ASSESSING TEAM PERFORMANCE: PREVIOUS RESEARCH ON THE USE OF TEAMS IN PROBLEM-SOLVING ENVIRONMENTS

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Research and political examples are needed to learn a whole host of new techniques for working with distributed groups.
Parker, 1991

A number of major factors are known to influence how teams of people work. Three factors most often cited with regard to the educational and industrial use of teams for problem solving form the basis of this research. The first factor is *location of the team members* that provide both knowledge and structure to the problem-solving effort. An important aspect of the location factor in distributed problem-solving environments is the use of technology to bridge the location gap. The second factor is the organizational strategy whereby the team members attempt to form a team and subsequently mature into a working body with knowledge required to solve the problem and the ability to process that knowledge to arrive at a single, common solution. The application of technology to bridge the location gap introduces team organization requirements stemming from the location of the needed team members. The location variable has traditionally been omitted through travel and meetings. New enabling technologies require a greater focus on organizational strategy—an important motivator for this study. The third factor is the *team* itself. Teams are not static, process-bound entities. They are comprised of individuals who are dynamically motivated, based on less-than-well-known forces. Building a team that can function well in a distributed environment requires that organizational managers understand how teams form and how they work toward a goal since the formation of the team (membership and goal orientation) are both resources and constraints on the team itself.

Before turning to a detailed discussion of these three factors, part of the premise for this study was the need to consider how each individual benefits from participation on the team. In both educational and industrial settings, teams are tools for accomplishing tasks, and thus the nature of the task is a key factor in structuring the team. Considering that the purpose of this study was to identify the benefits of teaming (to both the team and the individual), dependent measures were sought that would allow a new team assessment methodology using both team measures and individual measures. This is the basis for examining the individual gains during participation on a team. Learning styles and instructional models played an important role in structuring the experiment, and thus the literature surrounding the procedure used for this study becomes relevant. The subjects in this study were asked to solve a problem that was not related to their past experiences in any significant way. They received instruction in one of two disciplines, and then participated on a team where that knowledge gained was required to assist the team in solving the problem. This form of instruction is deceptively similar to the constructivist theories of education discussed earlier. In business, as well as in education, the constructivist theory focuses on the individual as part of the societal fabric and seeks to use that individual's own motivational energy to enhance both participation and learning. Organizations could benefit from this approach in that they could use such techniques to enhance organizational learning.

LOCATION AND TECHNOLOGY

Team problem solving often requires significant interaction among multiple individuals whose biases and experiences surface and affect the outcome. Complex team problem-solving exercises often require more than one field of expertise to arrive at an appropriate solution. Therefore, the location of the knowledgeable individuals is a primary consideration.

In a traditional team problem-solving environment, the team members gather together, and the principal communications are *same-time, same-place interactions*. In this study, these interactions are referred to as "in-group" communications. Same-time, same-place interactions are often characterized by the team members' attempting to influence and debias each other, seeking what often is a compromise, or an acceptable "group" solution. The advent of technology that allows simultaneous participation by distributed/remote team members has led to the *same-time, different-place* model of human interaction. In this study, interactions are referred to as "informal" or "formal" communications; a directive (command) would be formal, and all other communications would be informal (including questions).

The intrusiveness and limitations of the technology required to support same-time, different-place communication often lead to individual and team organizational consequences far greater than those found in same-time, same-place team problem-solving exercises. Examples of these consequences are a technology interruption, such as waiting for the squelch and noise-canceling features to re-open voice communications, or the lack of a signal from the other end suggesting that a party has "hung up" when in fact the automatic activation feature of the microphone is simply not sending a signal.

An area of improvement involves “computerizing” the team’s interactions (Dierolf, 1990; Huber, 1990), organizing the requisite knowledge for the task or problem under consideration by the team. Most of this technology falls under the general category of computer-supported decision technology; with teams, it is most often referred to as group decision support systems and computer-supported collaborative work environments (Duffy, 1993; Dierolf, 1990; Huber, 1990). A group decision support system is “an interactive computer-based system that facilitates the solution of unstructured problems by a set of decision makers working together as a group” (DeSanctis and Gallupe, 1985). The use of such a system does have several positive impacts. According to Dierolf (1990), decision support systems increases the group’s depth of analysis, participation, decision quality, and consensus reaching; the confidence of group members in the group’s decision; and members’ satisfaction with the group process and the decision (Dierolf, 1990; Huber, 1990). Computer-supported collaborative work is a more software- and video-focused approach, which focuses on the joint creation of documents and design projects, the integration of teams with information support systems, and cooperative work systems (Duffy, 1993; Morrison, et al., 1990; CSCW, 1990).

According to Duffy (1993), the hardware and software of group decision support systems and computer-supported collaborative work environments have the following objectives (Duffy, 1993):

- Provide information more accurately, more completely, and in faster accession time.
- Reduce coordination effort.
- Reduce the negative group influence effects.
- Allow a wider audience view of the same material, with the assumption that this leads to faster common understanding (Kraemer and King, 1988).

Two types of communication requirements are influential in computer-supported communication. The first is social presence (Short, et al., 1976), the degree to which a medium communicates the actual physical presence of the participants. The second is information richness, which is defined by Daft and Lengal (1986) as the proposition that communication channels differ in their ability to convey the richness of information needed for a task (Duffy, 1993).

ORGANIZATIONAL STRATEGY

In team problem solving, a second major challenge is the organization of work among the members of the team. Often the knowledge required is in one location, while the process experts are in another location. Organizing work to mitigate these location-based problems may interfere with the timeliness or the quality of the outcome. Grouping people into teams requires a certain amount of forethought. The strategy used to organize the team should be compatible with the desires and social culture of the members. To allow the most opportunity for success, organizers should strive for a cross-section of skills, experiences, ages, and personalities within each team. Team members can learn from one another and achieve the flexibility needed to perform in a self-directed manner. By channeling teamwork toward well-defined goals, boundaries (defined primarily by a charter or mission statement) help shape the social norms and technical innovations of the team. Team boundaries help managers and supervisors retain appropriate control of the team, create an atmosphere of relevance, induce self-direction, and yet reinforce that the team is still accountable for its performance. A key objective is to let the team know that it has a genuine opportunity to improve procedures for achieving team performance goals (Osburn, et al., 1990).

Defining the organizational structure of a team can be difficult and confusing. Many past research efforts have focused on team structure, but without reporting on the effects of the structure itself, rather on the outcomes from a sociological perspective that does not identify the best structure. Several examples of team structures can be cited from the literature. *Autocratic decision making* involves a team leader who obtains all necessary information from team members, then decides on the solution alone. In *consultative decision making*, the team leader shares the problem with the team members and then gathers ideas and suggestions before making the decision alone. In *participative decision making*, the team members share the problem, as well as the generation and evaluation of alternatives in order to reach a mutual agreement on the solution (Duffy, 1993; Orasanu and Salas, 1993; Osburn, et al., 1990). Sundstrom, et al. (1990) conceptualize teams using two dimensions: *differentiation of members* and *integration within the organizational structure*. Differentiation refers to the degree of task specialization, independence, and autonomy of team members.

This study was designed to take up where the literature leaves off regarding team organizational strategy. In the main, team research studies have examined either the decision culture or the use of a facilitator as the key experimental variable. Accordingly, teams are either facilitated or self-directed, and the study results are oriented toward the need for a facilitator as a factor in team performance. *Facilitation* involves managing processes for the team. It might involve a colleague managing the team's progress toward a goal and tracking the appropriate use of time. A *self-directed team* might be a team of students working on a class project, with the role of the facilitator being divided among (1) the course syllabus requirements, (2) the instructor's in-class directions, and (3) daily activities supplemented by a team member's interpretation of the project goals and objectives.

A process oriented toward the use of emerging technologies as tools for a team represents a third aspect of facilitation. Examples of such technologies are groupware or collaboration software. It has been discussed at length in the literature that in a distributed teaming environment, the need for a local champion or leader at the site cannot be overlooked (Osburn, 1990; Parker, 1994). Yet this need exists because the organizational aspects of the team and the mission are mismatched such that the team cannot orient itself toward its goal without a single leader to describe and interpret the tasks involved. This is why the goal-directed behavioral needs of the team must be reflected in the mission statement. The simple task used as the experiment in this study helped eliminate the effects of not having a facilitator. A contribution of this experiment is the procedure for identifying and reporting the effects of organizing a non-facilitated team using knowledge rather than facilitation as the key influence. In light of this research objective, the development of a measure suitable for detecting the effects of knowledge location within the team as the independent variable became a major factor in the scope of the literature review.

To satisfy the need to develop adequate measures for assessing team performance in both education and industry, a review was conducted of the educational and the team organization and performance literature on the links between human nature and technology underpinnings relevant to this study. The components of a learning system are the learner, the facilitator, and the material elements on which knowledge is based and which frame or hold solutions for the problem. Thus, two-thirds of the components and all of the reasoning processes are centered around the human. It is not simply a matter of technology to resolve the communication link; rather, this study looked at the human node of that link as the integral component and the area most suited for improvement where team applications are concerned.

TEAMS

This section reviews findings from the literature on how teams make decisions, how individuals learn and provide information to a team, how individual learning styles affect team performance, and how constructivist theories can guide team performance.

How Teams Make Decisions

Osborn, et al. (1990) identify the need for a set of "parameters" that establish guidelines for the operational decisions of a team (see also Parker, 1994). A mission statement is an attempt to stimulate and focus the energies of the people involved on a team and to provide the team with the relevance it needs to have as part of the organization. The key to drafting an effective statement is not so much in identifying the "right purpose" as in allowing the right people to follow an open process in formulating a shared vision (Osburn, et al., 1990). People can draw on and integrate many different views when they have common agreement on a set of tasks (Lipnack and Stamps, 1993). Organizational strategies are often the result of a flexible set of norms and beliefs that the corporate culture imposes on the individual. Frequently, the team will form around these cultural influences and struggle to define the best process by which its mission can be achieved. Every successful team must endure the confusion long enough to leave an old culture behind and seek outside sources of new knowledge and process (Osburn, et al., 1990).

Orasanu and Salas (1993) define team decision making as the process of reaching a decision undertaken by interdependent individuals to achieve a common goal. A critical feature of team tasks is that they require multiple, interdependent participants for successful accomplishment. For some tasks, tight coordination and collaboration among participants are required. The experiment in this study did require coordination between the groups in a team. It was critical to the study to identify and develop a complex problem that would challenge the participants to act as a team. As discussed in Chapter I, motivation enters into a team's ability to work together. For example, the desire for a satisfactory grade in an academic course or corporate allegiance would be strong motivators, and the clarity of the desired outcome could create a sense of homogeneity among the team in pursuit of a common goal. This study used the novelty of the experimental apparatus, combined with the complexity of the problem, to challenge the subjects to collaborate. Furthermore, the design of the experiment forced collaboration since the team's goal was to present only one result.

Emerging research on team decision making consists mainly of descriptive studies of complex tasks performed in natural environments (where the decisions are embedded within tasks), or analyses of communication within/between teams performing natural tasks. New technologies and analytical methods have spawned new conceptual frameworks for team decision making (Orasanu and Salas, 1993). Orasanu and Salas (1993) offer two related theoretical frameworks that have emerged from recent investigations of team decision making in natural environments: shared mental models (Cannon-Bowers, et al., 1990; Orasanu, 1990) and team-mind (Klein and Thordsen, 1989b). While these are not fully developed theories, they account for certain team phenomena and provide direction for future research. This study stops short of these theories and takes a different approach, building in part on the theories, but also on a more pragmatic understanding of the role of the individual on a problem-solving team—effective participation and contribution of relevant knowledge. This leads to an emphasis on the need for a common understanding of the problem space, which acts upon the shared mental models theory. The motivational aspects of the individual's understanding his or her role on the team and how that role is meaningful are essential to achieving the effective participation this study seeks to explore.

Communication is an essential element of team performance, whether in the form of gestures, eye contact, verbal messages, or any other form of feedback. When a team is faced with non-routine tasks, communication becomes vital. Without communication, such tasks cannot be performed as a team effort, and a lack of familiarity with the task (knowledge set or procedural) can interfere with the ability to have a "common understanding" of what is involved in accomplishing it (Orasanu and Salas, 1993; Cannon-Bowers, et al., 1990; Orasanu, 1990). Individual skills and knowledge are not sufficient for successful team performance; individual resources must be appropriately utilized through interaction processes (Orasanu and Salas, 1993). Research has shown, and common sense dictates, that teams can make better decisions than individuals (Hill, 1982; Michaelson, et al., 1989), under certain conditions. Team organization is a major factor in the ability of the team to perform. Team performance depends on the knowledge the team members have available to apply to the problem and their ability to communicate that knowledge effectively to each other when it is needed.

Orasanu and Salas (1993), and other authors, clearly state that errors in team decision making can also result from mis-matches within teams based on inappropriate knowledge, personalities, and the organizational environment (Orasanu and Salas, 1993; Osburn, et al., 1990; March and

Weissenger-Baylor, 1986). Other factors affecting team performance can include task circumstances, spatial arrangements within the organization, the degree of technological support, the degree of informational support, the reward structure, and inappropriate lines of authority (Rochlin, et al., 1987). “Socially distributed cognition” that is not taken into account will also degrade performance (Duffy, 1993; Orasanu and Salas, 1993; Osburn, et al., 1990; Cicourel, 1990; Hutchins, 1990).

A number of team interaction effects can have a negative impact on team decision making. Perhaps the most well known is "group think," in which a group suspends rational judgment in order to maintain group cohesion (Orasanu and Salas, 1993; Janis, 1972). Another way in which a team can go wrong is to fail to challenge assumptions about goals or values (Orasanu and Salas, 1993; Osburn, et al., 1990). Teams are likely to engage in poor problem-solving behavior for social as well as process reasons. Misdirection and poor clarity of purpose can result in misconceptions and misguided communication about the task or process. Teams may also make poor decisions as a result of outright hostility, lack of cooperation, or lack of motivation (Orasanu and Salas, 1993). One social factor that contributes to faulty decision making is rejection by a high-status member of relevant information offered by a lower-status member (Orasanu and Salas, 1993). This was exhibited in the present research during run 1.

Parker (1994) defines an emerging culture of team decision making that is capable of leveraging organizational knowledge by working through mostly informal communication channels to achieve goals. Parker and others agree that teams that do not communicate effectively in their early stages, but can eventually work together to form a network which then can support larger problem-solving efforts by improving communication effectiveness. Parker believes the best networks start as teams and grow into teams of teams (a teamnet). Parker's notion that teams of teams exist provides a foundational reference for the need to understand how groups work together. This study defines groups as the basic components of a teamnet and the combination of groups (Parker's teamnet) as a team when all groups (Parker's team) have a common goal. A distributed team is made up of groups. Groups are made up of people. This is thought to simplify the organizational terminology.

The experiment in this study was organized into two groups, which networked with each other, forming what Parker would refer to as a teamnet. The communication that took place through the audio portion of the experimental setting was either formal (directive) or informal (all other between-group communication). Parker's notion that participation is key and that each person brings energy, change, and different perspectives to the team's purpose was facilitated by the "continuing social presence" of the other group, the experiment having been set up so each participant could hear all the others when the talking was loud enough. This format of full-duplex audio created a sense of awareness of each other among the team members.

Parker (199[0][1]) offers a reasonable breakdown of the roles team members might play as the team forms: (1) collaborators; (2) communicators; (3) contributors; and (4) challengers. One of Parker's key contributions is the notion that leaders are not just born; the group itself makes them (Lipnack and Stamps, 1993). Parker believes that in a teamnet, there is no single person on top all the time. One or more members take and shift responsibility to represent the group at different

[1] The original citation by Parker is 1990; however, Lipnack and Stamps inadvertently cite 1991. Both are cited in this study according to the original source dates, and listed as such in the reference section.

times. In this light, the experiment for this study appears to have found a viable approach for not requiring a facilitator and thus can be expected to be meaningful to both students and professionals in daily team activities where facilitation is not always practical. A consensus decision is one without significant opposition, one the teamnet members can support or at least tolerate; this latter circumstance is often referred to as "an agreement to disagree" (Lipnack and Stamps, 1993).

Too much communication interferes with the ability of people and groups to cope with and assimilate information more rapidly and with less effort (Parker, 1994; Duffy, 1993). An important aspect of the human ability to cope with the information flows that result from team activities is the use of technology to filter and distribute the information. Moreover, capturing answers and solutions in desktop computer tools can greatly enhance chances for success in the shared management of dynamic distributed processes (Lipnack and Stamps, 1993).

Groups ideally involve the most effective and knowledgeable people in the most efficient way. A learning organization is one that can use individual knowledge to both the advantage of the immediate task and the long-term transfer of that knowledge to build upon strategic successes. Teams work as informal networks of knowledge and information, often teaching each other as the process evolves. The sharing and teaching often act as a conduit to move the team toward its goal. Indeed, the ability to share work is a critical success factor in networks. A teamnet, no matter how small, does its real work in even smaller subgroups—in ones, twos, and threes. A facilitator should be able to display the group links by tasks so that everyone can understand them (Lipnack and Stamps, 1993). On the other hand, sharing of knowledge and learning is a major problem for modern organizations. Few organizations know how to capture the experience generated by all the ad hoc teams and networks that increasingly populate the business world. One way to capture group learning is to keep a simple, structured record of a process as it unfolds. Templates are records of experience that can be adapted to new circumstances (Lipnack and Stamps, 1993).

Lipnack and Stamps (1993) adapted Parker's five teamnet principles to establish causation in any team. The five teamnet principles proffered by Parker and adapted by Lipnack and Stamps (1993, p. 299) are:

> *Purpose.* While the team is initially able to maintain a clear view of its purpose, it loses sight of that purpose because the context changes. Without a constantly revisited clear purpose, teamnets collapse.
>
> *Members.* In many internal teams in which people come from different parts of the same organization (or school), members do not have the autonomy they need to survive independently.
>
> *Links.* As noted above, communication is key to teamnet success, and information access is critical to meaningful communication. However, too much communication, too much information, and too much interaction can lead to overload, and thus can also cause teams to fail.
>
> *Leaders.* The earlier multiple leaders assume their position, the more successful the teamnet will be.
>
> *Levels.* Many internal teams fail to manage up [providing feedback to the enabling managers], an all too prevalent problem. When a teamnet fails to manage down [providing clear direction to staff], it runs the risk of losing touch with the organization as a whole.

Finally, some authors have focused on the factors of team decision making as a product of organizational design elements. The latter include, for example, team size, member proximity, task type, centralization of control, temporal distance, and degree of cooperation (Duffy, 1993; Dierolf, 1990; Huber, 1990; Hughes, 1986).

How Individuals Learn and Provide Information to a Team

Each experience with an idea—and the environment of which that idea is a part—becomes part of the meaning of that idea. Therefore, constructivists emphasize "situating" cognitive experiences in authentic activities. Instruction should not focus on transmitting plans to the learner but rather on developing the skills of the learner to construct (and reconstruct) plans in response to situational demands and opportunities.

Duffy and Jonassen, 1992

Understanding the actions of teams in problem-solving environments involves more than measuring motivation or team performance. Much like the classical observations made when studying students by observing their levels of self-motivation for learning, the business community could learn to judge the true value of a team by assessing the knowledge shift of the individuals that participated on the team. Experienced adults face problem-solving tasks every day in an industrial setting far from the educational environment with which they were once familiar. Yet in the past, there has been a lack of research focused on understanding why teams perform differently in each environment. The differences could be due to the experience of the participant, the level of information available, and/or the type of motivation the particular team exhibits. All of these factors certainly are important, yet the basis of performance in problem solving is almost always the level of knowledge of the participants and their ability to gather and apply the needed information. According to Duffy and Jonassen (1992) there have been a large number of educational studies that may shed light on the issue of how teams learn. An exhaustive review of the current and classical literature reveals that the methods of learning vary greatly among adults, and that the results are difficult to assess.

How Individual Learning Styles Affect Team Performance

Instruction in the United States emerged from an “objectives” tradition. *Objectivism* is defined by Lakoff (1987, pp. 1-15) as the understanding of a set of entities, properties, and relations that are completely and correctly structured. Lakoff describes the role of the learner as having a "goal of understanding," which is categorized as "coming to know the entities, attributes, and relations that exist." Clearly Lakoff proposes that the objectivist approach is a front-end analysis that focuses on identifying the entities, relations, and attributes the learner must "know." An objectivist view of instruction may call for an active student learner, but the purpose of that activity is to cause the student to pay closer attention to the stimulus events, to practice, and to demonstrate mastery of the knowledge.

Constructivism, like objectivism, is founded on the principle that the learner is part of a set of real-world experiences. The difference between objectivism and constructivism is that the constructivist believes the learner assembles constructs that take on meaning to the learner, relative to his or her world. This facilitates recall and utility of the knowledge as a previously tried model. Objectivists believe that meaning already exists in the world, and that it is "out there" for the learner to discover and make sense of in some manner relevant to the learner. Bednar, et al. (1992) echo the claims of many previous authors that it is not a *correct* meaning that learners are striving for, but the *attribution* of meaning—rooted in, and indexed by, experience (Brown, et al., 1989a).

A possible approach to address this need for attribution is to support the learner with the motivation and practice required for learning. Motivation and practice are elements in any theory of adult education. They become relevant to this study in light of the work of Bednar, et al. (1992). Many of their arguments are linked to their strong belief in the role of the learner as a *knowledge acquirer* during the problem-solving process. The authors challenge the concept that the eclectic nature of the field of instructional systems technology is necessarily a strength. Bednar, et al. (1992, pp. 17-34) argue that "abstracting concepts and strategies" from the theoretical position that spawned them strips them of their meaning. The present study takes the view that Bednar, et al. are correct in their assessment of the past and the importance of the individual as a knowledge acquirer; however, it seeks to go beyond their “call for action” to demonstrate that the inter-connectivity and psychological benefits of teaming with physically remote people to explore and acquire knowledge support the need for a transition to a constructivist-based methodology for achieving team objectives. To this end, a major variable in the methodology of this study was a design that would force collaboration and cause the individual to seek knowledge during the problem-solving portion of the experiment.

Educational teaming strategies have yet to be clearly defined by the educational research community. The results of this experiment provide evidence that teams can be productive and educational simultaneously, and that the organization of the team does have an effect on the participants’ ability to gain knowledge. Part of the problem facing the team designer is the correct identification of when to implement a constructivist approach as a motivation strategy for performance enhancement and how to assess that performance.

When will a constructivist approach, coupled with a team approach, improve human performance in a distributed environment? To answer that question, a thorough reconsideration of the team process for use by groups of problem solvers is needed. The central premise is the *motivation* and *ability* of the learner to seek out the *correct* knowledge and then *attribute* the meaning and *build* a relationship for future cognitive use. Current curriculum designers are moving in this direction, but generally without recognition of the value of teams and collaboration. Instructional systems technology designers believe that the transfer of knowledge is most efficient if the "excess baggage of irrelevant content and context" can be eliminated (Bednar, et al., 1992, pp. 17-34). Behaviorist applications focus on the design of learning environments that optimize knowledge transfer, while theories of cognitive information processing stress efficient processing strategies (Bednar, et al., 1992). Applying simple learning constructs such as those identified above can improve both team and individual performance.

How Constructivist Theories Can Guide Team Processes

The constructivist view of cognition and learning theory is that it acts as a catalyst for many of the "tools" of the psychology field. In describing the constructivist view of cognition, many of the psychological theorists have found the opportunity to relate their principles to the apparent value of the constructivist view of cognition. The researcher considers the constructivist view of cognition as the mortar for the building blocks of learning theory. Bednar, et al. (1992) review many of the past theories, including connection approaches to cognitive science (Rummelhart and McClelland, 1986), semiotics (Cunningham, 1987), experimentalism (Lakoff, 1987), intertextuality (Morgan, 1985), and relativism (Perry, 1970). Bednar, et al. find that learning is a constructive process in which the learner is building an internal representation of knowledge, a personal interpretation of experience. Consistent with the constructivist view of knowledge acquisition, they suggest that learning environments must be:

- Situated in a rich context.
- Reflective of real-world contexts.
- Transferable to environments beyond the school or training classroom.

Because this study was intended to explore the impact (on team and individual performance) of team organizational strategy settings where members are distributed, a definable instructional pedagogy is required. This need was met through an exhaustive review of the literature on both team performance and instructional environments designed to support a constructivist approach. Two elements seem to be important in the constructivist theory:

- *Perspective* is developed through exposure to other individuals and is developed so as to be effective in working in a given area (a personalized perspective).
- Individuals should be able and willing to defend their judgments (perspectives) using the *knowledge gained.*

The foundation for the dependent measures of this study is, then, twofold: perspective, manifested by the differences in problem-solving style, and knowledge gained, as measured by individual and team score analysis. It is in this area that the use of technology and team interaction provides an opportunity for the measurement and evaluation whose lack has previously inhibited the widespread use of constructivist educational theory.

Education strives for the retention, understanding, and active use of knowledge and skills (Perkins, 1992). Bednar, et al. (1992) provide further insight into the constructivist view by describing the traditional approach to instructional design. In a constructivist view, the "learner" must construct an understanding or viewpoint; the content cannot be pre-specified. Bednar, et al. (1992), Perkins (1992), and others believe that the "learner" is encouraged to search for other knowledge domains that may be relevant to the issue; in the case of the present study, this phenomenon acts as a stimulus to support the collaboration needed to gather the knowledge required and arrive at a solution. The constructivist view does not accept the assumption that types of learning can be identified independently of the content and the context of learning (Bednar, et al., 1992). Instead of dividing up the knowledge domain based on a logical analysis of dependencies, the constructivist view turns toward a consideration of what real people in a particular knowledge domain and real-life context typically do (Brown, et al., 1989a; Resnick, 1987). The overarching goal of such an approach is to move the learner into thinking in the knowledge domain as an expert user of that domain might think (Bednar, et al., 1992). Thus the value of correctly organizing a team is that both the individual and the organization benefit from the increased potential for learning.

Central to the vision of constructivism is Perkins' (1992) notion that the learner is "active"—not just responding to stimuli, as in the behaviorist rubric, but engaging, grappling, and seeking to make sense of things. In particular, learners do not just take in and store given information; they make tentative interpretations of experience and go on to elaborate and test those interpretations (Perkins, 1992). Many argue that a major cause of poor performance on tasks that require the generation of relevant sub-problems, arguments, and explanations is that most curricula emphasize the memorization of facts and the acquisition of relatively isolated sub-skills that are learned out of context; the result is knowledge representations that tend to remain inert (Brown, et al., 1989b; Cognition and Technology Group at Vanderbilt, 1990; Resnick and Klopfer, 1989). Participating on a team facilitates this process in education and allows new knowledge to be found in the workplace.

Alternatives to fact memorization and out-of-context practice include an emphasis on in-context learning that is constructive or generative in nature and is organized around “authentic” tasks that often involve group discussions (Gragg, 1940; Cognition and Technology Group, 1992). Further definition of the Cognition and Technology Group's concept of “authentic” supports the present study’s claims of the values of teams, as well as real-world and contextual learning environments. Generative learning environments developed over the past five years are based on a theoretical framework that emphasizes the importance of anchoring or situating instruction in meaningful, problem-solving contexts that allow one to simulate in the classroom some of the advantages of apprenticeship learning (Brown, et al., 1989; Cognition and Technology Group at Vanderbilt, 1990, in press). A major goal of this approach is to create shared environments that permit sustained exploration by students and teachers and enable them to understand the kinds of problems and opportunities that experts in various areas encounter

(Cognition and Technology Group, 1992). Bednar, et al. (1992) summarize the constructivist literature by documenting the importance of the learning experience and of its being situated in real-world contexts (Brown, et al., 1989a, 1989b; Rogoff and Lave, 1984).

The challenges of retention, understanding, and active use of knowledge and skills have led to two emerging practices involving information processing technologies and the diversity of educational practices surrounding the idea of constructivism (Perkins, 1992). A basic function of educational environments has been to provide tools for the construction and manipulation of symbols. Technology expands the power of such tools in a number of ways according to Perkins (1992) who elaborates on those tools, such as word processors, that allow the easy editing and rearrangement of large chunks of text. Some of the favored tools include drawing programs that facilitate carefully controlled composition of drawings with flexible editing, and various kinds of construction kits that are a classic part of settings for learning. While Perkins is referring to childhood learning theory and Piaget's theory as a basis for concrete knowledge, it holds true that these “construction kits” for construction and manipulation of symbols are the tools of the "real world," and that the contextual application of these tools is a requirement in adult life and thus for adult learning, as supported by the discussions of Perkins and others (Perkins, 1992, pp. 45-55; Cognition and Technology Group, 1992; Bednar, et al. 1992).

Some real-world applications have emerged that represent the physical constructs of these construction kits, but are designed for adults. With commercialization and focused design effort, information processing technologies have expanded the kinds of construction kits possible in the classroom. Now learners can assemble not just "things," but also more abstract entities, such as commands in a programming language, creatures in a simulated ecology, or equations in an environment supporting mathematical manipulations. Part of many learning environments is what might be called a "phenomenarium," an area for the specific purpose of presenting phenomena and making them accessible to scrutiny and manipulation. Information processing technologies offer a flexible resource for creating complex phenomenaria to explore (Perkins, 1992). Examples include the physics "micro-worlds" that allow students to observe and manipulate Newtonian motion (White, 1984; White and Horwitz, 1987) and programs that model other sorts of environments, for example, the popular SimCity software game, which operates on principles of civil engineering and planning through a knowledge base that guides the user to explore and learn the relationships and their meaning for the game's objective of building a profitable city (Perkins, 1992).

To date, there has been little focus on the value of the constructivist views of time management and problem solving in complex environments. These are both innate and acquired skills in adults. Perkins (1992) asserts that the final element in any learning setting might be called a task manager. Task managers are elements of the environment that set tasks to be undertaken in the course of learning, guide and sometimes help with the execution of those tasks, and provide feedback regarding process and/or product. This feedback can be in the form of a critic, interactive or passive, oriented to the learner or the instructor (which is yet another method of gathering measurement and evaluation data appropriately). Computer-based information banks, symbol pads, construction kits, phenomenaria, and task managers could greatly increase the effectiveness of the enterprise by reducing tedious and repetitive chores and by affording opportunities for more complex planning, data gathering, experimentation, and documentation (Allen, 1992).

Hypothesis testing is a fundamental exercise in constructivist learning environments, where the information gathering and exploration are as much a part of the learning process as is the correctness of the results. It should be noted that there may be a fine balance between discovery learning and constructivist learning theories in this area, and that constructivists believe the line needs to be wider…to the point that correctness is part of the learning model. The present experiment will ensure that modification to the theory can take place.

Information processing technologies and constructivism, separately and often together, have reformulated substantially our conception of the challenges of learning (Perkins, 1992). Perkins reports a number of surprises in recent investigations of advanced learning in ill-structured domains, including improved student performance in an environment that was defined as classic constructivist. This then conflicts with the results of others who have found that constructivism is not a suitable organizational strategy for ill-structured problems. Results reported by several researchers support in one form or another the findings reported by Perkins (Coulson, et al., 1989; Feltovich, et al., 1989; Myers, et al., 1990; Spiro, et al., 1989). Results relating to the scope of Perkins' research include widely varied performance among subjects and tangential learning effects, as well as social implications for the learning of habits which are known to interfere with the learning process.

Clearly there is a need for further definition and structuring of the constructivist approach if its application is to be successful in distributed learning environments. Fundamental to the transfer of knowledge to the workplace from an educational environment is the acquisition of the knowledge that other experts use as tools (Cognition and Technology Group, 1992). Unfortunately, the way individuals actually transfer knowledge to the organization is not discussed in any detail in the current literature. This study proposes that team activities in organizations are the means by which most of that transfer of knowledge takes place. Using a well-formed team to create a meaningful context for problem solving is the basis for learning in organizations, and according to the Cognition and Technology Group (1992), it is the basis for learning in educational settings as well. Hence this study developed and applied a measure for assessing the learning effect(s) of the team activity on the individual.

“The more the problem-solving learning situation represents the real world, the more likely it is that the student will transfer the skills to other problem-solving situations” (Dick, 1992, pp. 91-98). It is an important point that the context in which skills will be used must be identified in the needs assessment, and subsequently incorporated, to the extent possible, in the instructional design and instructional process applied to the student (Dick, 1992; Perkins, 1989). From the research reports of Utah State University comes the following fundamental claim: "Knowledge [a mental model] is constructed from experience."

Merrill (1992, pp. 99-114) does subscribe to extreme constructivism, stating, “There is no shared reality, learning is a personal interpretation of the world.” Such absolute views make the value of constructivist environments appear too risky where measurement, performance assessment, and value to the individual are sought. Controlling the environment is not enough to ensure benefit to the individual or the team. Papert (1980) warns of the pitfalls of being too extreme, having noted the fact that degraded constructivist environments can trap individuals in mindless activities that serve only short-term ends and are difficult environments from which to assess an individual’s performance. On the other hand, Papert acknowledges that even carefully designed "constructivist" learning environments can revert to “objectivism” when teaching styles are inappropriate—as when students are systematically led through criterion-based instruction or when impatient teachers prematurely prompt students for "correct" answers during hypothesis formation (Savenye and Strand, 1989). Many teacher-managers of constructivist learning environments would also acknowledge the usefulness of learning systems that can help students master specific skills (Allen, 1992). Allen's position holds true in many decision-making and problem-solving exercises where skill sets can be highly context dependent.

Current impediments to student understanding include lessons dominated by "teacher-talk," lessons that are predominantly textbook oriented, devaluation of student thinking, and overemphasis on curriculum mastery. Instructors and facilitators must begin to make a difference in how students learn by encouraging student-to-student interaction, initiating lessons that foster cooperative learning, and providing opportunities for students to be exposed to interdisciplinary curricula (Jackson, 1993). Most important, students must understand that they are ultimately responsible for their own learning within a learning environment that includes all the aforementioned strategies (Allen, 1992). Educators must abandon the mimetic approach to learning, and encourage students to think and rethink, demonstrate, and exhibit (Jackson, 1993).

Complexity of activities serves to generate relevance, interest, and transfer of information (Jackson, 1993). According to Piaget and Inhelder (1971), knowledge comes neither from the subject nor the object, but from the unity of the two. “Educators must invite students to experience the world's richness, empower them to ask their own questions and seek their own answers, and challenge them to understand the world's complexities” (Grennon-Brooks and Brooks, 1993). Schooling is not necessarily conducted in this way, and in many adult learning programs it is not. Classrooms can become settings in which teachers invite students to search for understanding, appreciate uncertainty, and inquire responsibly (Grennon-Brooks and Brooks, 1993).

The above observations can be applied to teams in industry. The value of the team in the industrial setting is that the individual can be exposed to, and explore, knowledge that is tangential and relevant. This is where the literature departs from the developmental theories of constructivism and into the unknown. It may be simple enough to ask the question, "Is the constructivist theory in adult learning really still the constructivist theory?" Answering this question requires continual analysis of both organizational planning and teaming methodologies during the problem solving, practices for which most managers have not been prepared. On the other hand, most professors have not been prepared to apply the constructivist view in instructional settings, and thus perform unsatisfactorily. Grennon-Brooks and Brooks (1993, pp. 15, 22) assert the importance of teacher preparation in the “constructivist proposition” and ways of putting this proposition into practice:

> Constructivism stands in contrast to the more deeply rooted ways of teaching that have long typified American classrooms. The constructivist vista is far more panoramic and, therefore, elusive. Look not for what the students can repeat, but for what they can generate, demonstrate, and exhibit. Educational settings that encourage the active construction of meaning have several characteristics: a) they free students from the dreariness of fact-driven curriculums and allow them to focus on large ideas; b) they place in

> students' hands the exhilarating power to follow trails of interest, to make connections, to reformulate ideas, and to reach unique conclusions; c) they share with students the important message that the world is a complex place in which multiple perspectives exist and truth is often a matter of interpretation; and d) they acknowledge that learning, and the process of assessing learning, are, at best, elusive and messy endeavors that are not easily managed. We must always remember that in order to realize the possibilities for learning that a constructivist pedagogy offers, schools need to take a closer, more respectful look at their learners.

Piaget's (1952) research concluded that the growth of knowledge is the result of individual constructions made by the learner (Grennon-Brooks and Brooks, 1993). Piaget viewed the human mind as a dynamic set of cognitive structures that help us make sense of what we perceive, and thus he believed that the creation of "new cognitive structures" is based on the need to find a balance between the new set of information and the old when the two are in disharmony, that is, when perception and "reality" conflict (Grennon-Brooks and Brooks, 1993).

Piaget was less focused on group-driven conceptions of human cognition and more on the notion that all learners take in some information passively. The constructivist perspective suggests that even this information must be mentally acted upon in order to have meaning for the learner (Grennon-Brooks and Brooks, 1993). Piaget and other researchers have claimed that the development of a construct for problem solving can be enhanced by exposure to new knowledge—thus the value of a team when attempting to solve complex and knowledge-bound problems. Creating the best possible situation for an individual and a team is the responsibility of the manager tasking the team with the problem. The definition of a good problem-solving situation is offered by Greenberg (1990), relative to an educational setting:

- Demands that students make a testable prediction.
- Makes use of relatively inexpensive equipment.
- Is complex enough to elicit multiple problem-solving approaches from the students.
- Benefits from group effort.

These requirements are similar to those posited by the research of Cannon-Bowers, et al. (1990). Grennon-Brooks and Brooks (1993, pp. 36-39) offer a similar set of applied aspects to creating a constructivist problem-solving situation:

> For a situation to be considered a good problem-solving situation in a classroom, the problem solvers must view the problem as relevant. Problems with little or no initial relevance to students can be made relevant through teacher mediation before or after the problem is posed (Grennon-Brooks and Brooks, 1993, p. 36). The structuring of the lesson around questions that challenge students' original hypotheses presents students with the initial spark that kindles their interest (Grennon-Brooks and Brooks, 1993, p. 37). The inquiring teacher mediates the classroom environment in accordance with both the primary concept she has chosen for the class' inquiry and her growing understanding of students' emerging interests and cognitive abilities within the concept (Grennon-Brooks and Brooks, 1993, p. 38). When posing problems for students to consider and study, it is crucial to avoid isolating the variables for the students, to avoid giving them more information than they need or want, and to avoid simplifying the complexity of the

problem too early (Grennon-Brooks and Brooks, 1993, p. 39). Constructivist teachers often ask students to think about questions they would not ordinarily consider on their own (Grennon-Brooks and Brooks, 1993, p. 39). Constructivist teachers seek to ask one big question, to give the students time to think about it, and to lead them to the resources to answer it (Grennon-Brooks and Brooks, 1993, p. 39). Constructivist teachers have discovered that the prescribed scope, sequence, and timeline often interferes with their ability to help students understand complex concepts (Grennon-Brooks and Brooks, 1993, p. 39).

SUMMARY POINTS: RELEVANCE OF THE LITERATURE TO TEAM PERFORMANCE STUDIES

Many studies seek to improve the organizational process of using teams to perform tasks when the team cannot be co-located. The contribution of these studies will be based on the results which, if successful, will document a method to charge, instruct, assess, enhance and measure individuals in distributed team environments.

1. It is critical to understand the role of the team in the organization when seeking to generate knowledge as the key product being offered by the team to the organization.
2. There is a need to consider the individual as a separate part of the team.
3. The individuals' effort to communicate, combined with a team goal, is what makes a team function.
4. Distance education and business environments alike are re-discovering the use of technology as a tool to bridge communication gaps in their team locations.

5. Towards the learning organization, the best methods of assisting an individual towards understanding knowledge— and motivating the individual—are found in the constructivist theories of education.
6. Measurement of individual performance in such an environment is difficult.

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