use of facilitation tools also has effects on the knowledge, cognition, and perspective of those using them.

For example, a tool such as list-making allows people and teams to "remember" many more things by referring back to the list, but the very creation of the list will also impact the memory of those elements in those making the list. Charting techniques such as PERT charts and matrices make far more visible critical relationships among elements, allowing more complex analysis and problem solving, but may also cause the team members to internalize the complex pattern of relationships.

People who brainstorm together not only are stimulated to create long lists of ideas, but also rapidly become familiar with the values, perspectives, and project relevant knowledge of other participants, while also increasing in the flexibility of their access to their own knowledge. People who are introduced to the usefulness and power of unfamiliar types of thinking such as "black box thinking" of general systems or the deliberate use of analogies or visualization will often continue to apply those approaches to other parts of the problem and to other projects.

B. *Tools affect cognition and social relationships*

Obviously, once individuals are teamed to create solutions, issues such as group dynamics, culture, communication, and group maturity affect the solution process. Facilitation tools have varying impacts not only upon cognition but also upon the social relationships within a collaborative process. Successful interaction among people with conflicting perspectives both creates new perspectives with less inherent conflict and strengthens team cohesiveness which enables the collaborating group to handle more intense conflicts and cognitive complexity.

C. *Image tools and complexity*

Many great inventors and artists report picturing their creations in detail before producing them and early researchers found correlations between this ability and performance on standardized tests of creativity. The quest for deliberate increases in the complexity of thinking performance leads to the question: can people deliberately choose methods that allow them to perform at higher levels of complexity? There is a hint in some research about testing.

Spatial visualization is the ability to picture a physical item in one's mind and to infer what it would look like if transformed in different ways. You may have taken tests designed to test your ability to think complexly in which you were asked to pick out which drawing could be a rotated version of another drawing.

One effective test for spatial visualization is the solving of anagrams, those scrambled combinations of letters that can be rearranged to form known words. The better your spatial visualization ability, the faster you can solve these problems. Gavurin [6] did some methodological research on anagrams to determine if there were any problems with allowing those being tested to manipulate the materials. He discovered that when the anagrams were presented with each letter on a separate piece of cardboard that could be moved around on the table, spatial visualization ability no longer affected the speed of solving the problem. As a test developer, he learned that if you want to effectively measure this talent, you must not allow the subject to use any external materials that can be manipulated. On the other hand, this research also means that allowing people to move the letters around externally allows those low in spatial visualization to perform as well as those who excelled in it. This is a good thing for deliberate creativity.

Kaufmann [8] investigated the usefulness of visual images in the solution of concrete problems. He took problems and puzzles that had already been assessed for their relative difficulty and presented then in different ways. He took easy, moderately difficult, and difficult problems and presented them as: word problems requiring word answers; picture problems requiring sketched answers; or actually putting the subjects in the physical situation described in the problem.

The most difficult problems were only solved by people working in a physical version of the problem. The easy problems were solved quite effectively when given as word problems, and presenting them as pictures or real world situations just slowed the solution process.

Problems of moderate difficulty were difficult to solve as word problems, but generally well solved as picture problems, with little advantage from putting the subjects in the real world.

Therefore, word focused thinking may only be effective for the easiest of problems. With more difficult problems, there is an advantage to drawing pictures to understand and solve the problem. For the most difficult problems, it seems that you need to just jump into the situation and muddle around until you get it solved

D. *Shared Images*

Drawing pictures and manipulating models seems to be very valuable to those working alone, but there also seem to be several advantages for team collaborations. Keeping notes of ideas and facts and work-in-progress in front of a problem solving group on flip chart sheets around the room seem to help them handle more complexity.

Blueprints of building or product designs give us a similar capability of looking together at various details in the context of the whole. Charts such as flow charts and PERT charts can represent complex interactions in a form that allows groups to both see the whole interaction and focus on simpler details and relationships.

The architect and planner Alexander [1], noted that while there seem to be a limited number of people who can invent new structural patterns, there are many more who can effectively evaluate those structures, their details, and their implications. So external models may permit people of higher cognitive complexity to present and manipulate their complex structural ideas while permitting those who operate at lower cognitive complexity to check their implications against their knowledge and values.

Therefore, it would seem that since deliberate creativity will often benefit from external sketches, notes, prototypes, and physical models, facilitators should be able to call on a variety of different techniques for different problems, and group support systems should be provide similar capabilities.

E. Asking the "Witch doctors"

In recent years pharmaceutical companies seeking new profits through new drugs have learned to send explorers to interview "witch doctors" and other native healers about plants and other substances they have learned to use in their healing practices. Samples of these candidates are taken to labs in which researchers seek out the elements that might provide the benefits and submit them to testing to determine effects. This has become necessary because they have discovered that many of our current drugs arose from such sources, and the application of science was not discovering enough new drugs.

Deliberate creativity is about the use of tools to increase creativity, and real world problem solvers have invented some fairly sophisticated methods which have been under-researched, probably in part because of their complexity of effects. Practitioners in areas such as Value Engineering, Creative Problem Solving, General Systems Thinking, Total Quality Management, Soft Systems Methodologies and many others have developed patterns of practice which handle far more complexity than have manifested in the research literature.

The adoption of these methods into collaboration support, learning, and knowledge management should have some interesting results, although much of their effectiveness may fall in the face-to-face domain, requiring research focused on the people and the non-electronic interactions.

F. Implications of tool issues

Tools must be seen not only as multipliers of certain capacities, but also as having effects in multiple cognitive and social domains. Tools interact complexly with abilities and problem complexity, with some tools contributing greatly to those low in a certain capacity working on certain types of problems, but possibly interfering with performance on other types of problems or with people of higher capacity. A more articulated contingency approach that considers the nature of the relevant knowledge, the nature of the problem, and the capacities of the individuals may produce some very useful discoveries.

VI. Research Implications for Collaboration

In light of these various issues and concepts, we can see cross-functional teams as groups of people with non-overlapping knowledge who use various facilitation tools and processes to share and interrelate their complex, conflicting knowledge and perspectives until new alternatives become obvious. This seems to imply some different research approaches than creativity seen as listing "out of the box" ideas.

A. Being Objective about the subjective

Creativity may be an area of research in which subjectivity must be embraced. While objective research basically consists of measurement - event - measurement, notice that in the insight model the creative process being investigated actually changes the measurement parameters of quality. For example, as creative and advantageous as lowering the water might seem, in the context of “how well did it raise the bridge” the idea has zero quality. So, either there is no common ground for measuring the quality of the ideas before and after, or the criteria do not emerge until after the phenomena -- a strange way to do research.

Although it violates most assumptions about objectivity in research, it does seem that the most valid criteria of the quality of the creative ideas and insights are generated by the creativity. Selecting some other context as the basis of evaluation simply measures the degree to which the creators were moving toward the perspective of those evaluators.

Even on the simplest tasks, the judgment of “expert” evaluators from some particular domain is probably not as useful as the team’s own experience of the relative creativity of different ideas and the creative effectiveness of different processes and support tools. In the original “brainstorming vs. nominal group” research, the conclusions might have been quite different if the participants had been asked to judge the relative creativity and quality of their ideas under the different conditions, and the effect of the process on their own thinking.

Therefore, it might be useful to focus creativity research on the subjective dynamics of generating insights within sets of knowledge. It would seem that we need to evolve an objective way to measure the subjective quality of the creativity, based in the new perspective of the creator or team, possibly a measure of the increased fit of the subject's concepts and paradigms to the subject's experience and knowledge base. One approach might be to ask the subjects to assess the improvement inherent in an AHA shift, possibly based on some taxonomy provided to them.

B. Problem Selection: Subjective and Complex

The very desirable goal of objectivity seems to have hampered creativity research with overly simplistic problems since the early days of evaluating the worth of brainstorming, especially on multi-perspective problems. Unfortunately any research design which compares the idea productivity of a face-to-face group to the combined efforts of individuals working alone (the “nominal group” that evolved into “nominal group technique”) requires the use of problems simple enough for the individuals available as research subjects to solve working alone, eliminating the types of problems which seem to benefit more from deliberate creativity This would seem particularly true of “ill-structured” problems, which are much easier to analyze when they are thought of as problems which must be solved simultaneously in multiple subjective domains

C. Articulate the effect/source links

It is not easy to build a complex systems theory of deliberate creativity. Many input variables being researched probably have no direct and consistent connection to collaborative effectiveness, but rather enhance some intervening variable that more directly affects results. Even more confusing, some input variables affect multiple intervening variables in different, even conflicting ways. In addition, of course, more than one input variable can trigger a change in any intervening variable. All of which is compounded by individual differences in reactions to input factors.

For example, a cohesive group that can share ideas quickly and effectively may be more successful in solving complex problems. That cohesiveness can result from one or more factors such as: a cultural trait shared by all members (national culture or organizational culture), a particular social structuring of the process (such as anonymity), a shared outside "enemy", strong training in a deliberate process, good internal leadership, an outside facilitator, even the physical structure of the workspace.

Lobert [10] proposes a more complex model separating outcomes from creative outputs from processes from organizational inputs. Woodman [12] goes further with an interaction approach, noting that most dynamics also work in reverse, such as individuals or outcomes affecting the organizational inputs.

D. Group Complexity and Dynamics

The mix of tools and technologies selected for deliberate creative collaboration have effects on communication and relationships that strongly impact the potential for synergy among perspectives as well as the creativity and complexity of thinking. Anecdotes often point out that cohesive groups with well-established relationships are far more capable of creative collaboration through distance technologies. Researching the impact of tools such as software systems on the social factors and the impact of the social factors on the effectiveness of the technology is quite complex, but worth the effort. It is important to note that this relationship is further complicated by individual differences in preferred styles of social interaction, a breadth of difference that may not be well represented within the community designing the systems. (The systems are designed to fit the styles of the kinds of people attracted to building and using software systems.)

When researching these social dynamics it is helpful to recognize that face-to-face groups use a much greater bandwidth than words, although some seem to treat these parts of the information bandwidth as noise, and are delighted with technologies that filter out this information flow. As problems grow in complexity, the technical conflicts can easily trigger social conflicts. Strong teams handle greater cognitive conflict with minimized social conflict by adjusting the meaning and implications of words based on historical relationships as well as non-verbal physical behaviors (some practitioners would even suggest chemical messengers). Rather than trying to add “virtual pheromones” to conferencing systems, research might prove it is more efficient to build team cohesiveness with face-to-face meetings and continue with an appropriate blend of face-to-face, distant, and asynchronous technologies.

E. Representing Complexity.

If deliberate creativity attempts to assist people in getting smarter about a particular problem, then support systems and tools might serve to help them not only keep track of the many details of work in progress, but also to help individuals comprehend and process more complexity than their minds can handle internally, and to share knowledge in forms that are useful to others in the process. By exploring the “levels of complexity” models proposed by various authors, systems can be tested which merge words, pictures, and simulated experiences in structures of increasing complexity. Many useful structuring systems implemented in software such as PERT charts, flow charts, causal maps, or other structures can be assessed for their social and cognitive effects.

It can be argued that any team that solves the problem as it is stated has not been very creative, so it would seem necessary for these systems to capture and utilize the lessons implicit in the ideas that emerge, allowing shifts in the project definitions and stakeholder expectations. Multiple conflicting views of the problem and its drivers would be essential. Critical to these representations of complexity might be ease of manipulation, allowing both new structurings and multiple simultaneous structurings to be investigated.

F. Knowledge Depth and Complexity.

As difficult as it makes research design, deliberate processes and techniques for bringing out and realigning deeply understood knowledge and goals are probably quite different from the dynamics of utilizing some explicit process points and knowledge elements provided to subjects as the session starts.

Even more interesting is the process of combining the knowledge and perspectives of disparate experts and stakeholders. Effective research seems to demand much more complex and realistic problems, problems that demand collaboration with people whose work one cannot check.

Part of this research may require standardized protocols used with existing groups working on problems of interest to them. Assessing the group’s experience of certain problem variables, process dynamics, and the quality of results may allow conclusions to be drawn across dissimilar groups working on dissimilar problems. Other researchers may be able to access populations of similar teams facing similar problems, such as strategic business unit (SBU) management teams in the same industry or company developing strategies or budgets.

G. Measuring knowledge-in-person change during the creative process

One perspective a researcher could take on collaboration is that the process changes individuals and communicating groups of individuals so the solutions are obvious. In this perspective, changes in the state of knowledge and belief in the individuals from the beginning to the end of the process would seem to be quite important. Therefore, assessing the changes in the various types of knowledge, belief, and attitudes related to the problem, methods of solution, and team members would seem quite productive. It should be possible to develop objective measures of learning in specific areas; such as how much more accounting do the non-accountants understand. It should be possible to measure attitudes toward other disciplines and individuals before and after the experience.

Although it clashes with some people's visions of "objective" research, at the end of the process, the creators themselves may best be able to assess their growth in knowledge and changes in attitudes through the process, and even to estimate the importance of the changes to the discovery of their preferred solution.

VII. Implications for Knowledge Management and Asynchronous Learning Networks

Each of the points made about researching collaborative systems would seem to be applicable to understanding the effectiveness of Knowledge Management Systems and Asynchronous Learning Networks. Although there are certainly elements of knowledge for which a storage, transmission and reference function is adequate, such as accessing maps for a driving trip, the essence of knowledge seems to be more about changes within the knower [4]. Without AHA's, there may be no actual knowledge development, just storage of information. Therefore, research into the effectiveness of alternative learning technologies like ALN may get quite different answers when considering information storage than when asking the learners to share subjective responses and to develop complex systems of understanding about that data. There also may be very powerful effects present or possible in the social structures involved in utilizing knowledge management systems and participating in distance learning, effects not obvious in the simpler more objective tests used to compare classrooms with distance learning.

VIII. Summary

This paper is more about suggesting possibilities than validating specific issues, proposing a broader spectrum of issues and elements which may need to be controlled and assessed in research into these knowledge related technologies. It is written in response to the more focused and fundamental research which has been accomplished in these areas, proposing that strictly constructed research with limited resources may seem to indicate conclusions which will be reversed as more comprehensive research with more complex and subjective test problems is carried out.

There is a great opportunity here. Computer mediated systems for learning, reference, and collaboration have the ability to capture a great deal more data about work in process, allowing more economical research than trying to analyze video tapes of face-to-face processes. A great many software tools have been developed that seem to have great potential for increasing the effectiveness of various elements of complex team collaboration, in depth knowledge management, and more effective learning, especially in the dimension of handling complicatedness. In addition, there are hundreds of years of experience of practitioners who have invented and improved techniques of education, knowledge organization, and collaboration. As these elements come together, the knowledge infrastructure available for the many different domains of knowledge and practice should grow in effectiveness, helping each domain contribute more productively. Of course, effective research may require the kind of multi-perspective collaboration these systems attempt to support.

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