Planning, Problem Solving, and Kirton's A-I Theory Within an Organizational Framework

Michael W. Creed

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Approved by:

Emil E. Malizia, Professor

William M. Rohe, Professor

Raymond J. Burby, Emeritus

David R. Godschalk, Emeritus

Kathryn W. Jablokow, Professor
Pennsylvania State University

ABSTRACT

MICHAEL W. CREED: Planning, Problem Solving, and Kirton's A-I Theory Within an Organizational Framework
(Under the direction of Emil E. Malizia)

Planners must be technically competent in many disparate facets of contemporary urban society. And, since planners cannot be experts in all things they must be skilled in problem-solving processes involving people with widely varying motives, knowledge, and personalities. This research investigates problem-solving processes in small groups solving a non-trivial and non-value-laden problem under tight constraints.

Planners are, first and foremost, problem solvers. Problem solving requires learning and learning requires reframing perspectives; i.e., destroying old conceptions and biases to make room for new understanding. These are cognitive processes that are explained in Kirton's Adaption-Innovation theory (cognitive style) which will be the major theoretical framework for this research. This research is based on the assumption that the most elemental decision-making unit in planning organizations is a small group. This research investigates interpersonal dynamics in small groups based on cognitive style theory and its relative cognitive gap theory.

A group of 88 volunteers from a multi-office engineering firm participated in one of 12 trials of the *Hollow-Square: A Communications Experiment*. Findings from these experiments were compared with prior research from two major university studies using *ad hoc* volunteers. In contrast, all participants in this research worked for the same company and were assumed to comprise *intact* small groups. Hypotheses were advanced positing superior problem-solving outcomes by *intact* groups over *ad hoc* groups. Participants were placed on teams based on their relative cognitive styles (KAI scores). The experiments were conducted under tight time and rule constraints. Means tests were conducted on *proportions of successful outcomes* for this research and the prior research. The *intact* groups in this research were no more successful in solving the puzzle than the comparison *ad hoc* groups.

Video recording of the exercises provided serendipitous opportunities to explore broader considerations than the initial hypotheses anticipated. The Jablokow-Booth problem-solving model was examined and its cognitive gap propositions were operationalized and employed in empirical research for the first time. These considerations were presented using an adaptation of Flanagan's critical incident technique. Cognitive style extremes and cognitive gaps were identified as causal impediments to successful small group problem solving.

DEDICATION

To my wife, Linda, who has patiently endured me being in school for most of her entire adult life; to my son, Derek, who has seldom known me to be out of school; to my daughter, Cathy, and her husband, Scott, and their two children, Mason and Maddy, who are just beginning school

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1. Plan versus Planning

Since the arrival of T. J. Kent's (1964) definitive statement of what *The Urban General Plan* should contain, the field of planning has evolved from an emphasis on product (*plan*) to an emphasis on process (*planning*-value determination and consensus building). Kent's classic work was based on his extensive experience in the field—the prior 30 years. It was published during a time of profound change in American society—from a democracy of obedience to a democracy of conflict. American society in 1960 was largely racially segregated, most married women were stay-at-home mothers, and draftees to military service acquiescently reported to their duty stations. The decade ended with desegregation in full force of law if not reality, women's liberation at the forefront of political and social consciousness, and with many American men and women openly refusing to report for military service. This decade in American history saw the death of Whyte's (1956) *Organization Man* and the emergence of tension between the establishment and burgeoning college aged *Baby Boomers* who openly questioned prevailing authority. This turbulence contributed to the evolution of the field of city and regional planning; it was no longer sufficient to be proficient in architectural form, transportation systems, water supply and wastewater collection systems, and commercial, retail, and residential interdependencies. Only a year after Kent's *The Urban General Plan* became the guiding template for city and regional planners, Davidoff (1965) announced an expanded responsibility for the planning profession:

> The present can become an epoch in which the dreams of the past for an enlightened and just democracy are turned into a reality. The massing of voices protesting racial discrimination have roused this nation to the need to rectify racial and other social injustices.

The emotional energy generated by this expanded vision of the role of the master planner of an earlier generation can trivialize the mundane need for planning in everyday life in both public and private organizations. An example of the degree to which the planning profession was impacted by the profound social changes of the 1960s is given by Kaiser et al.'s (1995) perennial textbook for graduate planning schools, *Urban Land Use Planning* in its fourth edition,

> Our proposed planning model is based on rational planning, which was also the primary planning theory base for earlier editions of this text. But it now incorporates critical theory and communicative competence, dispute resolution, and adaptive planning concepts within a broader model of discourse and consensus-building among the players in the land use planning game (p.3).

Clearly, process, in many varieties, has become a necessary part of the planner's education. Process includes many examples but all include interacting with people, establishing values and related facts, and collective problem solving with groups of interested people. For the last century the role of the professional planner has evolved from the technical expert to the facilitator of group decision-making meetings, as evidenced by Kaiser et al.'s quote above.

The focus of this research project will be to improve group problem solving processes for the purpose of improving organizational decision processes and outcomes. The organization could be a local municipal government, a civic club, or a private industrial concern. There is little difference in group problem-solving behavior within public bureaucracies or private corporations, but for the profit motive (Downs 1967).

2. Planning as Learning

Arie P. de Geus (1988), head of planning for the Royal Dutch/Shell Group of companies, used *Planning as Learning* to posit the importance of learning in planning. He asserted "…that the only competitive advantage the company of the future will have is its managers' ability to learn faster than their competitors" (p.74). Certainly Shell is a private, for-profit company. But, its revenue volume exceeds that of many small countries and, therefore, it is a valid subject of observation. De Geus' view is similar to earlier comments about planners' role as facilitators, "…every living person—and system—is continuously engaged in learning. In fact, the normal decision process in corporations is a learning process, because people change their own mental models and build up a joint model as they talk" (p.71). And, he acknowledged that who learns is important, "The only relevant learning in a company is the learning done by those people who have the power to act (at Shell, the operating company management teams). So the real purpose of effective planning is not to make plans but to change the microcosm, the mental models that these decision makers carry in their heads."

Three important findings have come from the last century of theoretical and empirical work in the field of administrative science which informs this work. They are:

1. From *man as machine* to *man as decision maker*
2. Boundedly rational actors *enabled by organizational constraints*
3. *Groups* as the most elemental decision unit

Fredrick Winslow Taylor's (1911) *Principles of Scientific Management* stimulated significant interest in the study of organizations and the people inside them. Unfortunately, the gist of his work produced the "man as machine" model. Following Taylor's lead, a group of scholars that came to be known as the structuralists produced considerable theoretical work asserting the importance of, among other things, unity of purpose, scalar chain, hierarchy, division of labor, specialization, autocracy, and executive span of control (Fayol 1949; Gulick 1937; Urwick 1943; Mooney and Reiley 1931; and Graicunas 1937). This group extended Taylor's man as machine model. While the man as machine model has long since been discredited, the structural aspects of these scholars remain important in varying degrees in consideration of how organizations function.

The much cited Western Electric Hawthorne Experiments showed in great detail the ways that people mattered in organizations and firmly introduced the person into the middle of the stimulus-response model commonly in use in lower forms of animal research. This work was richly detailed in the omnibus *Management and the Worker* (Roethlisberger and Dixon 1939) and stands as, perhaps, the most important empirical research involving humans in organizations in the first half of the last century. The idea of the efficacy of the informal organization was shown in several examples. Barnard (1938) also mentioned informal organization in his important *Functions of the Executive* but his observation was anecdotal in contrast to Roethlisberger and Dixon's. The Hawthorne Experiments showed that workers responded positively to almost any attention shown them by management. For example, when management increased lighting levels daily over many days, the productivity increased each day. And, when the lighting levels were diminished daily slightly over many days, productivity also improved even to the point that the employees could not see their tasks in the dim light! This work also showed unintended responses when management attempted to manipulate working environments or supervision. This important research provided convincing proof that the rational actor in the middle of the stimulus-response chain made research in the social sciences a bit more challenging than the earlier deterministic man as machine view from Taylor and his disciples. The focus of how human actors made decisions and they interacted with others in their social groups became the object of administrative science research following these important findings. These scholars were called behavioralists.

Simon (1947), drawing from the behavioralists' research, attempted to define a science of administration in his important *Administrative Behavior*. That work was the first to challenge classical economic theory about conditions necessary to rationality. Simon posited that human actors were unable to acquire complete information, process it, and make decisions within a constantly changing environment and therefore, only incomplete or "bounded" rationality was possible. Simon was interested in optimizing the potential for good decisions and he called decisions made under these circumstances "satisficing" rather than maximizing.

Simon realized that the decision-making process is even more confounded if there is more than one individual involved in the process. A group, i.e., more than one, will add further complications,

> …each individual, in order to determine uniquely the consequences of his actions, must know what will be the actions of the others. This [the way group members interact in problem solving] is a factor of fundamental importance for the whole process of administrative decision-making (p.71) [my inclusion].

It is noteworthy that Simon realized that group problem solving presented considerable challenges. He devoted much of his career on techniques to improve decision making (or problem solving) in organizations which led to his development of "procedural rationality," in contrast to substantive (or objective) rationality. Boundedly rational actors operating within an organization will be enabled to solve more complex problems when the organization sets forth procedural constraints; i.e., based on pre-established rules which anticipate a variety of choices. In a general sense, organizations imbue its members with important psychological meaning and frames of reference which shape their world view. Thus, the socializing environment of organization plays an important role in the stimulus-response activity of actors therein. Simon's (1947) words captured the thought quite well, "Social institutions may be viewed as regularizations of the behavior of individuals through subjection of their behavior to stimulus-patterns socially imposed on them. It is in these patterns that an understanding of the meaning and function of organization is to be found" (p.109).

Simon (1947), like Barnard (1938), recognized the importance informal organizations play in formal organization communications. He, therefore, included "training" as a method of communication that disseminates knowledge but its effectiveness depends on the participants' attitudes toward the training. Ideally, if the informal organization can be mobilized to care about training, it can be accomplished. If successful decision making depends, in an organizational context, on members understanding the standard operating procedures (thereby defining procedural rationality) it naturally follows that member education (training) is important. This is similar to de Geus' opinions mentioned above.

Harris and Sherblom (2005:4), small-groups and systems scholars, assert that "Groups are the fundamental building blocks of any organization." Small groups usually range in size from three to not more than 20 people during decision processes. Larger groups dilute the ability for each member to engage in meaningful participation. And, it is usually found that more effective groups are less than 10 people in size (see, e.g., Hare 1952; James 1951; Slater 1958; and Ziller 1957). Individuals are important, but only in relationship to all others participating together to solve problems (Aritzeta et al. 2005). And, for this research, the small group is the unit of analysis.

Groups may be classified as *ad hoc* and *intact*. The former consists of people who have little or no prior knowledge of each other, have no common sense of purpose, and who are not likely to be together again in the future. The latter consists of people who know each other, share a common set of normative views often because they work in the same organization, and who understand that they will be required to work together in the future. Interpersonal behavior and group problem solving between the two classes can be expected to vary; e.g., Axelrod (1984) conducted extensive empirical tests employing the “prisoner’s dilemma” game and found that one-off tests revealed much more aggressive (greedy and destructive) behavior than in tests where the participants expected to be working together indefinitely into the future, what he called the “iterated prisoner’s dilemma games.” Axelrod called this the “long shadow of the future” and it helps explain the significant difference between ad hoc and intact groups. This is a subject that this inquiry will investigate.

Small groups can be found in every variety of society; institutions, organizations, and municipal governments employ small groups to help guide and operate most of what transpires in their operations. The objects about which they come together to decide are usually problems which need resolution; i.e., problem solving. How can small group problem solving be made to be more effective? That is the central question this research seeks to address.

3. Problem A and Problem B

In any field of endeavor people come together for the purpose of solving problems. The problem about which the group comes together to solve may be called Problem A. The group which comes together to solve Problem A encounters another problem due to the differences of its members. The *management of diversity* that arises by virtue of a *group* of people being called upon to make decisions may be called Problem B. The objective of any such process should be to expend more time and other scarce resources on solving Problem A than on solving Problem B. Kirton (2003), a noted British industrial psychologist, has argued that the Problem A-Problem B analogy is the central challenge for the survival of civilization. This is a small part of Kirton's Adaption-Innovation (A-I) theory. Kirton approached both Problem A and Problem B from the perspective of cognitive psychology, covering any problem in any sphere. Inside organizations problem solving usually occurs in small groups in exactly the manner cited in the Problem A-Problem B analogy. Whether it is in the boardroom, the executive suite of offices, or in the production room, Problem B exists. How might organizations or institutions manage diversity in order to achieve optimal solutions is the question Herbert Simon (1947) wrestled with over 60 years ago. Kirton's work has been used in a variety of milieu for improving the allocation of resources between Problem A and Problem B and to help researchers understand behavioral preferences. In addition, Kirton's (1976, 1977a, 1977b, 1978a, 1978b, 1994, 1999, and 2003) A-I theory is rich in explanatory power for group interaction and problem solving, which is ideally suited to organizational and small group behavioral studies. This inquiry will explore A-I theory's potential contribution to the improvement of any type of group problem solving—which I view as a critical building block of the planning-learning process.

4. Small Groups and Teams

Harris and Sherblom (2005) reported that, by the mid-1990s, over 70% of all U.S. firms used small groups (teams) for execution of work. While the emergence of small group research seems relatively recent, it has long been a subject of study by scholars. In an early empirical study Watson (1928) asked, "Do Groups Think More Efficiently than Individuals?" He observed that no uniform opinion then existed about group versus individual thinking. But some, even then, suspected that there was a special potential for groups:

> In every coming together of minds that are serious in the effort to understand, there is something more than the minds. There is the Creative Plus, which no one mind by itself could achieve. A series of directions for discussion groups contains the statement, 'Trust the group.' There is no person in it who is not superior to the rest in at least one respect. The experience of all is richer than the experience of any. The group as a whole can see further and more truly than its best member (Overstreet 1925).

Overstreet was well ahead of his time, as was Follett (1924) in her suggestion of the integration of interests when two or more people are resolving a problem together. But, with the emergence of total quality management (TQM), exemplified by W. Edwards Deming (1986), Joseph Juran (1992), and Philip Crosby (1979), the concept of team problem solving became *de rigueur* in American business by the end of the last century.

While I have conflated the terms *small groups* and *teams*, there are important differences between the two. Harris and Sherblom (2005) differentiate small groups from teams. Small groups are generally less integrated. Teams share common boundaries, understand that members are interdependent, have a clear sense of purpose, and a common sense of goals; i.e., have Problem A's – a group may not. Tuckman (1965) and Fisher (1970) found four distinct stages in the transformation of small groups into teams—*form, storm, norm, and perform*. Kirton's (1978a) work illuminates the psychological factors that may help explain how the stages of development work as they do. In the interest of precision for this study I will use the term *group* or *small group* rather than *team*. Also, I will use the term *ad hoc group* to mean people with no prior knowledge or familiarity of each other. And, I will use the term *intact group* to mean people who have a general knowledge and familiarity of each other by working in the same office.

5. Management of Diversity

Small group problem solving, depending on the nature and complexity or the problem, is a form of social learning (Berger and Luckmann 1967). Small group problem solving is the process of building sufficient consensus to resolve different opinions which may contain conflicting frames of reference, different value systems, or different desires—all of which are affective cognitive states (Goffman 1974). Simon (1947) interestingly discussed the fact-value dichotomy as having significant importance in problem solving. Different values are often discovered solving Problem B while more manageable facts are encountered in Problem A. In the field of planning the values-facts dichotomy is usually resolved in the political arena. An organization's *values* are usually part of its culture and "the way things are around here." However, individual actors sometimes have personal value systems that can inhibit or accelerate their support for problem solving. The process that includes groups meeting, exploring the nature of problems and conflicts, considering varying alternative courses of action, considering the potential outcomes including relative risks, and arriving at the most desirable choice I call learning—it is group decision making.

The central thesis for this study is that all humans are problem solvers and, hence, creative. When two or more people come together to solve problems, there are cognitive style differences, level (e.g. IQ) differences, and motive differences (among others) that impinge on the process and could reduce the quality of the solution if improperly managed (see e.g., Jablokow 2008 and Kirton 2003). Judicious application of Kirton's A-I theory should improve group problem solving, facilitate the management of diversity, and help ameliorate those possible points of conflict. A-I theory posits that all people have unique cognitive styles that frame their views and approach to problem solving (Kirton 1976). When members of social groups (organizations or otherwise) assemble for solving difficult issues and planning for future activities, there could be value laden conflicting viewpoints (Schön and Rein 1994). Different problem-solving styles amongst the people can also impede optimal outcomes. *High adaptors* and *high innovators* are the terms which Kirton (1976) assigned to the extreme positions of a problem-solving style continuum which approximates a normal curve and which all people fall between depending on each person's need or distain for structure in problem solving.

High adaptors prefer to approach problem solving from within the existing rules (structure) and commonly held belief systems. They are perceived to be predictable and reliable (Kirton 1978a). High innovators, on the other hand, have relative disdain for the rules, and are viewed as unpredictable and not reliable. High innovators view high adaptors as "boring," while high adaptors view high innovators as "dangerous." Kirton (2003) is critical of the American (and now world-wide) propensity for "innovation bias," which views all innovation as good and all adaption as bad. Rogers' (2003) classic work in *Diffusion of Innovation* acknowledges innovation bias in research. I should note that Rogers' definition of innovation is somewhat broad; i.e., "An innovation is an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (p.12). Kirton is quite specific in his use of the terms adaptor and innovator. He takes issue with Rogers' more subjective definition of innovation, for which the term "change" might be usefully substituted.

Kirton drew from Kuhn's (1962) work, which popularized the term *paradigm*. As an example, Kuhn (1957) had earlier described the process of moving from the Ptolemaic view of the universe, which dominated from the fourth century B.C., to Copernicus' view in 1543 that was contained in his life's work, titled *De Revolutionibus Orbium Caelestium*. The Ptolemaic paradigm, which was deeply ingrained in church dogma, held that the earth was a small sphere at the geometric center of a very large rotating sphere upon which the stars were distributed. Ptolemy worked from centuries old concepts including the Theory of Homocentric Spheres, attributed to Eudoxus (c.408-c.355 B.C.), a student of Plato and Aristotle who had his own conceptual explanation for the cosmos (Kuhn 1957:p.55 and 79). Most ancient views explained that the sun, the moon, and other planets moved in the large space between the earth and the stellar sphere. Each was on a form of concentric sphere between the earth and the stellar sphere. And, outside the outer sphere there was nothingness.

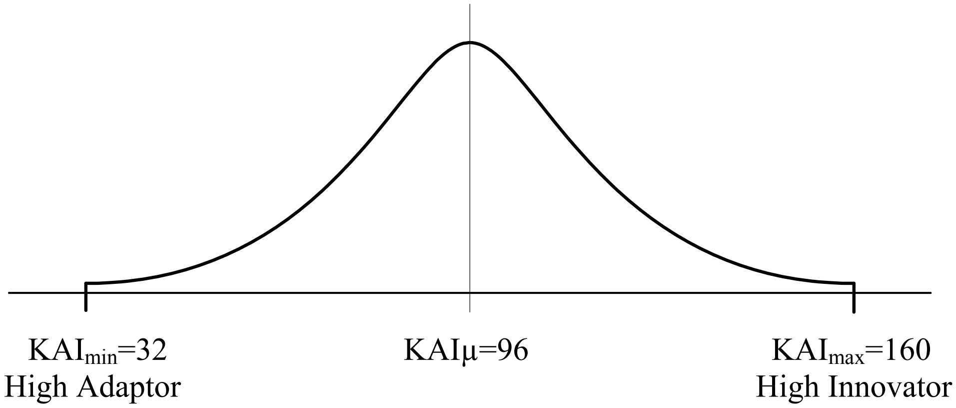
Nearly five centuries after Aristotle, Ptolemy formulated his concept of the universe. While these were not the only theories of the universe at the time, the Aristotelian version was the one which gained most support and which Ptolemy embraced. But to do so Ptolemy made copious *adaptive* adjustments to the mathematical formulation of the spherical trajectories that the planets, the sun, and the moon traveled on—these were called *epicycles* and *deferents*—a description of which would be exceedingly lengthy and excruciatingly detailed. I would suggest that Ptolemy was a high adaptor (and high level as well) based on the evidence of his work today. I make that observation to contrast Copernicus, who asserted that the sun, not the earth, was the center of the universe, was a high innovator, in Kuhn's vernacular.

Copernicus' proposition was highly controversial and initially almost universally rejected, particularly by the church. Some have suggested that Copernicus did not publish his book on the topic until his death was imminent just so he would not have to withstand the assault from the church and the scientific community which opposed this threat to the stability of science and religion. It was no small feat for Copernicus to advance such a radical reordering of the cosmos. The fact that Copernicus was only partly correct is secondary to the magnitude of the paradigm shift he initiated. In the sense first advanced by Kuhn, Copernicus was an innovator. In the sense advanced by Kirton (1976) Ptolemy was an adaptor. Clearly both were very high level and both contributed significant advances to the prevailing scientific knowledge of the day—one in an adaptive way and one in an innovative way. Note the particular precision of definition that Kirton uses to describe an innovator—it is something much less subjective as that employed by Rogers (2003) and should constrain the use of the term (and adaptor as well).

6. Adaption-Innovation Continuum

Kirton (1976) developed a psychometric instrument called KAI, or the Kirton adaption-innovation inventory. The inventory (KAI) places all people on a non-pejorative bi-polar continuum between high adaptors and high innovators (note the circumscribed use of the term from the previous example). See Figure I-1 for a graphical depiction of the normal distribution with the theoretically high, low, and average KAI scores.

Figure I-1. Adaptor-Innovator Continuum for Large General Population



I will elaborate on the scoring system which produces an absolute minimum (KAI_{min}) of 32, an absolute maximum (KAI_{max}) of 160, and a theoretical mean (KAIμ) of 96 in a later section. It should be noted that those scoring near the theoretical mean (and by statistical theory most do) are not considered lacking; i.e., being near the mean of a measure such as height does not mean one has no height. People whose scores are near the mean have less pronounced behavioral tendencies than those toward the extreme of high adaptor or high innovator. Table I-1 contains preferred behaviors and characteristics of adaptors and innovators who are near the extreme ends of the continuum shown in Table I-1. These should not be viewed as a dichotomy; rather, it is a continuum. The development of the inventory will be more fully described in Chapter II.

7. A-I Theory in Action

I propose to employ A-I theory in execution of an experiment on small group problem solving following two previous studies—Hammerschmidt (1996) and Scott (2007). The former was a study of mid-career professionals enrolled in Eckerd College Leadership

Table I-1. Behavior Descriptions of Adaptors and Innovators[1]

The Adaptor	**The Innovator**
Characterized by precision, reliability, efficiency, methodicalness, prudence, discipline, conformity.	Seen as undisciplined, thinking tangentially, approaching tasks from unsuspected angles.
Concerned with resolving problems rather than finding them.	Could be said to discover problems and discover awareness of solutions.
Seeks solutions to problems in tried and understood ways.	Queries problems' concomitant assumptions; manipulates problems.
Reduces problems by improvement and greater efficiency, with maximum of continuity and stability.	Is catalyst to settled groups, irreverent of their consensual views; seen as abrasive, creating dissonance
Seen as sound, conforming, safe, and dependable.	Seen as unsound, impractical; often shocks his opposite.
Liable to make goals of means.	In pursuit of goals treats accepted means with little regard.
Seems impervious to boredom, seems able to maintain high accuracy in long spells of detailed work.	Capable of detailed routine (system maintenance) work for only short bursts. Quick to delegate routine tasks.
Is an authority within given structures	Tends to take control in unstructured situations.
Challenges rules rarely, cautiously, when assured of strong support.	Often challenges rules, has little respect for past custom.
Tends to high self-doubt. Reacts to criticism by closer outward conformity. Vulnerable to social pressure and authority; compliant.	Appears to have low self-doubt when generating ideas, not needing consensus to maintain certitude in face of opposition.
Is essential to the functioning of the institution all the time, but occasionally needs to be "dug out" of his systems.	In the institution is ideal in unscheduled crises, or better still to help to avoid them, if he can be controlled.
When collaborating with innovators	***When collaborating with adaptors***
Supplies stability, order and continuity to the partnership.	Supplies the task orientations, the break with the past accepted theory.
Sensitive to people, maintains group cohesion and cooperation.	Insensitive to people, often threatens group cohesion and cooperation.
Provides a safe base for the innovator's riskier operations.	Provides the dynamics to bring about periodic radical change, without which institutions tend to ossify.

[1] This first appeared as shown in Kirton's (1976) original development of the KAI theory and also verbatim in Kirton's (1994) later work.

Development programs between 1990 and 1994. The latter was a study of engineering and technology students between 2002 and 2005 in the School of Polytechnic Studies at a Midwestern university. In both cases, the groups were ad hoc.

Hammerschmidt (1996) conducted a problem-solving experiment on 952 managers with average age of 42, 80% of whom were males. The participants were not told their KAI scores prior to the experiment. Between August 1990 and June 1992, the teams were assembled without regard to their KAI scores. There were 50 eight-person teams, hence, 400 participants. But, from August 1992 to August 1994, the remaining 552 participants were formed into teams using their KAI scores (more details will be discussed below).

Hammerschmidt used "Hollow Square: A Communications Experiment" (Pfeiffer and Jones 1974) for his problem-solving experiment. As the name implies, a hollow-square puzzle must be assembled during a fixed time period. The experimental setup requires each eight-person team[2] to be composed of a four-person *planning subteam* and a four-person *operations subteam*. Planning subteams are given a fixed time period to prepare assembly instructions for the operations subteam. The planning subteam must make its plans without the operations subteam present. After a prescribed time period the planning subteam presents the assembly instructions to the operations subteam. The operations subteam then has a fixed time period in which to assemble the puzzle.

The planning role is rule bound and structured. It is also relatively time constrained. Hammerschmidt posited that this part of the exercise was *adaptive* in nature. He hypothesized that the more adaptive subgroups would find this role in the exercise more in harmony with their cognitive style preferences (this was termed "team role conformity;"

[2] Contrary to my earlier comments about the use of terms *group* and *team*, Hammerschmidt used the terms *team* for the large (eight-person group) and *subteam* for the smaller specialized four-person group). For simplicity I will employ his terminology in this description.

similarly, if an adaptive subgroup were assigned a role more favored by innovative groups that would be termed “team role non-conformity”).

Conversely, Hammerschmidt posited that the assembly part of the exercise, which is the role of the operations subteam, was more innovative since it was somewhat less structured, unlike part one. Consequently, he varied the KAI score makeup of the subteams to investigate the predictability of performance based on cognitive style preferences and role match. Hammerschmidt assembled all subteams (four-person groups) to be “homogeneous,” which he defined as the KAI scores varied by less than 20 points. Subteams were “paired” with other four person subteams which were either similar (mean subteam KAI scores were less than 15.7 apart) or dissimilar (mean subteam KAI scores were over 15.7 points apart). The roles of the subteams were also manipulated: team role conformity and team role non-conformity.

Hammerschmidt formed five types of teams as follows:

> 1. Homogeneous <u>Similar-KAI Style and Team Role Conformity</u>. Relatively “adaptive” same score planners working with relatively “innovative” same score implementers.
> 2. Homogeneous <u>Dissimilar-KAI Style and Team Role Conformity</u>. Relatively “adaptive” same score planners working with relatively “innovative” same score implementers.
> 3. Homogeneous <u>Similar-KAI Style and Team Role Non-Conformity</u>. Relatively “innovative” same score planners working with relatively “adaptive” same score implementers.
> 4. Homogeneous <u>Dissimilar-KAI Style and Team Role Non-Conformity</u>. Relatively “innovative” same score planners working with relatively “adaptive” same score implementers.
> 5. Non-Homogeneous Dissimilar. Randomly arranged non-same score subteams with a KAI mean of 104.

The terms “relatively adaptive” and “relatively innovative” refer to the other subteam which combines to form the eight person big team. In fact, both subteams may have KAI scores which are on the adaptive or the innovative side of the theoretical mean. He hypothesized that the subgroup homogeneity would foster better communication leading to better performance rates for categories one and three. He also hypothesized that subteam role conformity would contribute to improved problem solving performance.

Hammerschmidt found that the relatively adaptive planners working with the relatively innovative implementers where the subteam KAI scores were more than 15.7 points apart were the most successful. He also found that relatively innovative planners and relatively adaptive implementers whose intergroup scores were more than 15.7 points apart actually performed worse than the randomly assembled teams, but the differences were not statistically significant.

It is important to note that subteam role assignment and KAI style preference compatibility were shown to be an important variable of consideration in this work. It is also noteworthy that all the subteams were composed so as to be homogeneous which was theorized to lead to better communication. This was borne out by the experiment. In addition, considerable communication conflict was noted between dissimilar subteams during the problem solving exercise where the subteams were performing non-preferred roles. In category four relatively innovative planners worked with relatively adaptive implementers and the subteams were dissimilar. The observers noted considerable conflict and the implementers used the following words to describe the planners, “abrasive, unprepared, unstructured, and insensitive” (p.19). Hammerschmidt said that it was clear the relatively adaptive implementers were uncomfortable in their role which was unstructured with few rules and little clarity of purpose. He said it was as if the two subteams were speaking a different language and, apparently, perceived the Hollow-Square exercise quite differently.

Animosity was common in this category and even when the teams were successful in solving the puzzle they seemed to not credit the other subteam. These types of behaviors between adaptors and innovators have elsewhere been reported by Kirton (1978a, 1994, and 2003) and Schroder 1994. When considering the degree of conflict and intergroup communication dysfunction reported here, it is important to note that the subjects were ad hoc.

Scott (2007) also used the Hollow Square puzzle in her study. Scott composed all teams (she used six-person teams rather than eight) based on a balance around the theoretical mean. Her teams were similar—meaning KAI scores were within 15 points of each other, and dissimilar—meaning KAI scores were over 15 points from each other. Scott did not further specify the definitions she used for subteams. Her independent variable was "knowledge of A-I theory." Her dependent variable was the solution of the puzzle within a given period of time. Scott found that the similar KAI score teams were most successful. This, it might seem, is in some conflict with Kirton's assertion that diversity in problem-solving groups improves outcomes, but that is if the problem contains diverse elements (is complex, i.e., diverse sub-problems), not if the problem is characterized by a particular quality—which is found in the group, as Hammerschmidt found. Scott did not make up subteams according to preference, so her results could have been compromised by subteams which were inadvertently more adaptive in the innovative role or more innovative in the adaptive role. Scott recommended that further research was needed using intact groups in industrial settings.

8. Research Objectives

I propose to conduct controlled experiments (specifically the "Hollow Square: A Communications Experiment") in professional services consulting firms among subjects who regularly work and interact with each other. This research intends to answer the following questions:

1. To what degree may group problem-solving outcomes be improved by judicious selection of group membership based on cognitive style preference?
2. To what degree do intact groups outperform ad hoc groups in solving problems which are outside the groups' problem-solving style preference as measured by group mean KAI scores?
3. To what degree do members of an intact organization modulate preferred problem solving style behavior to cope with fellow organization members?

The following chapter will review the extant literature on A-I theory, cognitive schema, the ways learning theory intersects with A-I theory, and identify hypotheses for testing. The third chapter will provide the proposed experimental set up, details about the execution of the experiment, methods of analysis, expectations, potential threats, and generalizations that may be drawn from this work. Appendix A contains the full statement of the "Hollow Square: A Communications Experiment." Appendix B contains a mockup of the KAI inventory. Appendix C contains forms which will also be used to collect information from participants. Appendix D contains a structured survey form for collecting post-exercise impressions.

CHAPTER II THEORIES, APPLICATIONS, AND HYPOTHESES

1. Group Problem Solving and Organizational Learning

When two or more people come together for the purpose of problem solving, there are a variety of interpersonal processes which are activated and which, ideally, should be understood (Kirton 2003). Within an organizational framework groups routinely meet for the purpose of solving any number of problems, including change initiatives and strategic planning (de Geus 1988). Planning, in any context, is about purposive change. And, planning is learning in the sense de Geus (1988) and his colleagues view the concept. To be more specific, group learning; i.e., a group (social group assembled for any decision-making purpose) must move from one set of collective beliefs and values to a new place in its collective belief system. This may be change within the existing paradigm (adaptive) or change which breaks the existing paradigm (innovative). In any given circumstance either type of change may require significant energy to "unfreeze" the existing system (Lewin 1951) and either type of change may be appropriate, depending on the situation (Kirton 2003). Searle (1995) called the existing knowledge/belief conditions *backgrounds* and Sabatier (1988) called them *deeply held beliefs*. Contemporary planning holds that the *process* of collective problem solving (fact finding and truth seeking) is at least as important as the final decision (see e.g., Elliott 1999; Forester 1999; Godschalk and Paterson 1999 and Innes 1998). This position accepts the proposition by Berger and Luckmann (1967) that reality is socially constructed. This relationship between group learning and organizational change is the way change is presently understood to occur in organizations and groups.

Kirton began his work as an industrial psychologist in Great Britain in the late 1950s and processes instrumental to organizational change were less well understood. In an effort to fully explicate A-I theory's genesis, I will elaborate on Kirton's early work in organizational change.

2. Management Initiative

Kirton (1961) studied how decision processes occur in organizations. (For my purposes, problem solving is the most elemental form of a decision process.) At the time of his research, organizational change processes were called management initiatives, hence the title of the book reporting the work. He found that there were three dominant and consistent processes involved in any management initiative:

> 1. In some instances, significant time lags—sometimes a number of years—were observed between the time the idea first emerged in organizations and the time the idea or change was implemented. Conversely, some initiatives became fully implemented policy with seemingly little analysis or resistance. Size of initiative was not highly correlated with time lag, although most of the initiatives in the study frame were quite large.
> 2. There seemed on very noticeable occasions to be well-reasoned resistance to change which retarded the adoption until some kind of precipitating event occurred; e.g., a competitor introduced a new product in the market, etc.
> 3. Perhaps the most revealing of Kirton's early findings was that the unpopular ideas were almost always the ones proposed by managers "who were themselves on the fringe, or even unacceptable to the 'establishment group.'" He also noted that, often, such outsiders failed to gain much acceptance to the mainstream management group (whatever its level or style), even after his/her proposed initiative became successfully implemented. And, conversely, the in-group managers who put forth more bland proposals were more acceptable to the establishment whether their proposals were accepted or even if their proposals were implemented and were unsuccessful.

Kirton's (1961) observations on processes involved in management initiatives are reflected in varying forms in other important work. Burns and Stalker (1961) were the first to explicitly assert that organizational innovation[3] could be influenced by management initiatives. They observed that experiments with different types of authority systems could accelerate or retard change. For example, they described mechanistic form and organic form as rough equivalents to the formal organization from the structuralists and informal organization from the behavioralists. These forms are both rational forms of organization in the sense Simon (1947) would recognize. The mechanistic form was more suited to stable situations and organic form was more appropriate to changing situations. Characteristics of the organic form are very nearly like Follett's (1924) of "power with" versus "power over" while the mechanistic form are much like the command and control authority relationships advanced by Gulick (1937).

While studying several industrial firms in post war England, Burns and Stalker (1961) isolated three variables that were important in their study of organizational change. The first variable was the rate of market and technical change. Since their research was in for-profit firms, there was an important motivation of firm leaders to change, based on market pressures for survival; i.e., a compelling reason to "unfreeze" or as Kirton's observed, a potential "precipitating event."

The second variable was "…the strength of personal commitments to the improvement or defense of status or power" (p.209). This variable is clearly about the human condition (personal power) and personal motivations, and is very much present in any social group in any organization. This variable is manifest in Kirton's observation that many

[3] Burns and Stalker specifically used the term innovation in the sense of organizational change. They imbued the term with positive connotation, a bias that is common in organizational change research.

organizational changes take considerably longer than expected. Personal power and position in organizations which are hard won are not easily relinquished.

Burns and Stalker's third variable concerns the degree to which managers understand the proposed change and are successfully able to interpret it to subordinates in ways that enlist the psychic energy and commitment of employees to support the change. This is similar to Barnard's (1938) assertion that the primary role of the executive was to communicate. Kirton (1961) also acknowledged an important role of managers in fostering the change initiative.

Another important contribution in the organizational change literature was contributed by Kaufman (1971). Writing on the ability of organizations to change, Kaufman provided observations similar to Kirton and Burns and Stalker. He identified three important considerations: 1) the inertia against change due to established power structures, giving rise to 2) calculated opposition to change, and 3) the mental or physical inability to adopt the change. While Kaufman's propositions suggest highly selfish motives which retard the rate of change, Rogers (2003) cited numerous examples of organizational and social change that took incredibly long periods of time to occur. Rogers attributed such resistance to change as naturally occurring in humans, based on deeply held beliefs, biases, and prejudices; similar to Kuhn's (1962) observations of the difficulty of scientists to even perceive empirical evidence which differed from their expectations.

The well-reasoned resistance to change is a common thread throughout organizational behavior research, as evidenced by the Burns and Stalker (1961) and Kaufman (1971) observations above (see also, e.g., Hage and Aiken 1967; Hannan and Freeman 1984; Schön 1971; and Tsouderos 1955). Kirton's observation that the originator of a change idea is frequently outside the existing power structure does not imply that the change suggested is necessarily innovative; it is simply different from the prevailing system or process. Should the existing power structure happen to be innovative, a high adaptive change would also be unpopular. In either case this is consistent with organizational change literature's (see e.g., Bennis et al. 1962 and Lippitt et al. 1958) assertion that a facilitator is helpful as suggested by Simmel's (1950) *stranger* and Rogers' (2003) *change agent*. Kirton's (2003) *agent of change* is a slightly different type of change initiator. In contrast to Simmel and Rogers, Kirton views aggressive change agents as being largely responsible for creating the apparent resistance to change that often is experienced. Kirton is quite specific in his critique on the "resistant to change" charge leveled against someone who does not like a particular proposition. He asserts that there is no who one likes all changes and, conversely, there is no one who likes no changes. A-I theory seeks to help people listen without prejudice to a variety of change options and to understand the aspects of cognitive processes which divide and/or unite joint problem solvers. In particular, A-I theory seeks to avoid placing people in out-groups and in-groups during problem solving and decision making exercises.

Kirton (1978a) recalled Drucker's (1969) observation that the objectives of organizations have been to accomplish tasks in ways that were consistent with prevailing norms. Drucker suggested that bureaucrats and managers were highly effective in solving problems within the established policies and procedures acceptable to the predictable functioning of the organization. He also suggested that others may have the "courage to do things differently" (p.50). Kirton (1978a) used this to explain the differences between people who had markedly different approaches to problem solving. From this and his own extensive experience in the difficulty that change initiatives had in gaining acceptance within organizations, Kirton hypothesized that those who preferred problem solving within the prevailing paradigms (Kuhn 1962) and structures of thought were more *adaptive* in problem-solving style. Conversely, he posited that people whose problem-solving preferences were to look outside the existing paradigms and structures preferred more *innovative* problem-solving styles. Kirton (2003) makes a strong argument that the two preferences of cognitive style (problem solving-approaches) actually lie on a continuum, and all, in general, are equally desirable on any given occasion—and all create change. He reasons that particular problems may require problem solvers who are either more adaptive or more innovative in approach, given the nature of the problem.

3. Theoretical Grounding for Psychometric Inventory

Kirton's (1976) theoretical development of linguistic inventory items that would isolate distinct cognitive style preferences was drawn from work of Carl Rogers (1959), Max Weber (1946), and Robert Merton (1957). He built his inventory on the theoretical arguments of these scholars and, via the process of factor analysis, found a high degree of support for a three-factor system.

Rogers (1959) was a scholar of creativity. He described a concept of "the creative loner," but his bias toward the innovator pole of the continuum led him to conflate creativity and the innovative style. High innovators seem to never cease creating ideas. While high adaptors also have the ability to generate many ideas (limited only by level), they appear to more quickly become satisfied as to the sufficiency of their ideas; hence, this factor is called the *sufficiency versus proliferation* (SO) factor. The quantity of ideas does not necessarily equate to quality of ideas, as Rogers might imply. However, the differing propensities for idea generation contribute to adaptors and innovators viewing each other pejoratively according to Kirton (1976). The adaptor is viewed wrongly by the innovator as unwilling to move forward (when they mean: out of the system when it is needed) while the adaptor views the innovator wrongly as unwilling to stop even for a little while (when they mean, in, for them, unlikely directions – at alarming speed); e.g., Kirton (1994) captured the essence of this different perspective as, "…the innovator claims that the adaptor originates with a finger on the stop button. The adaptor, in turn, sees the innovator as an originator who cannot find such a button" (p.25).

The second factor (E) evolved from Weber's (1946) work on the purpose of bureaucratic structure, improving efficiency, precision, and reliability. This is obviously focused on the adaptive pole in the A-I continuum. Innovation is usually anything but what we traditionally consider to be "efficient." It often is disruptive and causes delays and unreliable circumstances—at least at first. It is of course, more efficient in breaking out of the current system, while not necessarily solving <u>this</u> problem.

The third factor (R) is labeled rule/group conformity. This is similar to Merton's observation of bureaucratic structure as that which, "… exerts a constant pressure on officials to be methodical, prudent, disciplined … [and to attain]…an unusual degree of conformity" (Merton 1957:198). Kirton observed that high adaptors seem to respond as predicted and appropriately in this environment, while high innovators appear to be more immune to these pressures. Whyte's (1956) *Organization Man* exemplifies this factor.

A weakness of the adaptor is that he may stay within the existing systems and structures for problem solving when the problem demands different thinking. Merton

(1957:198) paints a clear picture of what Kirton (1976) called a pathologically inappropriate response:

> Trained incapacity refers to that state of affairs in which one's abilities function as inadequacies or blind spots. Actions based upon training and skills which have been successfully applied in the past may result in inappropriate responses under changed conditions. An inadequate flexibility in the application of skills, will, in a changing milieu result in more or less serious maladjustments.

Alternatively, the innovator behaves in ways that include higher degrees of risk and, consequently, is often viewed as threatening to the prevailing and acceptable problem-solving approaches (Kirton 1976).

4. Cognitive Schema and A-I Theory

Kirton, a cognitive psychologist, developed a cognitive schema between the years he first introduced A-I theory in 1976 and the publication of his seminal work in 2003. Cognitive psychology is concerned with the study of thinking processes. It is metaphorical and representational in that it attempts to define how the human organism perceives external stimuli, processes it, and activates a response. Kirton (2003) conceptualized cognitive functioning as composed of three independent but closely connected parts: cognitive *affect*, cognitive *effect*, and cognitive *resource*.

Cognitive affect is the gate-keeper for sorting through all external stimuli and, based on *motive*, determines what information will be accepted and processed and what the thinker needs and wants. Motive is determined by subjective needs, values, attitudes, and beliefs. Cognitive affect is the means by which the human organism apprehends *opportunity* in the external environment. Motive and opportunity are two important variables that influence human behavior. Motive is contained within the human subjective experience, while opportunity is external to the person and represents the environment in which the human exists.

Cognitive effect is the function through which behavior is manifest and is composed of cognitive level (how good-*capacity*) and cognitive style (in what way-*preferred manner*). An individual who is required to work outside his preferred cognitive style can do so for short periods of time at a cost, increasing with amount over time, through coping behavior. However, over long periods of time (with decreasing gain and motive) the individual who is working outside his preferred style will seek to leave the environment (Kirton and de Ciantis 1994). This has been demonstrated by research in climate theory where, through the process of "attraction, selection, and attrition," groups of people in organizations evolve to become isomorphic (see e.g., DiMaggio and Powel 1983; Kirton and McCarthy 1988; Schneider 1987 and Schneider et al. 1995). In A-I theory, this means high innovators will dislike highly adaptive environments, and high adaptors will be uncomfortable in highly innovative environments. Those with modest adaption or innovation scores will be wary of either extreme. See Figure I-1 in Chapter I for further descriptive information of adaptors and innovators.

Cognitive resource is the third aspect of the human brain. It is the repository for all learning, skills development, and knowledge accumulated by the person in his history. Cognitive resource stores coping techniques, which the individual develops through life.

An important aspect of A-I theory is Kirton's (1994) assertion that cognitive style and cognitive level are independent—not correlated. Kirton (1976) hypothesized the orthogonality of style and level in his initial work, but offered no proof. Since then, this has been corroborated by independent research (see e.g., Kirton 1978b; Torrance and Horng

1980; and Kirton and de Ciantis 1986). There are high-level adaptors who have made great contributions; e.g., Edison exhibited all the characteristics of a high adaptor and was a brilliant (high-level) inventor who was quoted as saying, “My principal business consists of giving commercial value to the brilliant, but misdirected, ideas of others” (Jablokow 2007). Similarly, there are high innovators who have made their own contributions; e.g., Nikola Tesla was considered eccentric and was less methodical or concerned with detail. However, his ideas were often ahead of his time, and some have proved to have high commercial value, such as the hydropower generator and guided missiles (Jablokow 2007).

Kirton (2003), consistent with earlier British philosophers Locke, Berkeley, and Hume, accepts the *tabula rasa* theory; i.e., that all people begin life with a blank mental slate. Thus, everyone begins life on the same footing relative to stored knowledge. This is consistent with Berger and Luckmann (1967) and Searle (1995), who contend that all learning is a social construct. Also, mankind, unlike all other animals in creation, does not possess instinct[4]—rather, he must learn all necessary survival information (Jones 1999 and Kirton 2003). The fact that each human has a unique life journey, which ensures that he views the world differently from anyone else, is important in A-I theory. This contributes to the diversity which is manifest in Problem B. Consequently, problem- solving style preference is of keen importance to human understanding.

Problem-solving style is, indeed, an aspect of personality that appears to be deeply ingrained within the psyche or personality development of individuals. Adaptors and innovators may have comparable cognitive capacity but quite different cognitive style preferences, and vice versa.

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[4] Instinct, in this usage, is strictly defined. Lower animals have differing degrees of pre-programmed determinism to do certain things at certain times, [perhaps] always triggered by specific stimuli, e.g., a specific climate or age change.

Some research has shown that there are biological differences between individuals which explain different behaviors that Kirton has termed more *adaptive* versus more *innovative* in problem-solving styles (van der Molen 1994). Citing work done by Cloninger (1986 and 1987), van der Molen reported how naturally occurring monoamine neuromodulators dopamine and norepinephrine have been measured in individuals in ways which support the argument that cognitive style is an inherited trait. This provides independent support for the argument that cognitive style is enduring through life and is consistent with test-retest experiments which have shown little variation over time. These findings led Italian KAI researcher Prato Previde (1984) to suggest that the concept (cognitive style) may be more deeply embedded in the psyche than culture (Kirton 1994).

5. Kirton's Psychometric Inventory

Kirton's (1976) psychometric inventory was developed over many years following his work on *Management Initiative* (1961). He resists attempts to call his instrument a test as being too threatening and misleading since tests are more commonly associated with level measurements. Likewise he resists attempts to call his instrument a survey as being too trivial. He prefers the more precise term *KAI Inventory* to characterize his instrument.[5]

A mock-up of the KAI Inventory (without the control item) is shown in Appendix B. The actual instrument is paper with carbon-back duplicate that makes for ease of scoring. Kirton's five-point Likert measurement instrument contained 33 items that are summed to yield a total KAI score. Since 32 items are scored (omitting control), they, therefore, produce a minimum score of 32 and a maximum score of 160, with a theoretical mean of 96. Kirton identified behavioral characteristics of people who scored fewer points on his inventory more

[5] Kirton made this comment during my KAI Certification Course in December 2006.

adaptive and those who scored more points more *innovative* in their preferred cognitive style as described above. His original work found that members of his research sample closely approximated a normal distribution around a mean of 95.33, nearly the exact theoretical mean. His work has been extensively tested and used in different cultures and languages, and large populations have produced means of 95, male means of 98, and female means of 91. The practical range of scores runs from 45 to 145, and the standard deviation is approximately 18.

Based on the items contained within the instrument, Kirton was able to conduct factor analyses and ultimately found three principal components that related to the typologies theorized by Rogers (1959) (SO-sufficiency versus proliferation of ideas), Weber (1946) (E-precision, reliability, efficiency), and Merton (1957:198) (R-rule-group conformity), as mentioned above. Kirton (1994) noted that these three factors (traits) were internally stable and reliable. He suggested that the three traits may also be viewed on the continuum by mathematically standardizing the three trait scores. If these three subscores exceed a certain degree of variance between what standardized expectations would predict, some interpretation may be required. Kirton and others have found that it is uncommon for these standardized scores to vary significantly on the adaptor-innovator continuum.

Kirton's (1976) original work was subjected to considerable test-retest reliability analyses. His initial validation sample (N=532) achieved an internal reliability coefficient of .88 using the Kuder-Richardson Formula 20, which accounted for 78% of the internal variance. He performed a replication sample test one year later and the K-R 20 was again .88. Cronbach Alpha coefficients were also calculated, which produced reliability of .88. Since Kirton's early work, over 7,000 KAI Inventories have been conducted in 12 countries using several different languages, which have yielded internal reliability scores of .79 to .91 (Kirton 1999).

Several additional studies have been performed for the purpose of comparing the KAI Inventory with other measures (see e.g., De Ciantis 1987; Goldsmith 1985; Goldsmith and Matherly 1986; Hammond 1986; Keller and Holland 1978; Mulligan and Martin 1980; Prato Previde 1984; and Pulvino 1979). The studies referenced were factor studies of the consistency of Kirton's KAI Inventory items. They included different population samples from the UK, USA, New Zealand, Ireland, and Italy. The average across all studies of all the items falling into the same factor as the original Kirton (1976) study was 83 percent, a finding that supports the stability of the underlying factor structure of the KAI inventory items. The KAI Inventory is widely held as a highly validated and reliable instrument (Jablokow 2005).

Construct validity is a consideration of whether the inventory actually measures what it intends to measure. Since the time of its inception, the KAI Inventory has been included in nearly 300 chapters in books or journal articles and has been employed in almost 100 higher-degree theses or dissertations. There have been no recorded incidents of problems by administrators who have used the inventory. Kirton has attributed the high construct validity, in part, to the fact that the factorial study indicated a high correlation with theoretical work by Merton (1957), Rogers (1959), and Weber (1946)— which was the basis of Kirton's original theory building, if not the genesis of the idea (Kirton 1999:30).

A good psychometric instrument should discriminate, meaning scores should be spread, the mean should appear near the theoretical mean, and extreme scores are rare. The reported range of responses is 45 to 145 and the scores distribute normally about the mean.

This means that two-thirds of the population falls within one standard deviation of the mean. All these factors contribute to support KAI as a well-conceived psychometric inventory.

One of the factors which may contribute to the success of the KAI Inventory may be the certification requirement for administrators of the measure. The course in question is five days in length and requires considerable reading preparation and a personal interview with Kirton himself. The certification course concludes with an approximately 50-item examination which covers the theoretical development of the measure, proper administration of the measure, feedback instruction on the inventory, and scoring information.

6. Problem Solving, Creativity, Level, and Style

A-I theory holds that all humans solve problems and are, therefore, creative (Kirton 2003). Humans solve problems with differing styles and with differing levels of cognitive function. As simple as these two sentences appear, they require some elaboration for complete understanding.

Problem solving, according to Gagné (1965), is the eighth, or top, hierarchy of learning types. Learning theory, in which Gagné is a significant contributor, contributes to A-I theory in its explication of the accumulation of learning. Gagné identified the following stages or hierarchies of learning (pp.33-57):

> -**Type 1-Signal Learning**: This may be thought of as learning that occurs as a reflexive (or emotional) response to some stimuli. For example, an air jet to the eye which is closely preceded by a sound will, over several repetitions, result in signal learning where the sound alone will produce the eye blink even without the subsequent air jet. This is referred to as S—R link
> -**Type 2-Stimulus-Response Learning**: This type of learning includes more thought processes than the Type 1 learning. The external stimulus creates a mental signal which then stimulates a response. These stimulus-response cognitions are what Skinner (1938) called a discriminant operant. This is referred to as Ss$\longrightarrow$ R link.

-**Type 3-Chaining**: This is a common occurrence in learning situations. It simply involves a series of two or more Ss $\longrightarrow$ R links. Language study provides an example of this type of learning; e.g., horse and buggy, boy and girl, love and marriage. The first name in a sequence gives rise to a second, etc.

-**Type 4-Verbal Association**: This is an extension of Type 3 but involves a number of chains which are contiguous in time with the next; i.e., contiguity is necessary for learning. This is most effective in learning when it occurs on a single occasion.

-**Type 5-Multiple Discrimination**: This means that the human has many chains which have been learned about various topics and retained in separate registers for future recall. They have been discriminated for appropriate use when needed.

-**Type 6: Concept Learning**: This is dependent on internal neural processes of representation. Gagné used the comparative analysis as a description of this learning type in which prior learning must be called upon to discriminate between alternative choices.

-**Type 7: Principle Learning**: Formally, principle learning is a chain of two or more concepts. It could be termed a relationship between concepts.

-**Type 8: Problem Solving**: The highest level of learning depends on all the lower levels of learning. All humans must grow to this level of learning through the earlier steps or hierarchies. Gagné defined four conditions which must be satisfied for this type of learning to occur:

1. The learner must be able to identify the essential features of the response that will be the solution before he arrives at it.
2. Relevant principles, which have previously been learned, are recalled.
3. The recalled principles are combined so that a new principle emerges and is learned.
4. The individual steps involved in problem solving may be many, and therefore the entire act may take some time. Gagné (1965) observed, “Nevertheless, it seems evident that the solution is arrived at ‘suddenly,’ in a ‘flash of insight.’”

Gagné offered a description of *conditions* which must exist for each type of learning to occur. He identified four conditions of learning under **Type 8: Problem Solving**. It is similar to the findings of other scholars of problem solving—an *illumination* following search and processing. For example, Wallas (1926) defined a process of thought that contained four distinct steps (pp.79-80):

1. Preparation-directed thought and compilation of extant information.
2. Incubation-non-directed thought, relaxation of body and mind away from the problem to be solved, thereby allowing the subconscious mind the freedom to explore and work on the problem.
3. Illumination-the “ah ha” moment that the problem solution appears readily available to the problem solver.
4. Verification-in the scientific world, this means observing the degree of congruence between the asserted solution and empirical application results.

Wallas’ description of problem solving is remarkably similar to the Poincaré (1914) four aspects of problem solving: 1) search, 2) gestation and diversion, 3) illumination, and 4) verification. And Helmholtz (1896) much earlier offered similar phases of problem solving: an initial investigatory stage, the rest and recovery stage, the stage of illumination or the “ah ha experience.” Gagné’s conditions pursuant to problem solving (the highest form of learning) are an ordered process in much the same way as all eight levels in his hierarchy for learning.

The consistent findings of an illumination or “ah ha” experience in the study of problem solving raises the question of the relationship of creativity, level, style, and their influence on problem solving. Eysenck (1995) devoted considerable attention to the subject and voiced considerable disagreement with Sir Francis Galton’s (1869) position that eminence and genius are somehow the same and are appropriately represented by the normal curve. The normal curve may adequately represent the distribution of intelligence but not of eminence, according to Eysenck. Eysenck cited many cases of high IQ children who achieve modest success in life. Also, true genius is quite rare. See Figure II-1 for Eysenck’s formulation that includes three important classes of variables important to this discussion[6]:

[6] See Eysenck (1995:39) Fig. 1.4: Creative achievement is a multiplicative function of cognitive, environmental and personality variables.

Figure II-1 Eysenck's Model of Creative Achievement

Variable Classes	Variable Components	Outcomes
Cognitive Variables	Intelligence Knowledge Technical Skills Special Talent	Creative Achievement
Environmental Variables	Political-religious Factors Cultural Factors Socio-economic & Educational Factors	
Personality Variables	Internal motivation Confidence Non-conformity	

Eysenck went to great lengths to differentiate "true" creative achievement and "average" achievement. Clearly, he holds the bar of creative achievement very high for special recognition. In his approach, only those whose achievement can be rated as *great* by *experts in the field* can be called creative. Most people will never reach the pantheons of intellectual genius sufficient to satisfy Eysenck's definition. Conversely, A-I theory views all people as problem solvers and, hence, creative but at different levels and with different styles. Therefore, Kirton's (2003) emphasis on the great mass, 99% of the population, should offer more hope for future human understanding than the fixation on the elusive 1% that has so consumed the likes of Eysenck.

Figure II-1 indicates three classes of variables which interact multiplicatively (synergistically) for creative achievement, according to Eysenck. He shows cognitive variables and personality variables as two different classes of variables. Kirton would argue that personality is part of the cognitive self. However, it is noteworthy to observe that Eysenck places non-conformity in the personality variables. Non-conformity could be considered a form of problem-solving style, perhaps tending toward the innovative end of the continuum. Eysenck places intelligence (or IQ) in a different variable class. This is consistent with Kirton's assertion that level (e.g., IQ) and style (e.g., KAI) are independent. Clearly they interact to contribute to problem solving, as both Kirton and Eysenck proposed. Eysenck's model has some of the attributes of Kirton's cognitive schema, including external environment providing opportunity, internal motivation helping decide which external stimuli to address, and the combination of cognitive level, resource, and style to manifest creative achievement or what Kirton called *behavior*.

Eysenck (1995) also offered a provisional theory for consideration that illuminated creative achievement and processes that contribute to it. His theory included ten points that are informative to this inquiry and will be presented for consideration (pp.81-82):

1. All cognitive endeavors require new associations to be made, or old ones to be reviewed.
2. There are marked differences between individuals in the *speed* with which associations are formed.
3. Speed in the formation of associations is the foundation of individual differences in intelligence.
4. Only a sub-sample of associations is relevant in a given problem.
5. Individuals differ in the *range* of associations considered in problem solving.
6. Wideness of range is the foundation of individual differences in creativity.
7. Wideness of range is, in principle, independent of speed of forming associations, suggesting that *intelligence* and *creativity* are essentially independent.
8. However, speed of forming associations leads to *faster learning*, and hence to a greater number of elements with which to form associations.
9. The range of associations considered for problem solving is so wide that a critical evaluation is needed (comparator) to eliminate unsuitable associations.
10. Genuine creativity requires:
    a) A large pool of elements to form associations.
    b) Speed in providing associations, and
    c) A well-functioning comparator to eliminate false solutions.

[The emphasis (italics) in Eysenck's 10 items were Eysenck's]

Figure II-2 Components of Learning

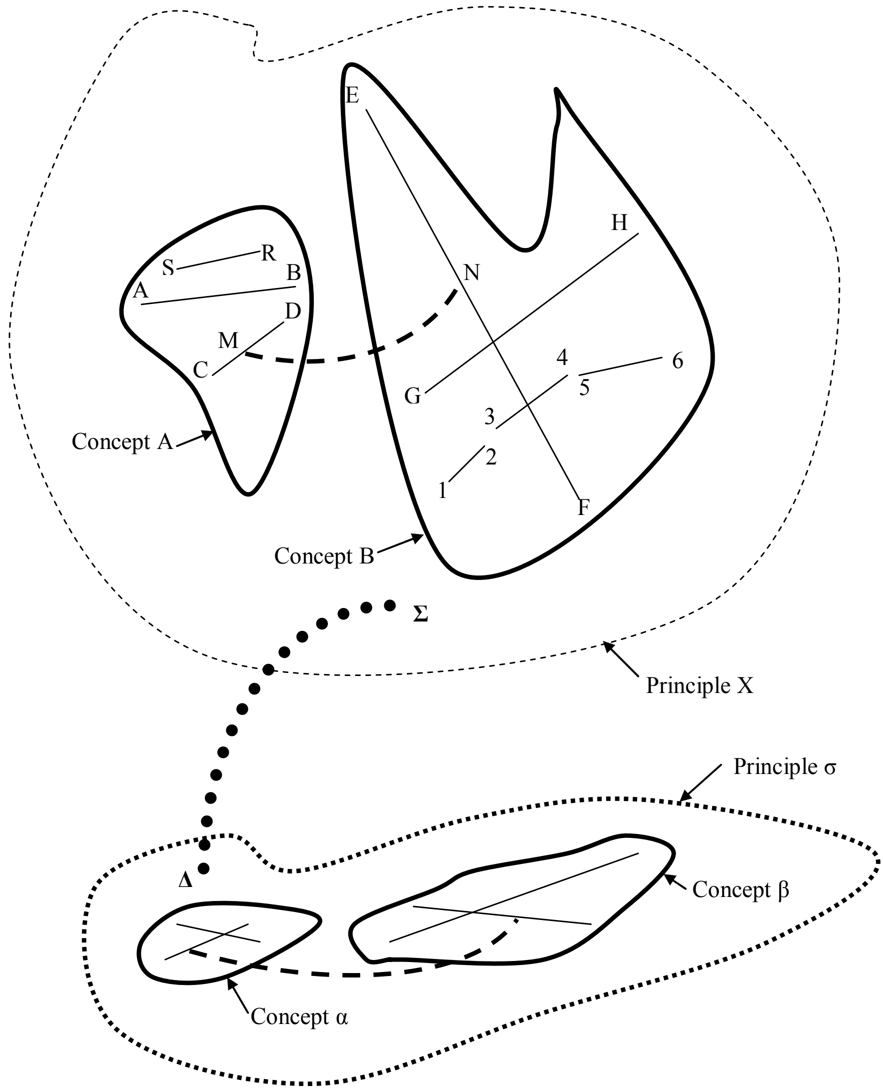


Figure II-2 is an illustrative representation of thought processes that integrates Gagné's (1965) learning theory and Eysenck's (1995) theory of creative achievement. I created this figure to help facilitate a visual conceptualization of the material presented earlier in this section. The terms used are taken from Gagné and Eysenck and for purposes of simplification I will italicize the specific terms used from those sources. Inside *Concept A* there are many *S—R* learned bits and *Ss—R* learned bits. Many of these are *chained*; i.e., A—

B represents a series of *Ss—R* bits which are related and sequentially stored. These are called *chains*. *Chains* are combined and stored in our cognitive resource in ways which allow our brains to retrieve them for useful purposes.

This process, called *multiple discrimination* simply means that the cognitive resource catalogs *chains* in ways that allow them to maintain separate elements of memory and be accessible at times when they are called upon.

A *group*, or *block of chains* which are related, forms an important part of *concept learning*; e.g., *Concept A* in Figure II-2 is composed of a number of *blocks* which Gagné asserted are used in groups of three such that the middle *block* is considered *in comparison* with the first and third *block*. Two or more *concepts* which are *chained* form *principle learning*; e.g., *Principle X* shown above represents *Concept A* and *Concept B chained* by *association M-N*. I am using the term *association* in the sense proposed by Eysenck (1995), presented earlier. Eysenck asserted that creative achievement was an outcome largely dependent on the speed with which individuals form *associations* during the process of *problem solving*. He posited that individual differences in intelligence (level) were manifest by the speed of *association* formation. However, all people problem solve by a process of *associations* and, by Eysenck's definition, are *creative* (at different levels).

Gagné placed *problem solving* at the highest level of his learning hierarchy. *Problem solving* requires the ability to recall previously learned *principles* whose antecedents are necessarily hierarchical in order of learning. Figure II-2 depicts two *Principles*, X and σ, which are linked by *association* Δ-Σ. *Problem solving*, according to Gagné, requires the recollection of learned *principles* which are combined (*associated*) in ways that a new *principle* is determined. The discovery of a new *principle* through the process of *problem* *solving* may involve many steps and take some time. By all accounts, this process may be called creative, whether by Gagné, Eysenck, Poincaré, or Helmholtz—all four of whom acknowledged the "ah ha" experience that accompanies the act of problem solving. Kirton (2003) would add the possibility that creativity manifest in problem solving may range between largely adaptive to largely innovative. Note that in Eysenck's (1995) ten point theory, item seven asserts that intelligence and creativity are independent. This partially supports Kirton's (2003) view that level, style, and creativity are all independent.

Jablokow (2008) has made the largest application of A-I theory in the development and implementation of a three-course sequence for engineering graduate students at the Pennsylvania State University's Great Valley School for Graduate Professional Studies. It is now also being converted into distance learning mode. She, like her mentor Kirton, makes great distinction between such terms as creativity and innovation in her courses on problem-solving leadership. One can be creative in different ways; i.e., from adaptively creative to innovatively creative—and all points in between. One can be creative while being high level or while being low level in cognitive capacity (IQ) or manifest knowledge. Finally, Jablokow offered her summary version of A-I theory (p.939):

> In summary: all humans are creative and solve problems, at different levels and with different styles, driven by different motives, and exposed to different opportunities (which they also view differently). In problem solving, we must—at a minimum—manage this individual diversity in order to manage change; to manage wider change, we must manage wider social diversity (i.e., that of the group) as well.

For a useful definition of creativity in this fashion, I will accept Kirton's (2003) simple statement, "… the generation and resolution of novelty." Jablokow (2008) extends this thinking to the definition of problem solving, "…the act of bridging a gap (of cognition and resource) between 'what you have' and 'what you want or need,' with variations in how (and where—as in ‘which discipline’) that occurs encompassed in the four key variables[7] described above” (p.938).

7. The Paradox of Structure and Kuhnian Science

Kelly (1963) theorized a psychology of personal constructs wherein he described the human brain as operating through a vast network of pathways. He said, “The network is flexible and is frequently modified, but it is structured and it both facilitates and restricts a person’s range of action.” Kirton (2003) employed similar logic in the development of A-I theory in his concept of the *paradox of structure*. Structure is, at the same time, enabling and limiting—similar to Kelly’s theory. It clearly sets forth the bounds of known solution regions and is, therefore, enabling for problem solvers. However, by definition, it also sets forth a limit of acceptable problem solutions; thus, the paradox of structure. Again, Figure II-2 may be used to illustrate this and Kuhn’s (1962) explanation of scientific discoveries. Principle X may be said to represent a region in scientific exploration. There are some known facts in this region represented, e.g., by Concept A and Concept B. There are, however, many unanswered questions inside region X, which, using Kuhn’s description, are called *residual puzzles*. Kuhn used the word *paradigm* to describe a prevailing scientific body of knowledge. He provided examples of the difficulty scientists have in resolving *anomalies*—answers outside the expectation of scientists. Some anomalies are residual puzzles; i.e., questions which will be ultimately answered within the prevailing scientific paradigm (Region (Principle) X in the current example). But, some anomalies may never be resolved inside Region X. They will require a paradigm-breaking discovery. The anomalies may be resolved by the emergence of a new Region; e.g., Region (Principle) σ in Figure II-2. Region σ

[7] The four key variables mentioned herein are opportunity, motive, level, and style (p. 938).

provides a new scientific arena for scientific exploration and will attract more research until a new paradigm-breaking discovery is made. Practically speaking, the invention of the airplane did not make the automobile obsolete, nor did the invention of the automobile make the horse and carriage obsolete. But the new paradigms did dramatically change the degree of use of the older technologies in specific situations. There is conflict, however, in the progression of science. Jablokow (2005), an engineering educator, termed it, "…the catalytic nature of science," using the chemical definition of effecting decomposition, dissolution, or release. Similarly, *catalyze* means to produce fundamental change in or transpose. This is at the heart of individual, group, or organizational resistance to learning (change): those most resistant to change are those that perceive the change to be detrimental to their position of power and prestige, are usually those who have the most invested in the existing paradigm.

Kirton (2003) suggested that high adaptors would be most likely to favor solving residual puzzles or working within the existing paradigm – or at least on the edges of it. Conversely, high innovators would be more likely to seek solutions outside the existing paradigm. The paradox of structure is enabling for both the adaptors and the innovators just as it is restricting to them both. Again, refer to Table I-1 for descriptions of preferred behaviors of adaptors and innovators that illuminate this discussion.

8. Decision Making and Group Problem Solving

The issue of problem solving was discussed earlier from the perspective of an individual. There is not a clear distinction between problem solving and decision making at an individual level of analysis. However, when considering any form of collective decision making or group problem solving, there are special considerations which come into play.

Kirton (2003) makes clear his purpose is to help resolve Problem B; i.e., in the management of diversity which has been central to the foregoing development. This means that when two or more people come together to problem solve, the first problem which must be solved is the fact that the individuals have uniquely different perspectives on virtually everything.

There has been a democratization of decision making in the last 80 years which is exemplified by Bernard's (1938) early assertion that executives were the sole purveyor of decision making in organizations, to the present time when work "groups and teams are ubiquitous in organizations" and which function to make collective decisions about product design, customer service, and a host of other decisions (Devine et al. 1999). Devine et al. provided a typology of teams in organizations that include dimension, purpose, and temporal; i.e., team size, team mission, and intact versus ad hoc. In contrast to Bernard's early description of decision making in organizations, Devine et al. concluded that the typical team performs multiple tasks, employs consensus in decision making, has a formal leader, operates non-hierarchically as a peer group, and is moderately diverse with regard to age and gender.

Devine (1999) asked an important question, "Do groups of experts with diverse backgrounds make decisions that reflect the sum of their collective knowledge?" (p.608). From the perspective of city and regional planning, this has been a major point of emphasis for decades, the answer of which produced Lindblom's (1959) *disjointed incrementalism*. Janis (1972) argued that highly cohesive groups can become more interested in group cohesion than discovering truth, an outcome he dubbed *groupthink*. Devine asserted that group conflict was constructive if handled properly—in agreement with Kirton, except that *debate* is preferred as less costly than *conflict*. Devine said cognitive conflict was about differences over the best way to achieve a group goal or objective. Kirton would agree but would include both *cognitive level* and *cognitive style* in his explanation of types and sources of conflict. Devine said affective conflict is personal and directed at others in the group. Kirton would call this *cognitive affect* conflict, but would generally agree that in the region of affect lie values and belief systems that are deeply ingrained and often intractable. Devine called cognitive conflict (cognitive style and level) strategic and suggested that it has the potential to increase the sharing of unique information and, thereby, increase the quality of decision making. Conversely, cognitive affect conflict is interpersonal and is destructive in decision making. This is consistent with accepted knowledge about the way emotion clouds decision making (which was Weber's (1946) central argument in advancing bureaucracy as the most perfect form of administration or decision making). Dialectical inquiry and devil's advocacy are two methods of inducing cognitive style (and level) conflict into debate leading to the management of cognitive diversity and on to solving of problems.

9. Synthesis and Extensions

From the beginning of this exposition I have focused on the important prerequisite of improving organizational decision making—*improving small group problem solving*. I have also shown from Gagné's (1965) work in learning theory that problem solving is the highest level of <u>learning</u> for Homo sapiens. And, I have classified the amalgamation of three to 20 people as a *small group*—the elemental decision unit in organizations (Harris and Sherblom 2005). If, as de Geus (1988) asserts, the only competitive advantage future companies have is the ability to <u>learn</u> faster than their competition, helping small groups maximize their problem solving ability may be the most important thing companies can do with their employees. In point of fact, Kirton (2003) said "problem solving is the key to life," and that in this ever changing world man must constantly deal with change in order to survive. Adaption-Innovation is the preferred cognitive style with which a person approaches problem solving and is, therefore, an important building block to achieve this research's ultimate goal—*improving organizational decision making*. The frame of reference for this study is organizations (irrespective of the fact that the unit of analysis is "small groups"). Important considerations stemming from organizational research and theorizing must be highlighted.

I noted that Roethlisberger and Dixon's (1939) ground breaking empirical work revealed that formal organizational rules, policies, and procedures only partly explain actual observed behavior which was described as informal organizational practices or tacit rules, policies, and procedures. March and Simon (1958) observed that organizational change (behavior) may be actively influenced or directed by either individual learning or by changing the specific rules that must be adhered to. They described this from a psychological perspective as follows: "Empirically, it appears that changes in the total content of the memory take place relatively slowly through the processes generally called learning." And behavior changes may be created, "…by bringing about changes in the memory content (learning), or by changing the active determiners of current behavior (evocation)" (p.29). This argument was simply that organizations could teach actors new information (and thereby achieve behavior outcomes desired) and/or provide behavioral constraints such that actors must make certain decisions in given circumstances. This view failed to acknowledge the well accepted fact that there is gap in congruence between formal organization and informal organization which became the central focus of latter-day behavioralists (see, e.g., Argyris 1957, Likert 1967, and McGregor 1960). The degree of gap is an indication of the degree to which organization members are psychologically integrated into the value system and mission of the organization. I would argue that the degree of congruence in question may be approximated by the difference between ad hoc group problem solving and intact group problem solving when both are solving non-role preferred, non-trivial problems.

March and Simon (1958), in the previous paragraph, rightfully acknowledged the importance of rules, policies, and procedures which manifest the values of an organization. Earlier, Simon (1947) defined organizational members as "boundedly rational actors" to emphasize the limited cognitive capacity for group members to understand all alternatives, know all consequences of actions, and have a well ordered preference of choices. Kirton's (1994 and 2003) paradox of structure provides a conceptual explanation of the boundedly rational actor who is, at once, enabled to problem solve within the established boundaries, and limited to the range of possible solutions by those boundaries themselves. If behavior change (different organizational outcomes) is desired, it logically follows that the rules, policies, and procedures defining the boundaries must be moved. I consider it the province of the sovereign (in organizations the board of directors and its delegate the chief executive officer) to modify the values from which the rules, policies, and procedures derive. Thus, that is outside the scope of this study. But once those rules, policies, and procedures are set, the question of conveying that information to the membership becomes paramount, as March and Simon noted above. How might that best be achieved in context of this research?

Overstreet's (1925) optimistic assertion of the "Creative Plus" points to small groups as the source of great potential. Since Roethlisberger and Dixon's *Management and the Worker*, the small work group has been viewed as the fundamental unit for study. And, as Harris and Sherblom (2005) observe, most organizations are today substantially run by small groups of people, it naturally follows that an emphasis on helping small groups learn faster is a worthy focus of study. I make an important distinction here between in-group and out-group classes of small groups; i.e., within organizations small groups are considered in-group and I have called these intact groups. Out-groups are not members of the organization and I have called them ad hoc groups.

I have amplified much of Kirton's (1976, 1994, and 2003) A-I theory in order to establish the valuable contribution it offers for improving problem solving in groups. In addition, I have recalled some important aspects of organizations because organizations matter in very important ways. Overlapping these two pieces of scholarship will enable me to investigate the important question about how organizations may learn faster—*the only sustainable advantage that companies of the future may rely upon* (Schein 1993).

Hammerschmidt (1996) and Scott (2007) have shown that appropriate consideration of individual problem-solving styles of members constituting problem-solving groups can make statistically significant impacts in the direction A-I theory predicts. They performed their experiments with ad hoc groups. I propose to employ the same experimental test within an organization using intact group subjects in contrast to the earlier work.

10. Summary and Hypotheses for Testing

I will summarize the essence of my exposition for the purpose of bringing all key concepts to the same location. All people are problem solvers and, hence, creative, but using different styles (KAI) and at different levels (e.g., IQ) (Goldsmith 1994 and Kirton 2003). Most problems in organizations are today solved by groups or teams (Devine et al. 1999 and Harris and Sherblom 2005). The problem about which the team is formed is called Problem

A, and the problem which arises in trying to manage the different people trying to solve a problem is Problem B. Most of the time and resources should be invested in Problem A and not Problem B.

People have problem-solving style preferences which may be located along a bi-polar continuum between high adaptors and high innovators (see Figure I-1). High adaptors prefer to work safely inside existing rules and structures. High innovators have less regard for existing rules and structures. High adaptors and high innovators view each other somewhat pejoratively (see Table I-1).

Cognitive style (adaptor versus innovator) is independent of cognitive level. Creativity may be manifest as adaptive or innovative regarding cognitive style. People may be creative high adaptors (Edison) or creative high innovators (Tesla) (Jablokow 2007 and Kirton 1978b).

Each person is unique in his mental representation of reality which is shaped by socialization (Berger and Luckmann 1967). Homo sapiens enjoy no instinct and, consequently, must learn all necessary information for problem solving and decision making in group contexts (which is at the heart of Problem B) (Jones 1999 and Kirton 2003).

The paradox of structure enables problems to be solved but restricts the range of problems which might be solved at the same time. The more adaptive differ from the more innovative in resolving this paradox. The former are more trusting of the limits and tighten them in making “better” changes. The more innovative are more wary of the limits and tend to loosen them in order to get different solutions (Drucker 1969 and Kirton 2003).

Individuals arrive at problem solving via opportunities in the external environment (either created or happened upon) and, depending on motive, tackle problems using their particular style and aided by their level and accumulated wisdom in memory (Jablokow and Booth 2006 and Jablokow 2008).

Lastly, with improved understanding of Problem B, we may achieve what Overstreet (1925) called the "Creative Plus," meaning the group performed better than the sum of the individuals.

My essential interest is helping improve group problem solving and, in turn, improve organizational decision-making outcomes. Recall my three objectives shown earlier:

1. To what degree may group problem-solving outcomes be improved by judicious selection of group membership based on cognitive style preference?
2. To what degree do intact groups outperform ad hoc groups in solving problems which are outside the groups' problem-solving style preference as measured by group mean KAI scores?
3. To what degree do members of an intact organization modulate preferred problem solving style behavior to cope with fellow organization members?

I will answer these research questions by conducting a controlled experiment in an organizational setting. The following hypotheses will be tested by the experiment:

- H1: Intact groups will perform better at problem solving than ad hoc groups, *ceteris paribus*.
- H2: Intact groups will perform better at problem solving even when performing non-role preferred tasks in comparison to ad hoc groups performing role-preferred tasks—*for limited duration tasks*.
- H3: The degree of congruence between formal organization and informal organization may be approximated by the degree to which intact groups out perform ad hoc groups on the same tasks.

Chapter III will present a description of the context into which the experiment will be introduced, a discussion of the experiment, expectations of the findings, and both limitations and potential generalizations of the results.

Chapter III Experimentation Procedures and Methods

1. Context and Controls for Experiment

I will conduct an experiment using subjects from professional services organizations who routinely work in teams or groups during the execution of their daily work. The subjects to which this experiment will be applied are technical professionals and, consequently, will be above average problem solvers in their respective domains. The teams that are assembled are knowledgeable of each others' basic abilities and integrity as a result of being employed at the same place of business and as a result of knowing the standards of qualifications that exist at that business. Consequently, groups formed will be considered *intact* for this study, while in their daily work they may not serve in the same subteam inside the organization.

Kirton (2003) asserts that the size of groups for problem solving should be that required by the problem; however, there are two dimensions of importance in this assertion: 1) the number of group members and 2) the range of KAI scores. I will focus my experimental setup based on the number of group members and will, therefore, hold the group size constant. Each subteam in the proposed experiment will consist of four people. That will effectively control for the size element of group problem solving. The subteams will be set according to dimension number two; i.e., I will compose the subteams based on the KAI scores.

In city and regional planning exercises, facilitators often spend considerable time on the "values" question as described above. Since the frame of reference of this research is within an organizational context the question of values determination is somewhat more easily established; i.e., as noted in the last chapter, the sovereign is assumed to have already established the values from which the rules, policies, and procedures derive. However, values' conflicts still persist in organizations—note the formal and informal organization discussion earlier. In an effort to control for the potential confounding effect of values' conflicts, I have selected a value neutral problem for the experiment.

The experiment selected for this research comes from the fields of human relations, leadership training, organization development, and communications, and has previously been used for studies involving A-I theory (Hammerschmidt 1996 and Scott 2007).

2. The Hollow Square: A Communications Experiment

The Hollow Square (Pfeiffer and Jones 1974) experiment requires two subteams to collaborate for the purpose of solving a puzzle. A planning subteam has 25 minutes to determine how to teach an implementation team to assemble the puzzle and to teach the implementation team. The implementation team has 25 minutes to solve the puzzle. After the planning team has completed its instruction to the implementation team, it may provide no additional instruction. Each subteam will conduct its work in rooms that are separated except for the instruction period. Proctors will observe the subgroups during the work process but will not be permitted to answer any questions or give advice. A full copy of the Hollow Square: A Communications Experiment is in Appendix A.

3. Group Identification

All subjects will initially be grouped together to complete the KAI Inventory. Additional information will be collected at that time pertaining to time in the organization, work unit in the organization, and position in the organization. During the initial assembly of the subjects, there will be no explanation of A-I theory to avoid biasing effects.

I will follow Hammerschmidt's (1996) general process of manipulating the makeup of subteams based on KAI scores. Hammerschmidt composed his subteams using the definition of homogeneous where the KAI score range was less than 20 points. He also defined "relatively more or less adaptive or innovative" as the basis for subgroup formation with the breakpoint between the two at 15.7 points. These definitions, however, were based on his range of KAI scores from his participants and could vary in different settings.

The outcome to be measured will be the percentage of total teams (meaning two subteams collaborating to solve the puzzle) which solved the puzzle in the prescribed time limit. I will deviate from Hammerschmidt during the subteam assembly and the subteam role assignment to investigate the particular psychological influence ("integrating" influence consistent with Argyris (1957), Likert (1967) and McGregor (1960)), and the organization has for its members. (See also Hayward and Everett 1983; Kirton et al. 1991; Kirton and deCiantis 1994; and Kirton and McCarthy 1988.)

For this research, two team types will be established. The first will be the same as Hammerschmidt's category two which will be used as a control for the experiment. The second will be the same as Hammerschmidt's category four. The difference, in both cases, is that subjects are part of an ongoing organization; i.e., intact groups. The following team arrangement will be tested[8]:

1) Dissimilar subteams with adaptive planning subteams and innovative implementation subteams.
2) Dissimilar subteams with innovative planning subteams and adaptive implementation subteams.

4. Analysis Methods and Expectations

Difference of means tests will be analyzed, based on number of teams which successfully completed the puzzle in the prescribed time. I will use all the prior findings by Hammerschmidt (1996) and Scott (2007) for ad hoc success rates, since both used ad hoc teams. I will compare those data with all findings for intact groups. Additionally, I will compare Hammerschmidt's findings for the cases shown above with the findings on intact groups this research will yield. All these data will enable me to test hypothesis H1: Intact groups will perform better at problem solving than ad hoc groups, *ceteris paribus*.

Difference of means tests will be conducted on findings from this research on the two team arrangements listed above in order to test the remaining hypotheses. Based on A-I theory, combined with prior research, I would expect the two teams to produce the following relative results:

Intact teams which are working in role-preferred tasks should perform better than ad hoc teams also working in role-preferred tasks. In the Hollow-Square Experiment that means that adaptive planners and innovative implementers will be working on tasks more

[8] Notwithstanding Hammerschmidt's definition of similar and dissimilar subteams and his definition of homogeneous KAI score subteam make-up, the final definition of these terms must follow the collection of KAI scores on the participants in this experiment.

compatible with their preferred problem-solving style. The average KAI subteam scores will be what Hammerschmidt called "dissimilar" for both classes of experiments. This means there will be wider KAI score diversity between subteams working together; i.e., the mean KAI score of the planner subteam will be very different from the mean KAI score of the implementer subteam. This poses a serious communications challenge between the two subteams working together to solve a single problem. I would expect that communications' problem to be more pronounced in ad hoc groups than intact groups. This is consistent with small group research which asserts a time dependent evolution of group functioning which is based on personal integration with the group (Tuckman 1965 and Fisher 1970).

The second team arrangement proposed for this research was based on the worst performing category reported in Hammerschmidt's research. My proposition is that intact groups will have sufficient individual motivation for cooperation that they will perform well even outside their preferred problem solving style for relatively brief periods. This is premised on the assumption that organizations provide an integrating influence—which some have called a psychological atmosphere or climate which could be said to be the degree of separation (gap) between the formal organization and the information (see, e.g., Kirton and deCiantis 1994; Kirton and McCarthy 1988; Lewin, et al. 1939; Schneider 1975, 1983b, 1987 and 1990).

Each subteam will be observed by proctors during the experiments. Each participant will be identified by code-name tag such that comments, behaviors, and participation levels may be attributed to someone according to KAI score. Also, following the completion of the exercise a short structured questionnaire will be administered which will ask for impressions as to each subject's role satisfaction, comfort or discomfort with the exercise, attitudes toward other participants, and appropriateness of the time permitted for the exercise. These findings will be compiled for qualitative evaluation of A-I theory as it is applied in this experiment. The Post Exercise Impressions questionnaire is shown in Appendix D. This feedback will add important qualitative findings that will illuminate the personal motivation and degrees of coping that would be predicted in A-I theory.

5. Threats and Generalizations

A-I theory holds that individuals can function satisfactorily outside their preferred problem-solving style for relatively long periods of time through the process of coping behavior. In this research, there is a relatively short period of time allocated for the experiment. While Hammerschmidt (1996) found statistically significant differences in the expected directions for adaptors and innovators, the short time of the experiment is a threat to the findings. However, I am purposefully composing subteams in non-preferred role tasks so as to magnify the influence of style on performance.

A-I theory views motivation as an important variable which, when presented with opportunity, determines the degree of interest and effort an individual will invest in problem solving (generation of and resolution of novelty). This presents the researchers with a precautionary thought; i.e., participants should not become too interested in competition against other teams. This means that the introduction and instructions provided in this exercise should eschew competition and emphasize collaborative participation. Consequently, a strict outline of information and instructions will be administered for all participants with minimal variation across offices or firms. Subjects will be invited to participate in a communications exercise as part of a research project for a doctoral student in the City & Regional Planning Department at UNC Chapel Hill. There will be no compensation for participants, and the exercise will be conducted outside regular work hours for the volunteers.

The experiment chosen for this research involves the solution of a puzzle of geometrical shapes which combine to form a 12-inch square with a two-inch square hole in its center. By virtue of the puzzle being geometrical, there is the threat of bias toward subjects which have more cognitive resource developed in the area of spatial relationships. As a method of control for this threat, I will ask the participants to indicate their preference for directions; i.e., would you prefer a map or written directions? This will serve as a proxy for and a possible indication of spatial intelligence.

A-I theory holds that the management of diversity is of critical importance in today's complex society in order to facilitate sufficient and appropriate change to help society survive. Simply put, that means methods for optimal solution of Problem B need to be developed and communicated. Within an organizational context there is great need to become a "learning organization," consistent with the earlier de Geus (1988) assertion. If the findings of A-I theory can be combined with organizational theory concerning formal and informal organization there may be opportunity for accelerating the learning upon which the future of all organizations is based.

Also, as A-I theory becomes more well known there is an opportunity to expand its application usefully into broader settings. Societal problems continue to get more complex and there are opportunities for more adaptive solutions and more innovative solutions depending on the problem.

Chapter IV Implementation, Framing, Literature, and Trials

1. General Issues

This chapter will detail the complete research protocol and provide summary reports of each experiment. This follows the hypotheses presented earlier and culminates in quantitative testing of those hypotheses in Chapter VI. However, the observational methods I used during the experiments and subsequent compilation provided a serendipitous opportunity to add a considerable body of exploratory work which enriches this investigation. Following the presentation of the research protocol I introduce a theoretical framework within which the research will be reported and elucidated. Next I review important empirical research which conflates cognitive style theory and small group behavior. I conclude this chapter with the summary reports of each experiment. I present the exploratory qualitative findings in Chapter V. And, finally I combine the quantitative and qualitative analyses in Chapter VII in an interpretation of these findings and possible implications in various contexts.

2. Implementation

2.1 Overview, IRB, and Plan

This research was conducted in a professional services firm which has multiple offices across several states in the southeast. The firm in question was one that I (principal investigator) co-founded over 30 years ago. My initial submittal to the Institutional Review

Board proposed to camouflage my involvement to prevent any semblance of coercion during solicitation of volunteers for the experiment. During the Institutional Review Board approval process the IRB chairman and I discussed the potential ethical dilemma that proposal created. Following a lengthy discussion of the culture of the company and its use of other psychometric instruments (e.g., MBTI) the chairman of the IRB suggested the only practical solution would be for my involvement to be completely visible. Consequently I informed all participants of my personal involvement during the solicitation process. I sent an email message to all host company employees in any office which had more than eight people (the desired number required to comprise a complete testing unit). That email is shown in Appendix E and lists “Research Opportunity” in the subject line. The official invitation letter shown in Appendix F was attached to the email. The official invitation was sent in late August 2009.

The original plan for conducting the experiment called for three meetings: 1) an introductory meeting during which the subjects would be administered the KAI Inventory and supply some additional information, 2) the actual experiment, and 3) a debriefing meeting. All the meetings were proposed to be held during the lunch hour at the various participating offices. I had proposed that the initial meeting would not be a lunch-provided meeting due to its shorter length. However, after initial tepid response to my invitation I offered to buy lunch for those participating in the initial meetings as well. The initial meeting included a very brief introduction to my work included in a scripted message which set forth the plan for all the meetings, including lunch. Because two of my colleagues assisted in the experiment I wanted to narrow the possible variation of information provided to the volunteers. The introductory scrip is shown in Appendix G and was used during all the initial meetings. The IRB Consent Form is also included in Appendix G. The initial meetings were conducted beginning in early September 2009 and concluded on November 16, 2009.

2.2 Data Compilation and Team Formation

Between November 16 and November 30 all subject information was processed for the purpose of making team assignments. Each participating office was considered a statistical unit for subteam assembly. The KAI total score for each participant was recorded and the subjects were rank-ordered from lowest to highest KAI score by office. The median was used as a cut point and all subjects with KAI scores below the cut point were assigned to the more adaptive group while subjects with KAI scores above the cut point were assigned to the more innovative group. A simple random-number generator was used to help make random assignment of subteams from the two groups (more adaptive versus more innovative). The subteams were then paired with sister subteams; i.e., a more adaptive subteam was paired with a more innovative subteam. The two subteams would combine to be a testing unit—what I called a "Trial" for this research. I computed the standard deviation of the testing unit and, to the extent possible, assembled Trial units with subteams mean KAI scores greater than one and one half standard deviations apart. This was my definition of "different" subteams from the perspective of mean KAI scores.

The Hollow-Square experiment, as I have presented it, calls for four-person subteams, one relatively more adaptive and one relatively more innovative. I compiled each subteam of four participants. Unfortunately, due to scheduling difficulties there were some absentees on the days the trials were conducted in three different offices. That resulted in three trials being conducted with only three-person planning subteams. I will expand more fully on the significance of three-person subteams subsequently.

2.3 De-identification of Subjects and Code Names

Because I had proposed to video record the actual experiments, the IRB required that I take care to protect the identities of participants. I, therefore, "de-identified" the subjects by asking them to assume a given alias during the experiment. In an effort to employ a system that would be revealing to the researchers while not having any pejorative meaning to the subjects I devised the following code naming convention (note that the terms adaptive and innovative relate to the specific measurement of the subjects' KAI total scores):

The relatively more adaptive subteam member code names are:

Abe—the most adaptive of the four subteam members

Bo

Chris

Dale—the least adaptive of the four subteam members

The relatively more innovative subteam member code names are:

Mel—the least innovative of the four subteam members

Nat

Pat

Ray—the most innovative of the four subteam members

2.4 Scheduling and Conducting Experiments

The actual experiments were conducted beginning on December 1 and were concluded on December 18, 2009. Generally the meetings lasted approximately one hour and were usually held during the regular lunch period in each office. There were two exceptions to the lunch schedule arrangement: Fort Myers Trial T1 was held at 7:00 AM on Dec. 1 and Wilmington Trial T1 was held in the late afternoon rather than at lunch due to some scheduling conflicts.

During the actual experiment the total team (all eight participants) would gather briefly and be told they were going to jointly solve a problem. The operations subteam was given a Hollow-Square Operating Team Briefing Sheet and would be sent to another room to prepare for their then unknown assignment. Pizza was served to the operating subteam during the time they were waiting to be summonsed by the planning subteam. There was no indication of variation between offices and trials within offices except for the Fort Myers Trial T1 where the facilitator reported that the participants were anxious to get going to their field assignments. All but one of the participants in the Fort Myers office had to travel by truck to their daily assignments. I will comment further during the specific summary reports concerning Fort Myers Trial T1.

2.5 Video Recording of Experiments

I video recorded the experimental procedure. All of the experiments were recorded with a small digital video recorder called the Flip Video. The Flip Video recorder is ideally suited for field application like this one since it is small (approximately 4”x2”x1/2”) and not very imposing to the participants. All but one of the trials were conducted with the Flip

Video set on a tripod and it appeared that after an initial period of awareness the subjects quickly ignored the camera and went about their business of solving the problem. For 11 of the 12 trials a full hour (or more) of video was captured. This provided the opportunity to record post-experiment comments and/or questions from the participants. The exception to that occurred with the first trial which occurred in Fort Myers. The facilitator held the camera in her hand thinking that would be less obtrusive and objectionable by the participants. Unfortunately that also meant that the facilitator turned the recorder on and off during times she felt appropriate and, consequently, I only have a limited record of that trial.

2.6 Facilitator Variation and Implications

I invited two of my long-time colleagues to assist me during the first two meetings (the initial information gathering meeting and the experiment meeting). Phyllis Elikai is director of human resources and Linda F. Vaughn was a customer services specialist at the host firm (Vaughn has retired from the company since the end of 2009). Both were certificated by Dr. Kirton after completing his week-long course in England in 2007. And, both have been MBTI certified as well. While both of these colleagues were eminently qualified to assist in this work I have noticed some variation of facilitation that occurred during the experiments.

Twelve experiments were conducted over a three-week period in December. Linda Vaughn conducted the initial trial in Fort Myers, Florida. Phyllis Elikai conducted two trials in Charlotte and two trials in Wilmington, North Carolina. And, I conducted two trials in Clearwater, Florida and five trials in Raleigh.

The facilitator's instructions were relatively vague and, consequently, there were a few examples of different interpretations of facilitation which were observed during the review of video. I will comment on specific facilitator actions within each of the summary reports on trials below.

3. Framing

3.1 The Critical Incident Technique

I will employ the critical incident technique for reporting, discussing, and concluding important findings during the qualitative phase of this research. Flanagan (1954) defined the critical incident technique as, "…a set of procedures for collecting direct observations of human behavior in such a way as to facilitate their potential usefulness in solving practical problems and developing broad psychological principles. The critical incident technique outlines procedures for collecting observed incidents having special significance and meeting systematically defined criteria" (p.327). It is noteworthy to observe that this work originated from the field of psychology and is clearly dependent on effective communications to ascribe meaning to events.

3.2 Critical Incident Technique, History, and Development

Flanagan is quite narrow in his definition of "critical," he asserts, "To be critical, an incident must occur in a situation where the purpose or intent of the act seems fairly clear to the observer and where its consequences are sufficiently definite to leave little doubt concerning its effects" (p.327). He traced the roots of the technique back to Sir Frances Galton in the late Nineteenth Century and more recent developments such as time sampling studies of observed activities, controlled observations tests, and some anecdotal records (those “more recent developments” are now roughly 70 years old, hardly recent). The critical event technique actually emerged from the Aviation Psychology Program of the United States Army Air Forces in World War II. In the summer of 1941 the Aviation Psychology Program was created for aiding the selection and evaluation of aircrews.

The first studies concerned themselves with failures during training of aviators. Over 1000 pilots were eliminated from the training program and studies were attempted which would help explain the causes. Their findings revealed that the observers used clichés and stereotypes that were not particularly helpful. However, there were some helpful observations which became the basis for selecting pilot candidates. But, the need for a more rigorous procedure for assessing factual incidents was evident from this study. The second study, which emphasized factual observations made by competent observers, was performed in the winter of 1943-1944. This came from reports on bombing missions and focused on those missions which were deemed failures. Again, these reports left critical information out and further research and study was called for.

During the summer of 1944 a series of studies was conducted on combat leadership in the US Army Air Forces. These were the first large-scale systematic studies of their type. The study identified specific incidents of both effective and ineffective behaviors with respect to specific missions. The researchers asked the combat veterans to, “…report incidents observed by them that involved behavior which was especially helpful or inadequate in accomplishing the assigned mission” (p.328). Several thousand incidents were recorded and analyzed in an effort to make an objective definition of the critical requirements of combat leadership. These several reports became the foundation of the critical incident technique.

Flanagan and a coauthor conducted the first application of the critical incident techniques in an industrial setting under the auspices of the American Institute for Research in 1949 (Miller and Flanagan 1950). This research project was to determine the critical job requirements for the hourly employees for the Delco-Remy Division of the General Motors Corporation. Foremen participated in a committee to develop employee review procedures and, in concert with other foremen in the company, collected 2,500 critical incidents in interviews. Based on this information, a form was developed for the purpose of recording incidents on a daily basis to aid in assessing job performance. Three groups of foremen were asked to fill out the form concerning hourly employee performance for a two-week period. One group of 24 foremen filled the form out daily. A second group of 24 foremen filled the form out at the end of each one-week period. The third group of 24 foremen filled out the form at the end of the two week period. The number of critical incidents reported by the three groups was surprising: the daily reports yielded 315 critical events; the weekly reports yielded 155 critical events, and the two-week report yielded only 63 critical incidents. Miller and Flanagan (1950) summarized this to mean that the foremen reporting weekly only remembered about 50% of the incidents and the bi-weekly reporting foremen apparently forgot roughly 80% of the critical events observed. The thrust of this observation was that the delay in observation and recording should be minimized in order to achieve best results. (In my research program, as will be further discussed, I avoid some of the problem of selective memory by use of video recording of group exercises.) These data were used by the researchers to develop tests for selecting employees based on both aptitude and attitude factors. Although the early application of the critical incident technique was geared toward finding people who were psychologically compatible with different job types, this has useful application in the field of small group decision making, particularly if there is a known goal or objective about which the group is deliberating.

Flanagan (1954) presented the critical incident technique not as a rigid set of rules but, rather, a set of principles which are flexible and should be adapted to the context in which the technique is being applied. He emphasized that only simple types of judgments should be employed by the observer and that the observer should be competent. Also, the communicative acts upon which the observer is rendering judgments should be based on a clear statement of the purpose of the activity; i.e., the goal of the deliberation. He opined, “In the absence of an adequate theory of human behavior, this step [classification of critical incidents] is usually an inductive one and is relatively subjective. Once a classification system has been developed for any given type of critical incidents, a fairly satisfactory degree of objectivity can be achieved in placing the incidents in the defined categories” (p.335) [my comment]. Flanagan called the critical incident technique *inductive* when applied in absence of an adequate theory. The technique is also applicable, but in a deductive sense, if a theory of human behavior is employed as in this research.

Flanagan (1954) provided five steps in the application of critical incident technique. I have briefly listed his proposed steps and followed his words with specific application of this technique to my research. The important elements of the technique are:

1. Determination of the general aim of the activity. In this research project the general aim of the group interaction is for providing solutions to solve the Hollow-Square puzzle in a prescribed fashion.
2. Development of plans and specifications for collecting factual incidents regarding the activity. The observers need clear directions as to what they are reporting. Critical

events are those communicative acts, both verbal or non-verbal, which represent relatively extreme behavior and which are either markedly effective or markedly ineffective regarding attainment of the goal—solving the puzzle. Plans and specifications for recording information include pertinent information about the persons, place, context, and other relevant information as may be available. Each critical incident will have to be judged as to its relevance to the goal attainment—both positively and negatively—and to its importance in attaining the goal.

3. Collection of the data. In my research many of the challenges which Flanagan warned about are circumvented by virtue of the recording the entire activity by video camera. And, I extracted important information from the video recordings which were deemed critical incidents. [There are exceptions which will be obvious to the reader which I have included for illustrative purposes].

4. Analysis of the data. This is to efficiently organize and describe the data so as to be easy to extract objective information. Again, this step is made much simpler due to the application of video technology. I will report important information on two levels; e.g., general communicative content later in this chapter and critical incidents content and causal attributes in Chapter V.

5. Interpretation and reporting of the statement of the requirements of the activity. I will finally synthesize the critical incidents that contributed to the team outcome in my final chapter and rate aspects of those incidents as to degree of influence on the outcome.

4. Research Interest *Redux*

My research interest focuses on improving group problem-solving outcomes and since most important decisions are made in small groups this is quite inclusive as to context (Harris and Sherblom 2005). I have posited that judicious application of cognitive style theory in selecting group members may contribute directly to improved outcomes. And, I have posited that intact groups will out perform ad hoc groups, *ceteris paribus*. These propositions are contained in my hypotheses and the results of hypothesis testing will be presented in Chapter VI. But, hypothesis testing is somewhat terse. However, my methods (video recording the proceedings) have afforded me the opportunity to include qualitative observations which are beyond my original hypothesis formulation. This additional richness and quality of material can be enhanced by selective additional review of empirical research involving cognitive psychology and where cognitive style fits inside that umbrella. Also, some additional discussion about small group behavior with respect to cognitive style should add depth to the subsequent presentation of group interaction.

5. Cognitive Psychology's Emergence

5.1 Scholarship and Schemas

This research program has been based on Kirton's (1976) Adaption-Innovation theory to the exclusion of other work in the field of cognitive psychology. This section will identify the major fields of psychology scholarship, discuss reasons for cognitive psychology's relative importance, and discuss two examples of cognitive schema.

5.2 Four Schools of Scientific Psychology

The four major "schools" which dominate scientific psychology are psychoanalysis, behaviorism, cognitive psychology, and neuroscience. Robins et al. (1999) investigated the relative interest in these four schools by developing an indicator of prominence based on subject matter analysis in the four flagship journals in each of the four schools, the subject matter analysis in dissertations, and the frequency of citations from each of the four schools. The study interval was from 1950 to 1997.

Journal articles on cognitive psychology have increased by about .39 percentage points per year ($p<.01$) and articles on behavioral psychology have decreased by .13 percentage points per year ($p<.01$). While these are not large, they have prevailed over 48 years and are, therefore, significant. The number of cognitive psychology articles has more than quintupled from 1950 to 1997; from three percent to 17%. Behavioral psychology has gone the other direction from an average of six percent of journal articles in 1950 to half that amount in 1997. Neuroscience and psychoanalysis trends are much weaker essentially suggesting no real change. Both these schools have averaged less than two percent of articles in the flagship journals. The striking observation from the graphical presentation is the rate of growth in cognitive school articles from the early 1960s to the mid 1970s.

Dissertations spawned in each of the four schools show a surprisingly similar trend. At the beginning of the study period the behavioral school was responsible for nearly 11% of dissertations and cognitive school dissertations accounted for about five percent. Both the psychoanalytic and neuroscientific schools accounted for less than one percent. At the end of the 48 year study period the cognitive school accounted for about 10% while all three other schools converged to approximately one percent of the dissertations. The cognitive school increased dramatically between the mid 1960s and the mid 1970s and appears to have plateaued at the 10% level.

The number of citations per year for each of the four schools revealed similar finding with behavioral school dominating the others at the beginning of the study but gradually giving way to the cognitive school and since the late 1970s the cognitive school has continued to climb while the behavioral school has plateaued at about one-fifth of the number of citations for the cognitive school. The psychoanalytic school showed very few citations over the entire length of the study. The neuroscientific school grew slightly from about 40 citations per year to about 50 at the end of the period.

These data strongly suggest that cognitive psychology has emerged as the most prominent of the four schools, clearly overtaking the behavioral school since the 1970s. The rate of increase in cognitive psychology has been attributed to the 1956 symposium on information theory; e.g., Gardner (1985) considered that symposium the birth of the cognitive psychology *revolution* [Gardner's term]. The rapid rise of electronic data processing about which the 1956 symposium was centered has certainly been a revolution, an assertion few would argue. The compelling parallel between the emergence of interest in cognitive psychology and the computer may well be because of the metaphorical model the computer provides for cognitive psychologists; i.e., "Computers provided scientists with a new metaphor for conceptualizing how the mind works, one based on information processing and associated concepts of storage, retrieval, computational operations" (Robins et al. 1999:124). I will present two examples of cognitive schemas which demonstrate the conceptual connection between how computers work and how the human brain works.

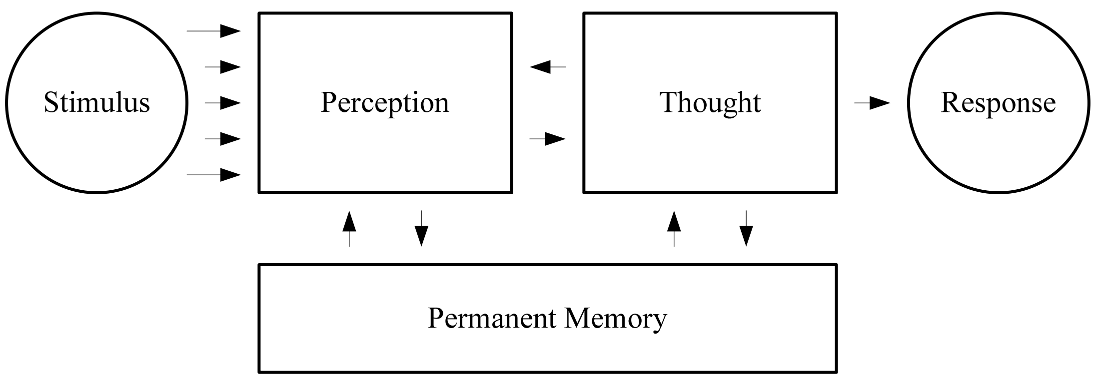
5.3 Cognitive Schemas

Cognitive psychology is concerned about the way humans perceive stimulus information, process that information, and respond appropriately. And, since each person constructs her own unique perspective of reality through their life journey the definition of "appropriately" is subject to wide variation except for rarest of occurrences (Berger and Luckmann 1967). This is the principal difference between cognition in humans and information processing in computers. The same input data will produce the same output findings with computers—consistently. This is hardly so across different people. In fact, it is hardly so with the same people at different times of their lives depending on affective states. In order to conceptualize these processes cognition scholars have proposed cognitive schemas which depict elements of the processes. These elements help narrow the range of study so as to focus on a few enduring individual differences which may be measured in an attempt to advance a model of human behavior.

Miller (1987) offered an information processing model of cognition for the purpose of studying the implication of cognitive style on education. His model is shown in Figure IV-1.

Miller acknowledged that his deconstruction of cognition into three parts was arbitrary. His three-component classification of human cognition provides a useful description for the sub-processes which contribute to the total. Figure IV-2 shows Miller's proposed component breakdown of the three major elements of his model.

Figure IV-1 Miller's Information Processing Model of Cognition (p.252)



I find Miller's review of the cognitive style literature illuminating and synergistic with the earlier work reported from Kirton (1976, 1994, and 2003; and Kirton et al.1991). It should be noted at the outset that Miller is a "two-category" system advocate. He quoted Nickerson et al. (1985:50) who said, "…the view that there are two qualitatively different types of thinking is widely shared. Among the terms used to describe one type are analytic, deductive, rigorous, constrained, convergent, formal, and critical. Representative of the terms used to describe the other type are synthetic, inductive, expansive, unconstrained, divergent, informal, diffuse, and creative. No doubt the partitioning of thinking into two types involves something of an over-simplification but possibly a useful one".

Miller asserted that the cognitive style dimensions shown in Figure IV-2 can be subsumed into a superordinate stylistic difference or dichotomy which he called an analytic-holistic difference. It is useful to discuss the elements shown in Figure IV-2 as they are part of the story of cognitive psychology and its subset cognitive style. The following review was summarized from Miller (1987).

Figure IV-2 Cognition Components and Attributes

Cognitive Function	What	How	Cognitive Style Dimensions
Perception	Pattern recognition Attention	Part/whole relations Selective attention	Leveling v. Sharpening Field Articulation
Memory	Representation Organization Retrieval	Memory codes Conceptual networks Search strategies	Analytic v. Analog Conceptual Complexity Convergent v. Divergent
Thought	Inductive reasoning	Classification Analogical reasoning Judgment	Serial v. Holistic Tight v. Loose Actuarial v. Intuitive

Pattern recognition is a part of the cognitive process called perception. There are two main theories about how raw stimuli are compared to data stored in memory: feature analysis and prototype matching (Moates and Schumacher 1980). Feature analysis is an analytic technique which investigates component parts. Conversely, prototype matching is considered much more holistic. Prototype matching involves comparing stored templates in memory with external stimuli for recognition and understanding. Miller suggested that these two approaches in processing stimuli appear to be different cognitive styles. With respect to perception he asserted that the two style differences *leveling v. sharpening* and *field articulation* were "individual differences" of pattern recognition and attention respectively.

The cognitive style commonly known as *leveling-sharpening* is similar to the analytic and holistic differences in pattern recognition (Gardner et al. 1959; Klein 1970; and Santostefano 1978). The favored measure of leveling-sharpening is the Schematizing Test which requires subjects to view sequential projections of a series of different size squares onto a screen. Levelers appear to lag behind the mental exercise by not recalling the sizes of the previous squares and, therefore having difficulty discerning differences. Sharpeners, conversely, are keenly attentive to the changing sizes of the sequential images projected and do a much better job at keeping up with the changes. Miller (1987) opined that it was reasonable to infer that the analytic orientation of the sharpeners could be construed to be a preference for feature analysis. On the other hand, levelers were said to be more oriented to prefer prototype matching according to Miller.

Attention is a basic term to mean the process by which the human focuses on some particular stimuli versus others. Anderson (1980) and Glass and Holyoak (1986) identified two channels of attention: 1) conscious and 2) subconscious. The conscious level (which Miller called the 'executive') handles stimuli and sorts the relevant and less relevant storing each to an appropriate location in the brain. The executive is an active manager of stimuli rendering judgments based on preconditioning. The subconscious (which Miller called 'automatic') is a superficial level of attention but, upon some trigger in the consciousness, the executive will be summons into action. Glass and Holyoak (1986) said that a shift of attention occurs when *automatic* signals the executive. These two types of attention could be said to be individual differences where executive attention reflects an ability to focus on important tasks at hand while automatic attention could be said to be less able to focus on tasks at hand—ignoring what he may assume to be unimportant stimuli.

There are two cognitive styles which appear to represent stable individual differences vis-à-vis attention. These are “field dependence-independence” (Witkin et al. 1979 and Witkin and Goodenough 1981) and “constricted-flexible control” (Gardner et al. 1959). The methods used for these measures are tests of ability to disembed items from an organized selection which involves distracting cues (e.g., the Rod and Frame test and the Embedded Figures test are typically used for this purpose). After additional work in this area of study, Gardner et al. (1959) concluded that both these might be included into a concept they termed “field articulation” (p.255). High articulators manifest greater ability to analyze or articulate stimuli by focusing attention on only the portions of the images which are part of the instructions and ignoring the distracting and contradictory cues. Conversely, low articulators are more influenced by non-important or non-salient information. Low articulators attempt to keep their cognitive ordering of stimuli as simple as possible and only focus on the most significant cues (Garner et al. 1959).

Individual differences in how information is stored in memory may be viewed as how it is “represented, organized, and retrieved” (Miller 1987:256). Representation of information stored in memory has commonly been classified as being coded verbally (analytic) and/or visually (analogue). Most of the work in cognitive style as it relates to memory coding by verbal or visual differences is located in hemispheric specialization research (Bradshaw and Nettleton 1983; Ornstein 1972; Springer and Deutsch 1981; and Zenhausern 1979). However, in spite of the linkage between hemisphere theory and verbal-visual dichotomy, Bradshaw and Nettleton (1983) suggest that the analytic-holistic descriptor seems more fundamental. Miller contends this observation is consistent with his own suggesting, "…that verbal codes facilitate analytical processing while analogue codes facilitate holistic processing" (p.257). Others have independently found support for Miller's proposition (see e.g., Riding and Anstey 1982; Riding and Ashmore 1980; and Riding and Calvey 1981). Riding and his colleagues have found consistently that "verbalizers" (verbal) are relatively slower processing information of a visual nature than are "imagers" (visual) and imagers are relatively slower processing verbal information than are verbalizers.

The manner in which information is stored in memory may be called *organization*. Tulving (1985) argued for a three-part interconnected/interacting subdivision of permanent memory systems that he called "episodic, semantic, and procedural" (p.257). Tulving defined this memory system as, "…a set of correlated processes: Processes within a system are more closely related to one another than they are to processes outside the system" (p.386). Procedural is the foundational level upon which semantic is based. Procedural memory is based on stimulus-response learning, chaining, and multiple chains. Tulving called procedural memory system anoetic (nonknowing) consciousness. The semantic memory system was termed the noetic (knowing) consciousness. It is the system that concerns itself with storing information about the internal and external world. Tulving called the objective of the noetic consciousness the accumulation of knowledge about the world. Episodic memory system is related to the autonoetic consciousness. This means that the individual has "self-knowing." Semantic memory is the Tulving aspect of memory which Miller has taken for his schema element memory.

Individual differences in the way information is organized in memory have been demonstrated by Chi et al. (1982) and Voss et al. (1983). Chi et al. (1982) conducted experiments using experts and novices solving physics problems. There were clear differences between the experts and novices along the line that has been called cognitive complexity versus cognitive simplicity. Novices performed less well than experts in integrating a wide array of physics principles in setting up the problem solution. Novices worked on superficial and unconnected facets of the problem whereas experts integrated the various problem elements into interconnected categories for the purpose of facilitating a solution. Bieri et al. (1966) and Harvey et al. (1961) have called the cognitive complexity-simplicity dichotomy a fundamental difference between people.

The concept of accessing stored information from the brain may be called retrieval. There are at least two different forms of information encoding which influence brain functions. Miller called these *styles* and said they might be considered individual differences. Tulving (1985) considered semantic memory as being composed of multiple conceptual networks. Therefore, retrieval may be regarded as a search, "…through the hypothetical pathways of the mind" (Howard 1983). Miller called the cognitive style in memory retrieval strategies convergence-divergence. The convergence-divergence dichotomy has been used for wider application in cognitive psychology. Guilford (1967) views, "…convergent retrieval strategies as narrow, deductive, logical, and using sharper search criteria; while divergent strategies are broad and associational rather than logical and use vague search criteria" (p.260). Kogan (1983) suggested that people who exhibit a marked divergent cognitive style tend more toward "ideational fluency and spontaneous flexibility than do convergers".

The third part of Miller's cognitive schema is *thought*. This portion of cognitive function deals with orchestrating response to selected stimuli. Directed thought may be called "reasoning." Economists consider the case in decision making (or rationality) where complete information is known, clear options for choice are understood, and a well ordered preference of choices is available. They term this utility maximization and it obviously fails to meet practical and reasonable expectations. Decisions made under this set of assumptions would be called, deductive reasoning. This is rarely the case in real decision scenarios; e.g., this realization gave rise to Simon's (1947) term *satisficing*. Conversely, most decisions are made with incomplete information, limited time for contemplation, and lack of well ordered preference for choice; i.e., the consequence of each choice is rarely known ahead of time. Decisions made under these circumstances are called *inductive reasoning*. Miller said that stylistic differences had been experimentally investigated concerning inductive reasoning. He identified three types of inductive reasoning subsumed under thought: 1) classification, 2) analogical reasoning, and 3) judgment. I will briefly discuss each of the three and connect them to cognitive style.

Classification is a way information is acquired, considered, and codified with respect to learning or decision making processes. Work by Glass and Holyoak (1986) have shown individual differences in hypothesis formation and testing. They observed that different kinds of hypotheses lead to different ways of categorizing observations. Several researchers have worked in this area but there are no commonly accepted terms relating to individual differences with respect to classification. Pask (1976) identified two distinctive approaches to classification. He called a serialist as one which considers one hypothesis at a time before moving to the next. On the other pole, he called a holist as one who considers multiple hypotheses simultaneously. Miller (1987) captures the spirit of Pask's suggestion, "In both sets of research the distinction being made is between an orientation in which the individual prefers to move systematically through the task, making sure that the situation is absolutely clear before moving on so that there are no loose ends that require later attention and, an orientation in which ambiguity is tolerated and solutions to the problem of classification are expected to crystallize slowly from a matrix of hypotheses" (p.261). This fits the name serial versus holistic in cognitive style regarding classification preferences.

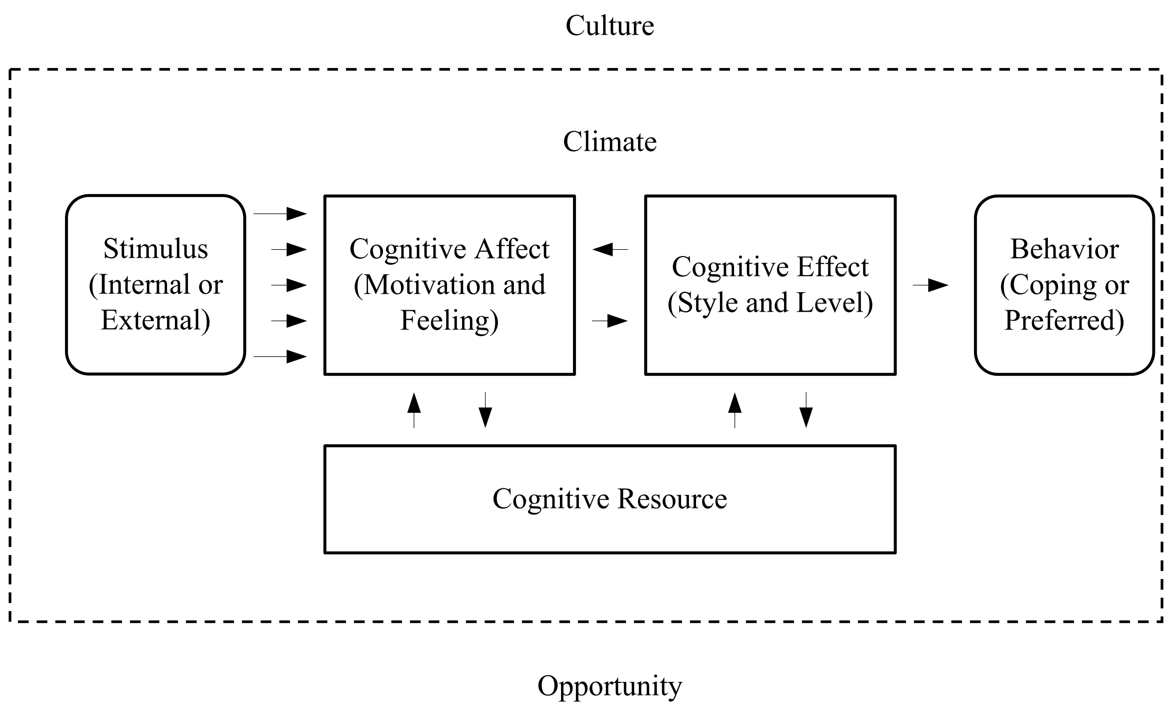
Analogical reasoning is the second of three facets or subdivisions within Miller's classificatory system for the cognitive function called thought. It is considered important in everyday life and especially in sciences and arts (Holyoak 1984). Sternberg (1977) has identified four "necessary stages": encoding, inferring, mapping, and application. Other studies and propositions have been made for this distinction. In particular, there has been some discussion about metaphor and its use in science. The logical positivists (analytic style) reject the use of metaphor. Miller concluded that there was a stylistic dimension which is distinct enough to be considered an individual difference which contrasts a preference for "tight, formal, literal analogies with that for loose, informal, deep (metaphoric) analogies" (p.262). This is abbreviated as tight versus loose.

The third facet of the thought portion of Miller's cognitive schema is *judgment.* The distinction used for judgment as an individual difference in the cognitive style scholarship are that some prefer to judge based on probabilistic estimates of "if-then" decision chains while others use a reference point process, basing a decision on known standards. This has been called actuarial (logical) versus intuitive (reference point) reasoning.

I am struck by the similarity of terms used in Miller's proposed cognitive schema and the earlier work by Kirton. Kirton also proposed a cognitive schema but his was more encompassing than was Miller's. I have adapted Kirton's schema into a graphical representation following Miller's approach and will use it to contrast the two. Figure IV-3 shows my adaptation of Kirton's schema showing Miller's influence.

I should note that Miller (1987) made no attempt to imply that his model could be used as a general model to explain human decision making, unlike Kirton (2003). I have employed Miller's (1987) block model to Kirton's description of cognition. I have placed the human actor inside an organization (consistent with my initial proposition this organization is any group, committee, company, or other psychologically organizing unity). This organization influence on the human I have called climate after Lewin et al. (1939) and others. Likewise, I have placed the organization (as indicated by the dashed line surrounding the human actor) inside something called culture. Culture is generally considered more deeply seated and basic and certainly would influence organizational entities in different ways across different parts of the world in different nations (Reichers and Schneider 1990).

Figure IV-3 Adaptation of Kirton's Cognitive Schema



The external environment provides opportunity for human decision making. In some cases the individual proactively creates the opportunity but for the purposes of diagrammatically demonstrating a cognitive schema this is a necessary element. Opportunity, in order to be perceived, must have stimuli. And, stimuli are the data which the human actor process. One important difference between Kirton's and Miller's schema is that the latter acknowledges cognitive style differences in all three compartments of cognition whereas Kirton seems to confine cognitive style into the part of the system he termed cognition effect. Kirton, however, acknowledges that all subparts of cognitive function are interrelated but for observational purposes it is helpful to consider Miller's subsystem within each part.

I have roughly equated Kirton's cognitive affect with Miller's perception. External stimuli may be perceived, processed, or ignored. I would suggest that Miller's deconstruction of perception, pattern recognition as defined by the style continuum 'leveling versus sharpening' and attention as defined by the style continuum 'field articulation' fit reasonably into Kirton's Adaption-Innovation measure. An important component of Kirton's schema which was missing from Miller's is motivation. Motivation stems from cognitive affect (thus emotional content laden) and ranges from very high to nonexistent depending on individual needs, wants, values, and opportunity.

I have roughly equated Kirton's cognitive effect with Miller's thought. In both cases this box is the action center and downstream from this point is manifest behavior. Kirton, unlike Miller, asserts cognitive effect contains two related but orthogonal parts: cognitive style (e.g., KAI Score) and cognitive level (e.g., I.Q.) Others have reported empirical work which supports the independence of style and level (see, e.g., Hayes and Allinson 1994 and Schroder 1994). Miller argued that thought was characterized by inductive reasoning. He offered three facets of inductive reasoning: classification which could be said to be a style of serial versus holistic, analogical reasoning which could be said to be a style of tight versus loose, and judgment which can be said to be a style of actuarial versus intuitive. These style dimensions, as discussed above, are very closely related to descriptive terms contained in Kirton's Adaption-Innovation theory.

Another important difference between Kirton's and Miller's schema is the concept of coping behavior. Kirton argues that behavior consistent with one's preferred cognitive style is natural and easy while required behavior inconsistent with one's preferred style requires coping. It is certainly possible and reasonable to assume people have the capacity for coping behavior; however, over a long period of time coping behavior can have an emotionally draining effect and induce stress (Kirton 2003). Additionally over long periods of time those individuals required to work well outside their stylistic comfort zone will seek to leave the organization (or group) to find comfort (Kirton 1994 and Schneider 1983a).

Cognitive resource, as shown in Figure IV-3, contains all the learned information, both conscious and subconscious, that the individual has accumulated through his life. It clearly equates to Miller's memory although Tulving's (1985) ternary classification concept may not fit neatly into Kirton's cognitive resource. In spite of the possible inconsistency with Tulving's notion of semantic memory used by Miller I think it is useful to indicate the component parts of Miller's schema on memory. The three facets of memory include representation (how information is coded) whose stylistic measure is analytic versus analog, organization (conceptual networks) whose stylistic measure is conceptual complexity, and retrieval (search strategies) whose stylistic measure is convergent versus divergent. Again, these three different measures of cognitive style fit within Kirton's Adaption-Innovation theory quite well.

I have made the effort to depict cognitive schemas and offer some comparative views with Kirton and Miller. Both have made contributions and I view Miller's more elaborate breakdown of cognitive styles within subparts of the cognitive function to be theoretically consistent with Kirton's overall theory of human behavior based on Adaption-Innovation theory.

6. Other Work in Cognitive Style

6.1 General

Research in cognitive style has contributed to better understanding of the way style contributes to how one perceives and relates to stimuli. There are some revealing reports of empirical studies which can add to understanding of cognitive style. This section will offer a review of the confusing number of dimensions of cognitive style. And, it will present important findings based on empirical studies which inform and expand my work.

6.2 Dimensions of Cognitive Style

Hayes and Allinson (1994) presented a chart containing 22 dimensions of cognitive style and suggested that the field was confusing based on too many people working, "…in cheerful disregard of one another" (p.56). In the interest of identifying this scholarship I will present the table showing the information as shown in Hayes and Allinson (1994:pp.58-59). Hayes and Allinson reviewed the cognitive style scholarship for its application in management practice.

Messick (1984), along with Hayes and Allinson (1994) describe abilities (cognitive level) as unipolar; i.e., from a little to a lot where the more you have the better. Conversely, cognitive style is viewed as bipolar; i.e., generally non-pejorative where having a stylistic preference related to one pole does not mean one has no ability to function in the other pole of behavior. Messick differentiates level from style and, like Kirton and others, says they are not related. He offered a typology which included four classes: intellective abilities, stylistic abilities, cognitive controls, and cognitive styles. And, he identified eight "pure stylistic dimensions of cognitive style." These are all contained in Figure IV-3 but he received criticism from Tiedemann (1989) who said it was unclear that these eight dimensions of cognitive style even met his own criteria. However, Hayes and Allinson identified Kirton's (1976) measure of cognitive style that satisfies all of Messick's criteria. I want to call attention to the fact that Hayes and Allinson (1994) collaborated to develop their own

Table IV-1. Dimensions of Cognitive Style (Hayes and Allinson 1994)

Dimension	Description	References
1. Scanning-focusing*	Entails identification of relevant versus irrelevant information in attempting to solve a problem	Schlesinger (1954); Bruner et al. (1956) [Personality theory]
2. Constricted-flexible control*	Constricted control shows more susceptibility to distraction; flexible control is characterized by resistance to interference	Klein (1954) [Motivation]
3. Broad-narrow* (Category width)	Preference for broad categories containing many items, rather than narrow categories containing few items. Broad categorizers tolerate errors of inclusion whereas narrow categorizers tolerate errors of exclusion	Pettigrew (1958); Fillenbaum (1959); Bruner and Tajfel (1961); Kogan and Wallach (1964) [Personality]
4. Analytic-nonanalytic conceptualizing*	Analytic style entails differentiating attributes or qualities. Non-analytic style responses may be more relational or thematic	Kagan et al. (1960); Messick and Kogan (1963); Kagan et al. (1963 and 1964)
5. Leveling-sharpening*	Individual variations in assimilation in memory. The leveler tends to assimilate new stimuli into previous categories and to blur memories, while the sharpener tends to differentiate new information from old, to magnify small differences and to exaggerate changes between present and past	Gardener et al. (1959); Klein (1970)
6. Field dependent-independent*	A global versus analytic way of perceiving. Entails the ability to perceive items without being influenced by the background	Witkin (1976); Goodenough and Oltman (1981);
7. Impulsivity-reflectiveness*	Impulsivity is characterized by quick responses, reflectivity by more deliberate, slower responses. The impulsive person is quicker but makes more errors	Kagan et al. (1964); Kagan (1965)
8. Risk taking-caution*	Risking taking is characterized by taking risks even when the odds for success are poor. Caution is characterized by reluctance to take chances except when the probability of success is great.	Kogan and Wallach (1964)
9. Cognitive complexity-simplicity*	Complexity is the tendency to conceptualize the world in a multidimensional way (characterized in terms of differentiation, discrimination and/or integration). Simplicity is the tendency to conceptualize in a unidimensional way	Kelly (1965); Harvey et al. (1961); Bieri et al. (1966); Driver and Mock (1974) ; Streufert and Nogami (1989)

10. Automization-restructuring	Preference for responding to obvious properties of simple repetitive tasks versus preference for restructuring tasks	Braverman et al. (1964); Tiedemann (1989)
11. Converging-diverging	Convergent thinking leads to a single correct solution using narrow, logical and deductive search criteria whereas divergent thinking is broad and open ended, using broad and associational rather than logical search criteria	Wallach and Kogan (1965); Hudson (1966, 1968); Smithers and Child (1974)
12. Tolerance for incongruous or unrealistic experiences*	Individual willingness to accept perceptions which vary from the conventional experience. Tolerance is characterized by a grater adaption to unusual perceptions. Intolerance is revealed by the demand for more data before the unusual is accepted	Klein et al. (1962)
13. Verbalizer-visualizer	The extent to which people favor verbal or visual strategies when processing information	Paivio (1971); Richardson (1977)
14. Preceptive-receptive/systematic-intuitive*	The inclination to assimilate data into concepts, or precepts, previously held (perceptive) versus the tendency to take in data in raw form (receptive). The inclination to develop clear sequential plans (systematic) versus the tendency to develop ideas freely from data and to skip from the part to the whole (intuitive)	Keen (1973); McKenney and Keen (1974)
15. Serialist-holist	Serialists progress in linear fashion through learning and problem solving material, taking a step by step approach and increasing understanding in small increments. Holistics take a more global approach and quickly lose sight of individual components	Pask and Scott (1972); Pask (1976)
16. Sensing-intuition thinking-feeling	Sensing-intuition reflects a predisposition for information gathering (perceiving): Preference for realities of experience (sensing) versus inferred meanings, possibilities and relationships of experience (intuition). Thinking-feeling reflects a predisposition for information evaluation (judging): Preference for logical order (thinking) versus personal values and emotions (feeling)	Myers and Briggs (1976)
17. Splitters-lumpers	Splitters deal with reality by splitting it into its component parts. They are analytical and obtain information through a series of clearly defined steps. Lumpers prefer to look for the big picture.	Cohen (1967)

18.	Concrete-abstract/ active-reflective	The preference for dealing with tangible objects (concrete) versus theoretical concepts (abstract). The preference for direct participation (active) versus detached observation (reflective)	Kolb (1976, 1984)
19.	Adaptors-innovators	Adaptors turn to conventional procedures when searching for solutions, whereas innovators prefer to restructure problems and approach them from new angles	Kirton (1976, 1977b)
20.	Literal-analytic/ poetic-synthetic	A style which contrasts preference for literal analogies which involve close similarity between the analogous situation and the situation for which a solution is sought with more loose, deep, metaphoric analogies	Kogan (1982); Kogan (1983)
21.	Logical-reference point reasoning	Logical reasoning involves a preference for a systematic approach and an adequate sampling of available data, whereas reference point reasoning involves a preference for reasoning from a specific known case	Rosch (1983)
22.	Reasoning-intuitive/ active-contemplative	The preference for developing understanding through reasoned argument involving the drawing of conclusions from premises (reasoning) versus immediate insight without reasoning (intuitive). The preference for direct participation (active) versus envisaging in the mind what is likely to be (contemplative)	Hayes and Allinson (1988); Allinson and Hayes (1988)

* Hayes and Allinson (1994) attribute these constructs to Nelson as reproduced by Claxton and Ralston (1978).

measure of cognitive style sometime earlier than this work (see e.g., Allinson and Hayes 1988 and Allinson and Hayes 1990). The fact that they cite Kirton's work as noteworthy is significant since they too are scholars in the same field. Additional observations contributed by Hayes and Allinson show that cognitive style can be an important factor in interpersonal behavior and communications, as argued earlier by Kirton (1980).

Hayes and Allinson (1994) concur with the remarks attributed to Miller earlier that the numerous dimensions of cognitive style lend themselves to a two class or a split brain typology. They drew from an unpublished dissertation by Wilson (1988) to classify many of the dimensions shown above. Table IV-2 shows Wilson's typology which was based on split-brain theory. I would place Kirton's adaptor under the left brain column and innovator under the right brain column.

Table IV-2 Wilson's Split-Brain Typology

Left Brain	Right Brain
Field Independent	Field dependent
Reflective	Impulsive
Receptive/systematic	Perceptive/intuitive
Focuser	Scanner
Serialist	Holist
Converger	Diverger
Splitter	Lumper

Hayes and Allinson (1994) affirm Kirton's arguments by offering, "Helping people understand the implication of their own and others' cognitive styles can provide a basis for team building and individual and group counseling activities designed to foster better working relationships" (p.67). I will conclude this discussion about the dimensions which may be used to describe cognitive style (as shown in Table IV-2) by suggesting that Adaption-Innovation theory is a relatively simple conception, although very theoretically sound, which could prove very useful without requiring the need to be well versed on over 20 different shades of definition and corresponding meaning.

6.3 Requisite Variety of Cognitive Style in Small Group Performance

Small groups are the basic decision unit in governments, organizations, institutions, and families. The fact that some small groups perform better than others is uncontested. For purposes of discussion in this section I will comment on organizational challenges and link empirical research in small group performance with the law of requisite variety.

Organizations exist within an environment of equivocality; consequently small groups which gather to solve problems seek unequivocal solutions to equivocal problems (Weick 1979). Consistent with the ongoing discussion in this research equivocality is viewed differently by people whose cognitive style preferences differ. Weick (1979) offered an admonition concerning decision making in equivocal circumstances, "…but it is crucial to remember that decision-making in the organizing model means selecting some interpretation of the world and some set of extrapolations from that interpretation and then using these summaries as constraints on subsequent acting" (p.175).

Weick (1979) discussed the concept of requisite variety following the work of Conant and Ashby (1970). Quoting Buckley (1968:495) Weick reported that the law of requisite variety, "states that the variety within a system must be at least as great as the environmental variety against which it is attempting to regulate itself. Put more succinctly, only variety can regulate variety." Weick suggested that it is because of requisite variety that organizations are obliged to have sufficient diversity in order to satisfactorily sense the kinds of diversity at play in the external environment. Equivocal inputs to organizations are, by definition, vague and ambiguous.

Weick argued for equivocality as an acknowledged premise in organizations and, consequently, the concomitant need for requisite variety. Because people have difficulty tolerating equivocal processes the possibility of missing important cues or information that might be helpful can occur. Weick suggested that a common mistake for groups of decision-makers is to shun equivocality which results in interpretations of reality resulting in solving the wrong problem. Weick (1979:189) said it well,

> It is their unwillingness to meet equivocality in an equivocal manner that produces failure, nonadoption, autism, isolation from reality, psychological costs, and so on. It is the unwillingness to disrupt order, ironically, that makes it impossible for the

> organization to create order. Order consists of data in which equivocality has been suppressed, but equivocality can be suppressed only after processes have first registered that equivocality. Accurate registering requires the matching of processes to the characteristics of their inputs. If people cherish the unequivocal but are unwilling to participate in the equivocal, then their survival becomes more problematic.

The law of requisite variety is assumed as a guiding principle, either explicitly or implicitly, for several scholars doing work in the area of cognitive style and small group performance (Allinson and Hayes 1996; Armstrong 2000; Armstrong and Priola 2001; Bobic et al. 1999; Buffinton et al. 2002; Devine 1999; Jablokow and Booth 2006; Priola et al. 2004; and Schroder 1994). Allinson and Hayes (1996) developed a cognitive style index for application in professional and managerial groups and accepted the law of requisite variety. They also asserted that Kirton's A-I theory was based on requisite variety. Armstrong (2000) studied how cognitive differences impact management education at the graduate level and also accepted requisite variety. Bobic et al. (1999) investigated group performance in the public sector of state government. Their work was based on A-I theory and they suggested that A-I theory may be construed as essentially equivalent to requisite variety theory in that both posit the benefit of diversity (variety) over the long term. Buffinton et al. (2002) was also based on A-I theory with specific application into undergraduate education. This report was on the first application of A-I theory into their educational program which was designed to provide students with exposure to a cross-functional educational experience—an implicit adoption of the law of requisite variety. Devine (1999) is a small group scholar and he argued in favor of diversity or variety as a counter move to guard against *Groupthink* as originally proposed by Janis (1972). Jablokow and Booth (2006) advanced a theory of cognitive gaps into group decision processes in an integrated organization model. Priola et al. (2004), also working in the area of small group research, made the same argument that Devine offered in support of diversity/variety. And, Schroder (1994) studied managerial competence and style to conclude that managers in organizations must exist in sufficient diversity (variety) on the cognitive style spectrum so as to offer a wide range of views from which to select during problem solving—essentially an argument for requisite variety.

I will present five of the studies listed above for the purpose of demonstrating similar research methods or concepts in the study of small group performance from the perspective of cognitive diversity, or requisite variety. The five studies of interest here include Armstrong (2000), Armstrong and Priola (2001), Bobic et al. (1999), Buffinton et al. (2002), and Jablokow and Booth (2006). The first two studies are based on Allinson and Hayes (1996) Cognitive Style Index, what I believe to be closely congruent with the Kirton KAI Inventory. The last three studies employ Kirton's KAI scores as their measure of cognitive style. Also, Jablokow and Booth (2006) posit a problem-solving model that includes both cognitive style and cognitive level. Prior to discussing the studies I will compare Allinson and Hayes' Cognitive Style Index and Kirton's KAI score.

I have explicated the Kirton KAI Inventory, its five-point Likert scale, and its general nature above. Kirton (2003) considers it applicable in any context and it has been successfully used across several cultures and languages, as referenced above. The KAI scale ranges from a low of 32 points to a high of 160 points with 96 the scale mean. Allinson and Hayes (1996) suggested that Kirton's measure and others were not as simple to use in business environments and, consequently, developed their own instrument called the Cognitive Style Index (CSI). The CSI is a 38-question self-reported questionnaire with answer choices of true, uncertain, or false, which are recorded as two, one, or zero. This means the maximum score is 76, the minimum is zero, and the mean is 38. Allinson and

Hayes felt that the three choices helped overcome the tendency of some people to have difficulty with five-point or more Likert scales; some people tend to answer toward the middle of the options while others tend to answer in extremes.

The important comparison I want to make between these two constructs is that the CSI defines a measure of cognitive style in concert with the split-brain theories which use the descriptive terms analytic and intuitive for the extreme ends of a bipolar continuum. Allinson and Hayes (1996) make clear their bias toward a simplifying theory of cognitive style similar to the work of Agor (1984). The analytic end of the continuum includes word descriptors like deductive, rigorous, constrained, convergent, formal, and critical. On the intuitive end of the continuum descriptive words like the following are used: synthetic, inductive, expansive, unconstrained, divergent, informal, diffuse, and creative (Nickerson et al. 1985:50). Except for the term creative at the end of the Nickerson list of intuitive descriptive words this sounds very much like the high innovator as advanced by Kirton. And, the list of terms used for the analytic is quite congruent with the terms used to describe the high adaptor. These terms may be easily compared by viewing Table I-1 above. I will concur with A-I theory in asserting that all people are problem solvers and, therefore, creative. But for that single term the CSI should be highly congruent with KAI scores. Certainly the two should be sufficiently close in conceptual measurement as to suggest comparable preferable cognitive styles. A complete comparative analysis of the two measures of cognitive style is outside the scope of this investigation.

Armstrong (2000) presented a review of the literature on cognitive style which showed significant diversity of opinion as to its definition. In particular, he cited considerable work done in the study of left/right brain hemispheric specialization that has been associated with cognitive style differences (Riding and Sadler-Smith 1993). Armstrong had previously reviewed the literature and found 54 dimensions about which cognitive style has been defined. He suggested that this magnitude of descriptive dimensions may all be subsumed into a superordinate dimension as proposed by Allinson and Hayes (1996) and which use the descriptive terms intuitive-analytic to define the end points on a bipolar continuum.

He defined analytic individuals, in work situations, as compliant, logical and linear thinkers, who prefer structured approaches to decision-making and who like systematic methods of investigation or step-by-step processes—a description that is very much like Kirton's high adaptor. The intuitive individual, in contrast, "…would tend to be nonconformist, their thinking relies on impulsive synthesis and lateral reasoning, they prefer rapid, open-ended approaches to decision-making, they rely on random methods of exploration and work best on problems favoring a holistic approach" (p.325). Again, this description sounds very similar to Kirton's high innovator.

The question that Armstrong posed involves the relationship between cognitive style and ability (or what Kirton called 'level'). The literature is not clear as to this relationship. Armstrong asserted that there would be no significant difference between the overall grades of students who are either high intuitive or high analytic. However, he added a hypothesis which posited better performance for high analytic individuals performing assignments (in specific, a research project grade) which demand cognitive style consistent with analytic types. And, he added a similar hypothesis for high intuitive types asserting their better performance on assignments (in specific, for the business policy and strategy unit grade) which lend themselves to high intuitive cognitive styles. He also hypothesized a better grade for high analytics in the marketing planning unit.

The research sample came from a university in northern England and was composed of 412 students in their final year of a business administration degree. There were 203 women and 209 men in the sample. Each of the participants was administered the Cognitive Style Index (CSI) as developed by Allinson and Hayes (1996) and discussed above.

Students' ability was based on scores from the university. The scoring system provided a range of possible scores from zero to 16 points where zero is the worst and 16 is the best possible achievement. Independent sample t-tests revealed no significant difference between men and women on the test scores, thus the study on cognitive style was deemed to be gender neutral. But, female management students were significantly more analytic than male students ($t=2.71$, $p<.01$). For the purposes of measuring the performance of students relatively more analytic versus those relatively more intuitive the cut point of 43 was used as a demarcation. This yielded two groups of similar size. However, upon reflection the researchers felt that the dichotomized approach to data did not account for the students who fell into the mid ranges of scores; i.e., a student scoring 43 points is considered "different" from a student scoring 44 points, with respect to cognitive style. The researchers created three classes of scores for consideration: CSI scores were defined as 1) low (intuitive) < = 38 points, 2) medium (integrated) 39 to 48 points, or 3) high (analytic) > = 49 points. These were the 33rd and 66th percentile of the sample. This approach followed earlier work by Agor (1984) wherein he argued that there are three broad types of management style for making decisions. The left brain type relies on linear, sequential, and logical thinking dealing with facts. The right brain counterpart relies on feelings over facts and reliance on looking at the whole issue during decision making when there is incomplete information. The third style, which Agor called *integrated*, employs both the left brain and right brain interchangeably as the problem to be solved demands.

This research showed that analytics scored higher on all the measures than did intuitives, a finding that was inconsistent with the initial hypotheses. This was true on the dichotomized scores. Also, when using the trichotomized scores (intuitive, integrated, analytic), the integrated participants scores were between intuitives and analytics in every case. Armstrong also evaluated the university's method of assessing grades for its students and concluded that there was a bias toward skills and tasks favored by high analytics. Thus, the skills and talents that high intuitives bring into the business world are not highly valued by university but the kinds of things businesses are looking for in higher order managers are decidedly more intuitive; e.g., Mintzberg (1989, p.49) reported:

> The key managerial processes are enormously complex and mysterious (to me as a researcher, as well as to the managers who carry them out), drawing on the vaguest of information and using the least articulated of mental processes. These processes seem to be more relational and holistic than ordered and sequential, more intuitive than intellectual; they seem, in other words, to be most characteristic of right-brain activity.

Armstrong proceeded to question the congruence between what the university is producing and what industry needs. He called for additional research in this area.

Armstrong's (2000) work could be recast as role preferred task and non-role preferred task analysis in the same sense that I used for my research method. Using my terminology, the student assignments appear to be more role-preferred for analytic oriented students (or, I would argue for marked adaptors). Armstrong and Mintzberg argue in favor of more intuitive oriented assignments for preparing students for the equivocal environment in which businesses operate as posited by Weick (1979). This too is outside the scope of this study but appears to support Kirton's assertion that there is an innovation bias (if we approximate intuitive with innovation).

Armstrong and Priola (2001) studied the effect that cognitive style had on task performance with self-managed work teams. They had 100 participants which were formed into 11 teams. All participants were seniors enrolled in a computing and technology program at a university in England. All group members were European except for one Indian. Roughly 80% of the participants were male. Ages of participants ranged from 19 to 51 with two thirds comprising the 19 to 25 segment.

This university program was called the Information Systems Group Project (ISGP) and was developed to provide real world experience to students with an emphasis on working in small teams. Representatives from industry prepared an *invitation to tender* for complete computer systems similar to the kinds of typical request for proposals that are sent to software/hardware companies. Student teams, which had up to 12 members on them and included several sub-disciplines, were required to produce a written response to tender request. After contract award each team had to carry the project from conception to the development of a prototype of software and user manuals. Each team worked as a small business with its own bank account. The only constraint was the due date for the project to be completed. Each team elected its own leader. And, the duration of each project was roughly five months.

Each team met weekly over the course of the intensive program period and the meetings were videotaped for later data analysis. The specific composition of each team was done by academic staff. The researchers used the Allinson and Hayes' Cognitive Style Index (CSI) for determining cognitive style preferences.

Table IV-3. System of Categories by Bales

Area		Category	Problem
Social-Emotional Area: Positive Reactions	A	1. Shows solidarity, raises other's status, gives help, reward	f
		2. Shows tension release, jokes, laughs, shows satisfaction	e
		3. Agrees, shows passive acceptance, understands, concurs, complies	d
Task Areas: Attempted Answers	B	4. Gives suggestion, direction, implying autonomy for other	c
		5. Gives opinion, evaluation, analysis, expresses feeling, wish	b
		6. Gives orientation, information, repeats, clarifies, confirms	a
Task Areas: Questions	C	7. Asks for orientation, information, repetition, confirmation	a
		8. Asks for opinion, evaluation, analysis, expression of feeling	b
		9. Asks for suggestion, direction, possible ways of action	c
Social-Emotional Area: Negative Reactions	D	10. Disagrees, shows passive rejection, formality, withholds help	d
		11. Shows tension, asks for help, withdraws out of field	e
		12. Shows antagonism, deflates other's status, defends or asserts self	f

Key:

a. Problems of orientation
b. Problems of evaluation
c. Problems of control
d. Problems of decision
e. Problems of tension-management
f. Problems of integration

This research was conducted using Bales' (1950a and 1950b and Bales' et al. 1951) interaction process analysis (IPA) to analyze the group interaction. Table IV-3 contains Bales' 12 categories for interaction process analysis. I have modified the original diagram used by Bales to help convey his intention about communicative acts being social-emotional (positive or negative) or task-oriented (asking or answering questions). Armstrong and Priola

(2001) investigated the effect of group composition concerning cognitive style. Aside from the fact that they used a different instrument to determine cognitive style this research could be viewed as complementary to mine. The interesting difference with Armstrong and Priola is that they evaluated group interaction using Bales' interaction process analysis (IPA) (Bales 1950a, 1950b, 1970; and Bates et al. 1951).

Bales' IPA is one of the most reliable and recognized methods for evaluating group interaction based on both verbal and non-verbal communicative acts. Bales asserted that group behavior may be classified into two major categories: 1) social-emotional activities and 2) task-related activities. Social-emotional processes, "…occurring in groups are concerned with group solidarity and attraction between members and task-oriented processes with goal attainment" (Armstrong and Priola 2001; p.290). Individuals are believed to fall into one or the other of these two categories. The social-emotional class also divides further into positive or negative acts; i.e., individuals are found to have naturally positive or naturally negative tendencies. The naturally positive acts would include things toward building up the group, being friendly, and agreeable. The naturally negative acts, conversely, would tend toward unfriendly acts, disagreeing, and not building up the group. Armstrong and Priola said, "These reactions lead to the maintenance or destruction of harmony, management of group tensions, integration, disintegration, and so on" (p.290). Task-related individuals focus energies on pursuing task goals via a discursive process narrowly focused on arriving at a solution. These activities are considered to be emotionally neutral.

Note that the Bales IPA is a numerical analysis of communicative acts; i.e., there is little subjective evaluation applied to each act aside from whether it is task oriented or social-emotional and the two breakdowns within those two classes. The IPA technique generally required the researcher to create written transcripts of the dialogue with as many non-verbal acts as possible also being recorded. Video recording techniques have ameliorated this laborious process and improved the short-term memory problem as earlier discussed in the critical incident technique I will employ in this research.

Based on the expectations of behavior when considering cognitive style theory and Bales IPA classification four hypotheses were posited for testing (p.291):

> H1a: The number of task-oriented acts initiated will be higher for those team members whose cognitive styles are analytic compared to those who are intuitive
> H1b: Teams tending toward homogeneity with predominantly analytic team members will initiate a higher proportion of task-oriented acts compared to teams with predominantly intuitive members
> H2a: The number of social-emotional acts initiated will be higher for those team members whose cognitive styles are intuitive compared to those who are analytic.
> H2b: Teams tending toward homogeneity with predominantly intuitive team members will initiate a higher proportion of social-emotional acts compared to teams with predominantly analytic members.

Bales' interaction process analysis is a method to evaluate group discourse within a predetermined frame of reference for various utterances, both oral and non-verbal. Each act, regardless of how small, is recorded. If a communicative act can be observed, it is recorded for classification into the IPA system. Bales considered these acts as the most basic unit of observation.

Armstrong and Priola (2001) found the median CSI scores in their sample of participants to be a score of 42, which is four points above the theoretical mean of 38. They used 42 as the cut point to separate those relatively more intuitive versus those relatively more analytical. (Note that in this system of cognitive style measurement the more intuitive are the lower scores and the more analytic are higher scores—opposite of Kirton's KAI scoring system for adaption and innovation.) Some adjustments had to be introduced to account for the differences in team sizes. Since more team leaders were intuitively oriented (8/11) some consideration of that was made.

Team leaders were significantly more intuitive than other team members $t(98)=2.9$; $p<.01$. Thus, separate reports were made for outcomes including team leaders and excluding team leaders.

These data revealed some noteworthy findings, "…the more intuitive the team member, the more he or she is likely to contribute to these acts, irrespective of their category" (p.298). In every category tested the more intuitive participants initiated more acts. The test of hypothesis 1a revealed that analytic participants initiated fewer tasks than intuitive participants to a statistically significant degree, $t(98)=2.04$; $p<.05$; thus hypothesis 1a is rejected. Also, the intuitive participants initiated more social-emotional acts than the analytic participants, again, by a statistically significant degree, $t(98)=3.07$, $p<.01$; this supports hypothesis 2a. If my assertion that Kirton's KAI scores are significantly related to the CSI scores these findings are not surprising. The high innovator naturally produces more ideas during problem-solving activities and the high adaptor is content to produce what he deems a reasonable amount which is considerably less, on average, than the innovator (Kirton 1976).

As noted above, the data were evaluated without including the team leaders due to the fact that they were statistically more intuitive than the other team members. When controlling for team leaders the analysis revealed that there was no statistically significant difference between task-related acts initiated by more intuitive or more analytic participants, $t(87)=1.43$, $p>.05$; this lends to the rejection of hypothesis 1a. However, the number of task-related acts initiated by more intuitive participants was substantially higher than for more analytic participants, a fact the authors called, "…worthy of note" (p.300). Also, using the participants' scores without the team leaders included, the number of social-emotional acts initiated by the intuitive participants was considerably more than the analytic participants by a statistically significant degree, $t(87)=2.52$, $p<.05$; supporting hypothesis 2a further.

The 11 teams were grouped according to three classification schemes: 1) analytic homogeneous, 2) intuitive homogeneous, and 3) heterogeneous. There were three homogeneous analytic teams, two homogeneous intuitive teams, and six heterogeneous teams. The number of task acts, social-emotional acts, and total acts were recorded within each team class for the purpose of an analysis of variance between classes. There was a statistically significant difference between the number of social-emotional acts between classes, $F=1.99$, $df=10$, $p<.05$. There was no statistically significant difference between classes for the number of task-oriented acts across the classes, $F=.708$, $df=10$, $p>.05$. These tests support rejection of hypothesis 1b. The tests support hypothesis 2b.

Armstrong and Priola (2001) cited prior work supporting their own findings and concluded,

> …that individuals with a tendency toward an analytic style will be more task oriented, preferring structure, less ambiguity, and a more technique-oriented environment, whereas individuals with a tendency toward an intuitive style tend to be emotionally expressive, relatively friendly, popular, and warm, preferring less structure and more ambiguity. If these conceptual relationships between the analytic-intuitive cognitive style and task-/social-oriented behaviors were to be proven, then it might be argued that instruments such as the Allinson-Hayes CSI may prove to be of significant value for organizations wishing to compose SMWTs in a more robust and meaningful way (p.304).

These authors were surprised that homogeneous intuitive teams and intuitive individuals were much more likely to initiate more task-oriented behaviors than their counterparts. I see this finding as being consistent with A-I theory with the high innovator demonstrating much of the behavioral characteristics as the high intuitive.

The generalizability of this study was said to be, perhaps, compromised by the fact that it was based on a student sample. This is a criticism other scholars have offered concerning using student samples (Keyton 2000). They suggested that a similar study conducted within the context of a real work context might lead to overcoming the potential bias from a student sample. This is a problem that my research will not face since my subjects are inside an organization in which many have significant tenure. The authors commented that homogeneity of cognitive style, "…in a team may increase the likelihood of satisficing behaviors, whereas heterogeneity reduces these effects but at the risk of increased levels of conflict" (Armstrong and Priola 2001:306) (observations also made by Kirton (1994) and Lindsey (1985)).

Bobic et al. (1999) were interested in the law of requisite variety as it relates to group performance and Kirton's assertion that diversity on teams should produce better outcomes. They employed Kirton's KAI scores as measures of cognitive style. Some organizational researchers have argued that requisite variety leads to the *Icarus Paradox*; that the organization's initial strength becomes the weakness that leads to its downfall (Miller 1990). Simply put, the external environment changes more rapidly that the successful organization can, thereby leading to failure.

Bobic et al.'s (1999) research project was not based on *a priori* assumptions. Their work was originally begun to inform students and managers about themselves so they could learn and share their experiences with their groups. They called this formulation method, *accidental populations*. Thus, they called the evidence presented in this work, *fragments*, and said that the strength of their findings lies in consistency. They observed that all the fragments pointed in the same direction. And, they acknowledged the importance that triangulation brings to evaluation research for supporting validity of findings.

Bobic et al.'s (1999) research process called for each of the middle managers in a state government department to be interviewed during a management development program and asked to tell autobiographical leadership stories. The interviews lasted from 20 minutes to over an hour and were audio taped and transcribed. The researcher reasoned that because the interviewees were telling stories in which they were actors they would describe themselves in styles which were comfortable to them—consistent with the theory imbedded in the KAI Inventory; e.g., recall the instructions to the KAI Inventory reads, "How easy or difficult do you find it to present yourself, consistently, over a long period of time as…"

Each interviewer had to interpret the stories and make an assessment as to the adaption versus innovation degree suggested in the story. There were two coders and each worked separately. For each characteristic of adaptor and innovator contained in the KAI Inventory the coders allocated one point. The coders then discussed and compared their scoring and made adjustments. Initially there was 80% agreement in coding.

Kirton (1994) argued that the KAI score is a measure of personality and therefore stable over time. Van der Molen (1994) and Clapp (1993) offered supporting evidence. Goldsmith (1994) suggested that training programs have no effect on KAI scores, as would be expected if one's A-I proclivity is part of one's personality. This would suggest that training programs intended to teach innovation may be a waste of money by organizations. Kirton would suggest that if an organization needed more innovative behavior the organization should consider recruiting people with different cognitive styles.

State manager training over the three month period was supposed to encourage risk taking and innovation. The intensive three month program was found to not impact KAI scores at all. This supports the argument that training cannot change KAI scores, or, better put, training cannot change a person's basic cognitive style. Note that some participants filled out KAI Inventories one to three years after the program and their scores remained constant.

There were, however, changes in KAI scores noted with black respondents. One to three years after the fact the black participants scored as innovatively as their white counterparts whereas the initial assessment of black respondents considered them more adaptive on average than their white colleagues.

During the time of the study a governor change occurred and the new governor introduced a different management philosophy. This was more restrictive to the managers since the governor's cabinet members now were subordinate. The KAI scores of the managers in the prior governor's administration were higher than in the new governor's administration. The researchers concluded that the innovative climate which exemplified the prior governor's administration fostered higher KAI scores. Also, by extension, an adaptive work place climate will foster a move toward more adaptive KAI scores. Again, this is consistent with a number of researchers on Attraction-Selection-Attrition (ASA) theory originally advanced by Schneider (1983a). ASA theory posits that over time organizations or groups evolve toward isomorphism; i.e., the dominant type in the group will attract and select people like them while those unlike the dominant type will seek to leave the organization. Bobic et al. (1999) inferred from their findings that, "…to effect change, the organization executive should restructure the environment or redesign the job rather than fire employees. Sending people to training programs may teach specific work behaviors, but does not appear to generate an innovative orientation" (p.26). Or, put another way, natural adaptors will remain naturally adaptive in spite of training to teach innovative thinking.

Bobic et al. (1999) said the comments about race and work environment were not part of their research assumptions *a priori*; they credited serendipity to the results. They offered two extensions to that information as possible hypotheses which need further testing: 1) A member of minority identity group or 2) Working in a controlling environment constitutes conditions which depress one's propensity to innovate.

Bobic et al. (1999) planned and conducted a quasi-experiment. A management training class was split into three groups with KAI scores being a major variable used for selection (also gender and departmental distribution were considered). A relatively more adaptive group was assembled, a relatively more innovative group was assembled, and a middling group (defined as one in which the members were relatively well distributed about the mean of the KAI measure). All three groups were charged with the same task: to "develop a proposal for handling the disposal of nonhazardous solid waste for the state." The groups were exposed to speakers who were experts in this field. Participants visited solid-waste sites and each group invested significant time on this research assignment. The report would be presented in both oral and written form to the state's Department of Health and Environment so the assignment was considered quite important by the participants.

The participants spent all summer on the assignment. A week before the completion period the three solutions were presented to an assembled panel of four domain experts who were asked to evaluate the plans on several dimensions using a 1-10 scoring scheme. *Departure from standard practice* was one dimension for innovativeness. Adaptive scores would approach the *standard practice* measure. All the project teams performed as predicted by A-I theory. Using an aggregated mean from the four domain experts the relatively more adaptive team scored three points, the relatively more innovative team scored seven points, and the middle team scored five points. This supports the validity of the KAI measure. Bobic et al. (1999) said, "When innovators get together, the decision will be innovative; when adaptors get together, the decision will be adaptive. Also in line with diversity theory, the experts evaluated the middle group as offering the best project plan" (pp.27-28). Kirton and Hammond (1980) conducted an interesting study which showed extreme adaptors and extreme innovators perceived themselves as less self actualized *than did more middling KAI scores*—a fact that may contribute to the better problem solving in this middle group.

This work supports Kirton's hypothesis that heterogeneous teams perform better than homogeneous teams of either adaptors or innovators. However, there may be specific problems which require a more adaptive solution which might favor adaptors and vice versa for innovators. But, *ceteris paribus*, heterogeneous teams over the long haul are likely to solve a wider range of problems than either homogeneous adaptors or homogeneous innovators.

This work also suggested that workplace climate or minority social status may be important factors when assessing the relatively adaptive-innovative nature of an organization. Bobic et al. (1999) observed, "KAI can be useful in enhancing innovative problem solutions, but an executive's demonstrated behaviors remain a factor influencing a subordinate's propensity to innovate" (p.28).

Support is again provided for using KAI scores among managers of an organization as an approach to achieving organizational effectiveness flowing from application of the requisite variety principle. Bobic et al. (1999:29) conclude with a significant corroborative statement concerning my assertion of employing A-I theory in building problem-solving groups:

> If the adaption-innovation dimension is significant for supplying needed variety for an organization, and if the theory of requisite variety applies to organizations, then (other factors being equal) organizations which use managers' KAI scores for building diverse work teams will be more successful than organizations which ignore such information about their employees when building teams.

Buffinton et al. (2002) investigated a summer training program in Bucknell University's Institute for Leadership in Technology and Management (ILTM). A-I theory was introduced into the ILTM program beginning in 2001. KAI scores were recorded but were not used in team composition. The program, which began in 1991, was originated to provide, "…an integrated academic program to address the challenges of technological change and the changing global economy" (p26). The program stretches over two summers and is designed as an intensive experience for Bucknell students majoring in either (chemical, civil, computer, electrical, or mechanical) engineering or in management or accounting. The concept is to provide some exposure to a cross-functional educational experience. The program includes on-campus course work and off-campus internships for participants following their junior year.

Students must apply for one of the 20 slots which are available each year. The faculty chooses only the most highly motivated juniors in engineering and management each year. The program is intentionally designed to push students due to the high expectations that both students and faculty have.

The students were divided into four teams of five persons each and were assembled to maximize diversity vis-à-vis gender, major, and GPA. In the first year KAI scores were available for the students but the faculty decided to not include those scores during the assembly of teams. The intent of placing student into diverse groups during this program was to force "students to work with others who may have different approaches to problem solving" (p.25). The intention of using KAI scores during the evaluation of team performance was to investigate if KAI scores can be used to help plan and manage group dynamics. The researchers required the students and faculty members to keep journals of their work during the program. The researchers kept up with journal entries of students and faculty members while considering the KAI scores of each. Buffinton et al.'s results indicated that, "…KAI scores help with understanding and appreciating problem-solving strategies of others, and predict trouble spots within project teams" (p.25). Their method is similar to the critical incidents technique mentioned above that I will employ for this research.

One of the investigators, Kathryn Jablokow, who is a nationally recognized leader in problem-solving pedagogy, administered a day-long workshop on A-I theory and its ramifications to problem solving. [Jablokow, as mentioned above, developed and teaches a three semester series on problem-solving at Pennsylvania State University's Great Valley School for Graduate Professional Studies based on A-I theory]. Subsequent to the A-I theory workshops the students were given instructions to keep a journal of their impressions of their experiences during the corporate project work, as mentioned above. In much the same way as the critical incident technique can be applied in an inductive manner the faculty identified six common major themes throughout all the journals. These were:

1. Structure
2. Conformity and consensus
3. Relevance
4. Conflict

5. Other personality factors (non-KAI)
6. Positive value

Additionally, two other themes considered of some level of importance to these findings were evaluation and leadership.

It is not surprising that the importance of evaluation would be an important theme which was observed in students' journals, given that students are typically keenly interested in grades on performance. These groups of students worked with each other for extended periods of time and there were reports of concern over how individuals were perceived based on the performance of other students' behavior.

Leadership was considered an important characteristic of the teams which were established. In the ILTM program teams were established with no intentional hierarchy. Leaders, therefore, may or may not emerge during team development. In one case a leader was selected in the first few days of the industrial phase of work. Unfortunately, journal entries indicated that the person was a non-factor regarding the team's performance. One student wrote (KAI 83), "It is interesting to note that Student D (KAI 97) does have the highest KAI score and is trying to assume the role of leader relatively speaking because our group dynamics are such that we don't have a 'leader' and it just works better that way" (p.30).

In another case the leader role shifted as the nature of the problem changed; i.e., initially the tasks were structured (goal setting) to less structured (presentation development). Some tension was noted in the journal entries with this team but, ultimately, leaders appropriate to the task stepped forward to help with the problem solving. One of these students (KAI 78) wrote, "Though we are enrolled in an elite leadership course, it is also important to realize that not all can be leaders at the same time. It is important to be a follower as well. I learned more about being a leader by being a follower. I learned that adaptors and innovators are great leaders, depending on the situation. A true leader realizes this and becomes a follower as the situation changes" (p.30).

One key theme that was evident during this study was structure. They found that more adaptive participants were more highly frustrated when incomplete information created ambiguity. They noted that, "The more adaptive the student (the lower the KAI score), the more frustration they expressed with issues such as open-ended project description, ambiguous tasks, or the inability to contact a corporate sponsor for clarification" (p.30). As expected, the more innovative students were less stressed by ambiguity or change during the process.

One very salient observation was made concerning resource management—specifically time management. They found a direct relationship between adaption and more stringent time management, including anticipation of the future. A revealing comment was made by one of the participants (KAI 78), "I am glad that we are more adaptive as a group. At this present time, the team needs more structure and direction rather than ideas. Assigning tasks is extremely important due to deadlines" (p.30). More innovative students were considerably looser with time management, took fewer notes, and were less sequential in their work that the more adaptive groups. The most innovative team, in this study, experienced difficulties with staying on task, boredom, and lack of focus, which were asserted to be typical with more innovative individuals. When some team members tried to contribute discipline they encountered resistance from others. Interestingly, this team's output came together at the last minute.

The theme of conformity and consensus was observed by the researchers. They noted a direct relationship between the emphasis on group conformity and adaption. In the more adaptive team members' journal entries tension was evident with respect to, "…moving forward together and getting along," anytime that they perceived that this was not happening to their satisfaction (p.31). The researchers also noted a direct relationship between amount of independent work and degree of innovativeness. More innovative students were more likely to work alone and then bring their work to the group for discussion. One telling observation concerning more innovative students was that, "…they were perceived as abrasive and even offensive. They were criticized for 'having their fingers in everything,' 'bringing new ideas in at the end,' 'stepping on toes,' and speaking up too much with faculty." Additionally, and not surprisingly, "The most adaptive members of two teams were perceived as offensive because of condescending attitudes and rejecting ideas of others" (p.31).

The theme of relevance was evident in the students' journals. In this case the more innovative students were the ones who felt their ideas were often ignored or disregarded. The most innovative person (KAI 99) of one team said, "My group is starting to form better, but I still feel as though I am the person who fits in the least. Sometimes my ideas take longer to process and the longevity of this does not comply with the swiftness of my team members" (p.31). More adaptive team members interpreted this kind of thinking as being destructive to the team. Additionally, the more adaptive team members felt that the more innovative members offered ideas which were not helpful or that, "…seemed tangential to project goals caused a loss of momentum" (p.31). The more adaptive students reported that the more innovative students were likely to be chaotic with respect to the adaptor's desired structure and process during problem solving.

Conflict was a clear theme in the students' journals. In the case of the ILTM program, students sought the approval of their contributions by faculty, peers, and the corporate groups with which they worked. Consequently, conflict was noted when students perceived that their contributions were not highly valued by any of the constituencies noted. The greatest conflicts were said to be due to cognitive style differences in the groups with the most adaptive and the most innovative members of teams perceiving the most conflict. For example, the most innovative member of one team (KAI 118) said, "Student A (KAI 94) and I disagreed several times, and I often felt that he was being condescending. Usually when I made a comment or suggestion, he would get defensive and didn't always listen to what I was trying to say. He would try to explain his way of doing things in a way that really bothered me at times" (p.31). Following some discussion of this between the two students Student A said, "We were arguing the same thing, just from a different perspective" (p.31).

The most conflict was recorded in the team with the greatest cognitive gap (defined as the largest range between KAI scores on the team). A very revealing comment was recorded by one team member in this situation, "For me it just seems emotionally draining when we meet as a group because I know we will not only have to tackle our [task] assignment but also internal group struggles. Personally, I prefer not to work with Student B because his ways of thinking are so different from mine" (p.31). It should be noted that adaptors also conflicted with other adaptors in some circumstances. In one case two relatively more adaptive team members conflicted over the defined structure of the project.

Buffinton et al. (2002) also acknowledged that other personality differences were evident in addition to cognitive style differences. In particular they noted that Jung's psychological types could be identified in some of the journal entries. I will omit any discussion of these types as my primary interest is on cognitive style. Other differences were noted related to gender and major. Additional psychological differences that were noted include self-efficacy, coping mechanisms, and achievement motivation. These too were considered to have an influence on the ability of teams to function effectively but will not be elaborated.

Buffinton et al. (2002) concluded that the application of cognitive style theory to group dynamics for individuals working in teams is "appropriate and useful" (p.32). However, they acknowledged that more rigorous research is needed. They suggested that although this research was conducted with students that similar results could be expected with more mature participants, citing work done by Kirton (1999) and Clapp (1993) on the stability of cognitive style in adults in longitudinal studies. Essentially, cognitive style does not change over time. Thus, behaviors by students as recorded in the various journals during this experiment can be expected to be reflective of impressions and behaviors of people more senior in their careers. They suggested that one possible difference with more mature people is that they have likely developed more advanced coping skills which enable them to deal with the diversity which exists in any kind of organized activity. That does not imply that the cognitive style differences no longer exist, but rather that the individuals are better at coping than when younger.

With regard to the Buffinton et al. study I would suggest that their findings may be used as empirical evidence which supports many of the stylistic differences A-I theory posits between high adaptors and high innovators. There are some interesting reports in this study where students' journal entries imply behavior seemingly at odds with what Bales would have suggested; e.g., one adaptor expressed concern that the high innovator was destructive to team formation and spirit. If, as I have suggested, the adaptor is an analytic, task-oriented person, it would seem that this expressed concern (social-emotional or intuitive) about team building would be a bit dissonant. This may be an example of the Bales' conception of intuitive tapping into another facet of personality than Kirton's innovator.

Jablokow and Booth (2006) suggested a theoretical conception of how differences in cognitive style and cognitive level may contribute to outcomes in for-profit, high-performance product development organizations. They based their work on the premise that all for-profit organizations seek competitive advantage in pursuit of profit. According to the authors, there are two fundamental factors necessary to achieve the aim of competitive advantage (p.313):

> (1) The ability to generate new intellectual property that offers superior value to customers
>
> (2) The ability to capitalize on it quickly

This is reminiscent of my earlier citation of de Geus (1988) who said, "…that the only competitive advantage the company of the future will have is its managers' ability to learn faster than their competitors" (p.74). *The ability to generate new intellectual property* has an implicit need to learn and learn fast (de Geus 1988). Jablokow and Booth (2006) accepted, although without explicit declaration, the law of requisite variety and provided a compelling conceptual model which I will explain and extend for application in this research. Jablokow and Booth were inspired and informed by an ethnographic study reported by Carlile (2002) on knowledge boundaries in new product development organizations. Carlile explained the challenges of working and learning across functional boundaries, what Jablokow and Booth called the Integrated Organization Model.

The Integrated Organization Model (IOM) in a product development manufacturing organization assumes that two or more different organizational units with different functional problem-solving objectives are tightly integrated. Carlile (2002) identified four business units in the product development company he studied: sales/marketing, design engineering, manufacturing engineering, and production. The IOM would contain cross-functional teams of people working to develop new ideas and products. Carlile's observations led him to, "…describe knowledge as *localized, embedded, and invested* in practice" (2002:442). The essence of this observation is that the knowledge reservoir of each individual is largely determined by the organizational subunit within which one works. This makes the issue of working across functional boundaries very challenging. I discussed another facet of this problem earlier during the presentation of resistance to change in organizations being related to the degree to which someone's power and position make her reticent to relinquish the old in order to generate and resolve novelty (Kaufman 1971 and Kirton 2003).

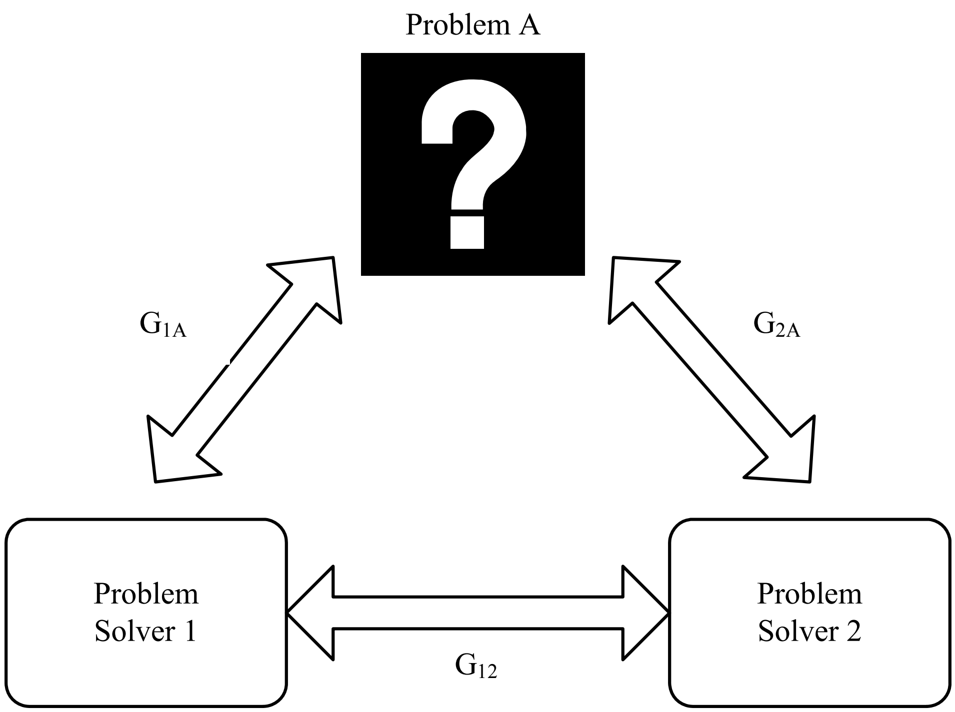
Jablokow and Booth (2006) focused their discussion on the important ways people's cognitive differences impact collaborative decision processes inherent in the IOM. They used Kirton's (2003) term *cognitive gap* to be the psychological processes that arise when different problem solvers combine to solve a particular problem. There are two aspects of cognitive gap: person-person cognitive gap and person-problem cognitive gap. In addition, there are two components of cognitive gap—cognitive *style* gap and cognitive *level* gap.

Cognitive style has been discussed above in considerable detail and as the previous section presented, there are numerous facets of cognitive style that could be considered. I have chosen to use Kirton's A-I theory and his KAI scores as a single measure of cognitive style for this research. His measure is general enough and simple enough to add value without complexity.

Cognitive level includes both potential and manifest capacities; i.e., one's potential capacity is a measure of how much someone can know based on the strength of the machinery, and the manifest capacity is a measure of the knowledge and experience accumulation through life (Jablokow and Booth 2006). Carlile (2002) called manifest capacity *knowledge* which is localized, embedded, and invested in practice. Manifest capacity also includes formal education, life experiences, family history, and all tacit learning which enables a person to solve certain problems but restricts the solution sets to those within her localized, embedded, and invested knowledge (Berger and Luckmann 1967 and Kirton 2003).

Jablokow and Booth (2006) offered a simple conceptual model in which they hypothesized two types of cognitive gaps in a problem-solving model. Figure IV-4 shows Problem Solver 1 (PS1), Problem Solver 2 (PS2), and Problem A. Kirton (2003) conceptualized the management of diversity with an analogy called Problem A-Problem B. Problem A is the question about which people assemble to answer. And, Problem B is the problem of managing the diversity of all the problem-solvers. The Jablokow-Booth model depicts Problem B as a cognitive gap, G_{12}, which means the gap between PS1 and PS2. In addition, this model shows a cognitive gap between person and problem, shown in the figure as G_{1A} and G_{2A}. It should be obvious that this is the simplest model which demonstrates the Problem A-Problem B analogy. In practical matters there are usually several problem solvers assembled to solve a particular problem. I will expand on the issue of number of problem

Figure IV-4 Simple Cognitive Gap Model for Problem Solving[9]



solvers and measurement of gaps following Jablokow and Booth's definition of gaps. Cognitive gaps are differences between cognitive styles and/or cognitive levels which can be present in any of the following (p.324):

> a. A gap between two individuals (i.e., between their respective styles and/or levels);
> b. A gap between an individual and a group (i.e., between the style and/or level of the individual and the style mean or aggregate level of the group, respectively);
> c. A gap between two groups (i.e., between their respective style means or aggregate levels); or
> d. A gap between an individual or group and the requirements of a particular problem (i.e., between the respective styles and/or levels of each).

Jablokow and Booth did not offer any more detailed operationalization of these gaps but reminded readers of prior research in cognitive style where KAI differences of 10 points

[9] Adapted from Jablokow and Booth (2006:314)

between people are noticeable over time (Kirton and McCarthy 1985 and Clapp and de Ciantis 1989). KAI gaps between individuals of 20 points or more have been shown to lead to more serious problems including distrust, conflict, and job loss (Lindsay 1985 and McCarthy 1988). And, with small groups interacting with other small groups, intergroup KAI mean scores as little as 5 points difference have been noticed (Kirton 2003; Kirton and McCarthy 1985; and Clapp and de Ciantis 1989). I will follow Jablokow and Booth in adopting Kirton's A-I theory for the cognitive gap concerning style. And, since considerable attention has already been paid to cognitive style, I abbreviate my discussion on that topic. However, I have spent little time on the issue of cognitive level and possible measurements. Since Jablokow and Booth introduced the notion of both style and level cognitive gaps, I will explore their propositions for due consideration in my research.

Recall that Jablokow and Booth (2006) studied the issue of cognitive gaps within the context of the IOM. They note the potential for group polarization in the IOM and posit that it, "…may be due in part to differences in manifest cognitive *level* (perceived as 'high in my job, low in yours'), such as: which training completed, which degree attained, which technical skills mastered, etc" (p.328). While they drew from Kirton's A-I theory in their discussion of cognitive style, they employed Carlile's (2002) conception of knowledge in their discussion of cognitive level. Because of the direct application of Carlile's concepts into my subsequent presentation I will sketch important elements of his work.

Carlile (2002) also studied product development organizations and cross-functional business units, although he did not call his conception an IOM. Rather, he termed the different units "communities" and was concerned how knowledge (novel ideas) emerges and crosses functional boundaries. His work is silent on cognitive style or cognitive level—

explicitly. However, it is quite clear that his interest is in useful knowledge in an applied setting. This is a significant aspect of manifest capacity—or *level* in the Jablokow-Booth model.

Carlile (2002) views, "…knowledge as localized, embedded, and invested in the particular objects and ends of a given function to frame the consequences of moving knowledge across boundaries" (p.443). He offered how boundaries have been understood in prior research and noted that knowledge, "…is both a barrier to and a source of innovation"—a notion that parallels Kirton's "paradox of structure" (p.442). Carlile discussed two popular approaches to knowledge boundaries and suggested his own improvement for understanding how knowledge moves across those boundaries.

The *syntactic* approach to knowledge boundaries originated with Shannon and Weaver's (1949) mathematical theory of communications. They were pioneers during the infancy of electronic digital processing when science had not yet fully developed the systems' concepts to enable computers to efficiently and reliably share information across man-machine boundaries. Today, the commonly used example of syntax is simply the combinations of zeros and ones contained in computer machine language—so called binary language. As a result of effective syntax, computers receive input information and process it the same way every time. Interestingly, systems theorists mentioned in my earlier discussion of requisite variety considered the boundary between the environment and an organization as a problem that information processing (syntax) could aid (see, e.g., Buckley 1958 and Conant and Ashby 1970).

Lawrence and Lorsch (1967) produced their well-known differentiation and integration model based on the developments in systems theory and syntax described above.

They measured differences across organization units based on the degree of uncertainty that tasks could be predictably completed. They compiled this across the different units and looked at the differences of predictability (differentiation) at the unit boundaries. They then considered the issue of integration (boundary-crossing knowledge) as a simple problem of "matching differences" at the boundaries of each unit. While Lawrence and Lorsch provided useful guidance for understanding boundary knowledge, Carlile found, "…that novelty does not arise from differences in degree of uncertainty but, more problematically, differences in kinds of knowledge required for the task" (p.444). Thus, he called on another approach.

The *semantic* approach is necessary for all those cases in which a common syntax or language has any room for interpretation—*meaning any time people are involved*. The collaborative model (like Jablokow and Booth's IOM) requires people to communicate effectively to successfully work together. However, as I have argued above each person has a unique language (syntax) with which she communicates and it is filled with socially constructed reality which shapes and shades meaning of words and phrases (Berger and Luckmann 1967 and Searle 1995). The semantic approach to knowledge at the boundaries recognizes both "differences in degrees" and "differences in kind" (Carlile 2002:444). The latter difference derives from the nature of knowledge creation; i.e., localized, embedded, and invested in a particular domain. The nuance of the semantic approach is to accept the epistemological differences of knowledge. Carlile (2002) expanded on this thought, "By paying attention to the challenges of 'conveyed meaning' and the possible different interpretations by individuals, they recognize that individual, context-specific aspects of creating and transferring knowledge must be taken into consideration, and like others pay particular attention to the tacit nature of knowledge" (p.444). The semantic approach accepts differences as expected during knowledge transfer at the boundaries and recognizes dependencies across those boundaries. It does not, however, deal with the consequences that different kinds of knowledge might generate. That takes the third approach to knowledge boundaries and it is the one proposed by Carlile (2002).

The *pragmatic* approach illuminates the things that are both dependent and different across functional boundaries and their concomitant consequences. Again, the nature of *my knowledge* versus *your knowledge* is important, "…interactions across practices are not inconsequential; the knowledge that people accumulate and use is often 'at stake.' They are reluctant to change their hard-won outcomes because it is costly to change their knowledge and skills" (Carlile 2002:445). The pragmatic approach accepts the need for a process of transforming existing knowledge based on conditions of difference, dependence, and novelty all present at the boundaries.

Carlile (2002) applied the pragmatic approach in his study of a product development organization which operated in a fashion similar to the IOM discussed above. He developed a two-class framework to compare how knowledge was structured in an applied setting. Within a particular practice unit he focused on the *objects* and *ends* used. He defined objects as, "…the collection of artifacts that individuals work with—the numbers, blueprints, faxes, parts, tools, and machines that individuals create, measure, or manipulate." "Ends," he continued, "…are outcomes that demonstrate success in creating, measuring, or manipulating objects—a signed sales contract, ordering prototype parts, an assembly process certification, or a batch of high-quality parts off the production line" (p.446). He observed that collecting information about knowledge in practical settings was difficult. And, he viewed surveys or self reports as too unreliable to count on. Therefore, he observed individuals in actual practice while focusing on the objects (defined above) they routinely use and the ends they seek (also defined above). In this manner, he reasoned that he could record sufficient information about objects and ends as to discuss dependencies and differences within the development of successful products.

Calling himself an ethnographer, he said the challenge was to collect a large collection of observations and to condense them into something understandable. His method for that was to write summaries of interactions which demonstrate the application of knowledge in action with his subjects. I mention this method challenge because it is one that I faced and I have used his approach with my research project.

Carlile (2002) adapted Star's (1989) four categories of boundary objects to identify acts of knowledge in action in his study. Boundary objects, "…work to establish a shared context that 'sits in the middle'" and thereby fosters cross-boundary knowledge exchange (a.k.a. *learning*) (Star 1989:47). Carlile's adaption yielded three classes of boundary objects (p.451): 1) *repositories* are shared databases or storehouses of information whose labels or definitions are accepted and mutually understood across functional boundaries; 2) *standardized forms and methods* provide a common language and structure that has shared meaning across functional boundaries; and 3) *objects, models, and maps* comprise the artifacts that enable transformative knowledge. Objects or models include any depiction of a specific finite goal such that the differences and dependencies across functional boundaries can be understood. Maps of boundaries are any depictions of boundary-forming knowledge which helps expose the cross-functional dependencies.

Carlile discussed "effective" boundary objects as those which provide a shared syntax for communicating, that provide a semantic process which illuminates the differences and dependencies, and a pragmatic process through which cross-functional groups can, "…jointly transform their knowledge" (p.452).

Lastly, Carlile (2002) circled back to the Lawrence and Lorsch (1969) work on "integrating devices" and used his findings as an improvement over the earlier work. He defined "integrating devices" for each of the three approaches to boundary knowledge. In the syntactical approach, the integrating device is the shared repositories of knowledge and the processing of that knowledge across boundaries. In the semantic approach, the integrating device includes a process by which information is translated across boundaries such that differences and dependencies are learned. And, in the pragmatic approach, the integrating device is the recognition by cross-functional groups that in order to create new knowledge old knowledge must be changed, which Carlile called transformative knowledge.

Carlile's (2002) exposition about boundary objects and how they may foster cross-functional group collaboration provides me with a framework within which I can elaborate concerning the implications about cognitive gaps, in general, and cognitive level gaps, in specific. I next turn to Jablokow and Booth's (2006) formulation about cognitive gaps and extend that to work within my research.

Jablokow and Booth's proposition about four parts of cognitive gap has intuitive appeal. Few would argue that gaps exist in both cognitive style and cognitive level. And, few would argue that those gaps have an influence in problem solving. But, the measurement of both style and level creates challenges. As I demonstrated earlier, there are about two dozen concepts of cognitive style. And, I would suggest that each has some utility, depending on the specific problem under consideration. Cognitive level, as discussed at length in the Carlile research above, has several facets as well. In order to usefully employ the concepts proposed by Jablokow and Booth in my research, I must first examine the collected data and make a determination as to what to use and how to use it.

I collected a considerable amount of information about the participants in my research program. Also, I constructed several additional variables to simulate the group effects. For my exploration of what to use and how to use that data, I began with the following variables:

- Age
- Gender
- Education
- Average Education (for each subteam)
- Cumulative Education (for each subteam)
- Tenure
- Other Experience
- Job Status
- KAI Score
- Role (planner or operator)
- Total Experience (=tenure + other experience)
- Map versus Written Directions Preference

I conducted a factor analysis of all the variables shown except Gender and Map. (I will later discuss the lack of statistical significance between both Gender and Map with successful solutions to the experiment.) The first analysis suggested three factors which were distinctive: F1(TotExp, Age, Tenure, and JobStat); F2(Cumed, Aveed, Educ); and F3(KAI). However, upon closer consideration I judged that the second factor contained individual measures and team measures which inflate its importance level. Consequently, I reran the factor analysis eliminating the aggregated subteam educational factors and only used the individual educational characteristics, educ. That analysis produced a two-factor model with F1(TotExp, Age, Tenure, JobStat) and F2(KAI). Education loaded lightly on both factors (F1, .002 and F2, .003) and showed near the origin in the component plot in rotated space.

Based on those observations I concluded that, *in the context of my experimental program*, education was not a significant variable for the evaluation of gap analysis. Consequently, I conducted a third factor analysis using five variables which seemed to be significantly related to the work at hand. Figure IV-5 shows the factor loadings for cognitive style and cognitive level which I will employ for this research report.

Figure IV-5 Factor Loadings for Level and Style [a]

Variable	Factor 1 Cognitive Level	Factor 2 Cognitive Style
Total Experience	.950	
Age	.935	
Tenure	.622	-.118
Job Status	.432	
KAI Score		.999

[a] This is a rotated Principal Component Analysis using the covariance matrix and the Varimax Rotation with Kaiser Normalization. These two factors explain 89.2% of the variance.

I am adopting Carlile's (2002) knowledge in practice which is evidenced by the four factors loading on Factor 1—which I have called Cognitive Level. Clearly, this is a proxy for level as level is multi-dimensional. But, with respect to the knowledge reservoir and with respect to the Problem A which this experiment examined, the items included in Factor 1 are reasonable.

The two items loading, one positively and one negatively, on Factor 2 caused me some problem. Since the major focus of my research project is about Kirton's A-I theory and how KAI scores may be a significant indicator of cognitive style preferences, I substituted the actual KAI scores (standardized Z-scores for KAI) in lieu of the scores shown in Figure IV-5. This was due to my desire to keep the Cognitive Style factor as unadulterated as possible. I conducted a bivariate correlation analysis to check the accuracy of this change. I found that the KAI Z-scores correlated r=.999, p<.01 (2-tailed test) with Factor 2 shown in Figure IV-5. This was sufficiently close to the tabulated factor score such that I could retain KAI as an independent measure of cognitive style without introducing other effects.

I have included supporting quantitative information on the factor analysis described above in Appendix H as follows. Table H-1 is the Correlation Matrix for the principal components. Logically, as total experience rises one's corresponding age rises as well r=.794, p<.001 (1-tailed test). There was a more modest positive correlation between tenure and age, r=.485, p<.001 (1-tailed test). And, job status was modestly correlated with age r=.334, p<.001 (1-tailed test). Importantly, KAI was not significantly correlated with any of the other variables, as expected. I mention these specific correlations due to my decision to use this facet of cognitive level as a proxy to some unknown true level measure. The context of this study was in a consulting engineering firm which employs relatively well-educated people. The daily tasks of these people include considerable work in *puzzle solving* of all types. Therefore, vis-à-vis the exercise which was used for this experiment, I considered the relative time spent inside the company and outside the company doing similar work to be reasonably indicative of the specific accumulated problem-solving capacity, hence *level*, of the subjects.

Table H-2 shows the Communalities for the factor analysis. Table H-3 contains the Total Variance Explained. Note that this two-factor solution accounts for 89.2% of the total variance. Figure H-1 is the Scree Plot and Figure H-2 shows the Component Plot in Rotated Space. Tables H-4, H-5, and H-6 complete the supporting quantitative reports for the factor analysis discussed above.

Recall Jablokow and Booth's (2006) proposition about the four components of cognitive gap vis-à-vis their problem-solving model shown in Figure IV-4. I will restate each of the four parts and develop a process for tabulating each value. For purposes of brevity I will use the term Level and Style to mean Cognitive Level factor score and KAI Z-scores, respectively.

The first component of cognitive gap is Part A: a gap between two individuals and their respective styles and levels. The Jablokow-Booth model shown is the elemental condition; i.e., any fewer problem solvers would rend the model moot. Unfortunately, most problem-solving groups have more than two problem solvers and the manner in which gaps are recorded is an unsettled topic. For example, when several people band together to form a decision-making unit (sometimes called team), there are other interactions that occur: individuals do not interact in a one-on-one arrangement. Rather, there are combinations of "pairs" which individuals interact with that should be considered. In a rare mathematical approach to the question of group interactions from classical organization theory, Graicunas (1937) advanced a formulaic definition to the issue of communication within groups. I realize that communication, strictly speaking, is not a gap, but for purposes of discussion it provides a useful example. For a group with a leader, the following formula applied: $n(\frac{2^n}{2}-1)$; where n is the number of subordinates reporting to a superior. This formula yields the number of communication interactions to which the superior must attend. Graicunas did not adequately specify the nature of that interaction. This concept can inform our analysis of cognitive gaps. He identified three types of interaction: 1) direct single relationships; 2) cross-relationships; and 3) direct group relationships. Graicunas asserted that "if the number of subordinates reporting to a superior is n, then the number of the first type of relationships is n; the second type, those involving interactions between any two subordinates is n(n-1); the third type, those involving interactions between the superior and various subsets of subordinates, can be found by $n(\frac{2^n}{2}-1)$. The total of these three types is the potential number of relationships of a superior" (Massie 1965:398). Classical theorists accepted Graicunas' theoretical proposition with no empirical support. It is significant to note that the number of interactions gets quite large beyond just a few levels. For example, the number of interactions increases as follows:

> If n=3 subordinates, total number of interactions=18.
> If n=4 subordinates, total number of interactions=44.
> If n=5 subordinates, total number of interactions=100.
> If n=6 subordinates, total number of interactions=222.

In the cognitive gap analysis for my research program, there are no "bosses" or "superiors" *per se*. This leads me to reject the full formula as inappropriate since there are no superiors. The cross relationships in his formula are given by n(n-1) which, for my case, three-person groups would be 3(3-1) = 6 and four-person groups 4(4-1) = 12. There is evidence that within small groups of decision-makers there are subgroups which form and combine forces to wield greater influence. After considering this possibility I concluded that, in my research, the randomization of subteam formation combined with the relatively brief period of the actual exercise eliminated the possible formation of "cliques" which would have necessitated the n(n-1) formulation shown above. Thus, I have only used the first type of interaction measure that Graicunas called "direct single relationships."

My initial examination of cognitive gap will be assuming an additive relationship of gaps. In the following analysis, PS1 stands for "Problem Solver 1" (etc.) following the notation in the Jablokow-Booth model. The analysis is as follows for the three-person groups: PS1, PS2, and PS3, and four-person groups PS1, PS2, PS3, and PS4. Note the term "Abs" shown in the equations below indicates absolute value in Microsoft Excel© syntax.

The following are the person-person cognitive gaps in Gap Part A:

- Gap Part A: (P=3) =Abs (PS1 – PS2) + Abs (PS1 – PS3) + Abs (PS2 – PS3)
- Gap Part A: (P=4) = Abs (PS1 – PS2) + Abs (PS1 – PS3) + Abs (PS1 – PS4) + Abs (PS2 – PS3) + Abs (PS2 – PS4) + Abs (PS3 – PS4).

This aggregated gap will be recorded for each subteam (N=24). My assumption concerning using absolute values of differences was based on my desire to record the aggregation of total cognitive gaps and avoid potential algebraic cancellations of values; i.e., the sum of the gaps matters.

The second component of cognitive gap in the Jablokow-Booth model is Gap Part B, which they define as the gap between the individual and the group—this is tabulated by first finding the mean score for each subteam and then doing a variation analysis of each team member versus the mean score. I will abbreviate the subteam mean score by STM and use the prior number scheme for this measure. These are also considered person-person cognitive gaps.

- Gap Part B: (P=3) = Abs (STM – PS1) + Abs (STM – PS2) + Abs (STM – PS3)
- Gap Part B: (P=4) = Abs (STM – PS1) + Abs (STM – PS2) + Abs (STM – PS3) + Abs (STM – PS4).

I have used the same logic as before in the use of absolute values of the differences. This aggregated gap will be recorded for each subteam.

The third component of cognitive gap in the Jablokow-Booth model is Gap Part C, which they define as the gap between two groups that will be measured as differences between the subteams' mean scores. These also considered person-person cognitive gap:

- Gap Part C: = Abs (STM1 – STM2)

For the purpose of combining all elements of the gap analysis, I have again used absolute values of the subteam gaps.

The fourth component of cognitive gap in the Jablokow-Booth model is Gap Part D, which they define as the gap between an individual and the group and the requirements of a particular problem. This will require an assumption of two aspects of the problem: 1) an estimate of the relative adaptive-innovative (style) optimum of the problem versus the population style mean and 2) an estimate of the relative degree of difficulty of the problem versus the population level mean. Strictly speaking there are three problems which could, perhaps, be assigned an optimum problem style (OPS) and a problem degree of difficulty (PDD):

1. The planners' defined task of developing a method to instruct the operators how to solve the puzzle and to instruct the operators within the prescribed time. This was characterized as relatively more adaptive, in cognitive style, by Hammerschmidt (1996)—which I extended to mean that the problem itself was adaptive and, consequently, I assigned it an OPS of one standard deviation below the cognitive style mean. Likewise, I judged that this PDD was at the cognitive level mean *for this problem and this population of problem solvers.*
2. The operators initially defined task as shown on the Hollow-Square Operating-Team Briefing Sheet. This task is really just an organizing period for the operators to think about solving some as yet unknown task. Since it is relatively open-ended I could make an argument that this is relatively more innovative in style. After observing this portion of the task and discussing this with the operators in post-test periods I concluded that this task was, for all practical purposes, a red herring. Consequently I

did not consider this as a separate cognitive level and cognitive style which needed to be defined and used in the tabulations of gaps.

3. The actual operators' task of solving the puzzle, *given the solution technique developed by the planner subteam*. All instructions by the planners, if necessary and sufficient to enable the operators to solve the puzzle, must be narrowly focused on only one correct solution, must be time constrained, and must follow the prescribed rules in the material the planners worked from. These instructions must therefore be, in a word, *adaptive*. Thus, I would call the task the operators must complete relatively more adaptive. And, *faute de mieux*, I would make the assignment to be the same as the planners' initial problem, one standard deviation below the style mean. As for the PDD, I would also make the same assignment as for the planners' task; i.e., the mean of the cognitive level for the population following the same logic as for style. Given the degree of subjectivity in making these assumptions I judge them as reasonably simplifying for this research.

In my sample (N=88), the mean and standard deviation of KAI scores are 94.43 and 14.29, respectively. Recall that I substituted KAI Z-scores for the KAI Principal Component factor found in the analysis; thus, the KAI Z-score mean = 0 and standard deviation is 1. Based on the discussion of the three problem facets above, I will assume the relative adaptive-innovative optimum is one standard deviation below my sample mean, or 94.43 – 14.29 = 80.14, which by definition of Z-scores is conveniently -1.00. Thus, I will use this score for evaluating the cognitive style gaps between the OPS and the styles of both the problem solvers and the subteams' means.

As stated above I have pegged the PDD to be the cognitive level mean for this problem and this population of problem solvers. Again, since I have standardized the level variable and the mean of those scores is zero, I will assert that the PDD for this problem is <u>zero</u> for use in this analysis. For the raw score tabulation the mean cognitive level score is 66.26 for all the subjects.

Earlier I operationalized the person-person cognitive gaps using absolute values of differences between persons and person-subteam means. As I contemplated person-problem cognitive gaps I concluded that a different approach to operationalization was called for. First the person-person cognitive gaps highlight the interpersonal dynamics of group problem-solving activity. Large gaps potentially create communication problems and can lead to distrust and poor collaboration. I developed the approach using absolute values based on the fact that I wanted to magnify the degree of gaps, believing that there is some unknown optimum degree of person-person cognitive gap, both style and level, in the pursuit of solutions to problems. And, I noticed that the mathematical expressions were cancelling, and therefore, minimizing the degree of gaps in the groups. Thus, I used absolute values for the person-person cognitive gaps, both level and style.

Concerning the person-problem cognitive gaps I first approached this considering cognitive level gap between the problem and the person. Arguably a positive gap is better than a negative gap vis-à-vis solving the problem. Put another way, having more cognitive level (knowledge is local, embedded, and invested in the particular objects) than the presumed PDD is better than having less. Consequently, the operationalization of the person-problem cognitive gap led me to assert an algebraically additive relationship of cognitive level gaps from the PDD. For example, if the PDD is pegged at 5 and there are three persons whose cognitive levels are 10 each, that means there are positive 15 points ((10-5) x 3 = 15) of cognitive gap—which I believe to be indicative of abundance of cognitive level with respect to solving the problem under consideration. However, if there are three persons whose cognitive levels are 1 each for the same problem, this yields a negative cognitive gap of -12 points ((1-5) x 3 = -12) of cognitive gap—which I believe to be indicative of shortage of cognitive level with respect to solving the problem under consideration. Had I employed the same logic as with the person-person cognitive gaps (i.e., using the absolute values of gaps) these two groups of people would have registered very nearly the same cognitive level gap for the teams; i.e., 15 points and 12 points, respectively. Since the operationalization of person-problem gap required the assignment of some presumed optimum cognitive level for the problem, it logically follows that the different person-problem gaps should be algebraically additive.

I used similar logic to assert an algebraically additive relationship between person-problem cognitive style gaps. Granted, style is bipolar where more is not necessarily better. But, with respect to OPS it is logical that if a problem is pegged at optimal cognitive problem style of 96, then having too many problem solvers with style scores of 130 might lead to problems and having too many people with style scores of 60 might also lead to problems. Treating the cognitive style scores as algebraically additive would allow for some degree of balance between high adaptors and high innovators balanced around the OPS. For example, if a problem OPS was 90 and there were four problem solvers on the team with style scores PS1=60, PS2=70, PS3=130, and PS4=100, this would yield the following cognitive style gap with respect to the problem: 60 – 90=-30; 70-90=-20; 130-90=+40; and 100-90=+10. In total the person-problem cognitive style gap would yield: -30 -20 + 40 + 10 = 0; an aggregate of zero gap of cognitive style between the team of problem solvers and the problem. I have assumed that person-person cognitive style gaps cover group dynamics and interpersonal style conflict. I have assumed that the same type of conflict does not occur between the person and problem. Hence, a person-problem cognitive style gap of zero (based on the tabulation shown) is better than a person-problem style gap of either +X or –X.

I will use the following analysis with style variable for three-person subteams and OPS= -1.00:

- Style Gap Part D (P=3) = (PS1 – (-1)) + (PS2 – (-1)) + (PS3 – (-1)) + (STM – (-1))

  This reduces to:

- Style Gap Part D (P=3) = (PS1 +1) + (PS2 +1) + (PS3 +1) + (STM +1), or
- Style Gap Part D (P=3) = (PS1 + PS2 + PS3 + STM) + 4

For the four-person subteams and OPS:

- Style Gap Part D (P=4) = (PS1 – (-1)) + (PS2 – (-1)) + (PS3 – (-1)) + (PS4 – (-1)) + (STM – (-1))

  This reduces to:

- Style Gap Part D (P=4) = (PS1 +1) + (PS2 +1) + (PS3 +1) + (PS4 +1) + (STM +1), or
- Gap Part D (P=4) = (PS1 + PS2 + PS3 + PS4 + STM) + 5

The level gap for Part D requires an estimation of the degree of difficulty of the problem. The puzzle used in this experiment has been considered of moderate difficulty and, consequently I will assume it to equate to the level proxy variable mean score; i.e., *zero*.

- Level Gap Part D (P=3)= (PS1 - PDD) + (PS2 - PDD) + (PS3 - PDD) + (STM - PDD), or with PDD=0

  This reduces to:

- Level Gap Part D (P=3)= PS1 + PS2 + PS3 + STM

For the four-person subteams and PDD:

- Level Gap Part D (P=4)= (PS1 - PDD) + (PS2 - PDD) + (PS3 – PDD) + (PS4 - PDD) + (STM - PDD), and with PDD=0

  This reduces to:

- Level Gap Part D (P=4)= PS1 + PS2 + PS3 + PS4 + STM

Because I plan to examine the cognitive gap analysis also based on raw scores, I must calculate these expressions. Recall the assumption that the OPS was one standard deviation below the mean. In my case that is 1 s.d.=14.3 KAI points. Thus, 94.43 – 14.29 = 80.14 points is the presumed KAI optimum for the problem solver. That means that the style gap for Part D is as follows:

- Style Gap Part D: (P=3)= (PS1-80.14) + (PS2-80.14) + (PS3 – 80.14) + (STM – 80.14)

  This reduces to:

- Style Gap Part D: (P=3)= PS1+ PS2 + PS3 + PS4 + STM -320.56

For the four-person case

- Style Gap Part D: (P=4)= (PS1-80.14) + (PS2-80.14) + (PS3 – 80.14) + (PS4 – 80.14) + (STM – 80.14)

  This reduces to:

- Gap Part D: (P=4) = PS1 + PS2 + PS3 + PS4 + STM – 400.7

I will use the following analysis with level variable for the raw score tabulations. For three-person subteams with PDD = 66.26 (mean of all subjects).

- Level Gap Part D (P=3)= (PS1 - PDD) + (PS2 - PDD) + (PS3 - PDD) + (STM - PDD), or with PDD= 66.26

  This reduces to:

- Level Gap Part D (P=3)= PS1 + PS2 + PS3 + STM - 265.04

For the four-person subteams and OPS:

- Level Gap Part D (P=4)= (PS1 - PDD) + (PS2 - PDD) + (PS3 – PDD) + (PS4 - PDD) + (STM - PDD), and with PDD=66.26

  This reduces to:

- Level Gap Part D (P=4)= PS1 + PS2 + PS3 + PS4 + STM – 331.3

The person-person cognitive gaps are measured as absolute values. The person-problem cognitive gaps will be sign sensitive since they are measured either above or below an assumed style and level for the problem.

As mentioned earlier, the formulation of cognitive gap measurements and aggregations have assumed a simple algebraic difference approach to tabulation, which I have called the additive model. For exploratory evaluation of how my findings fit the model, I also developed a multiplicative relationship between persons. And, since the relatively small numbers which are produced in a factor analysis are frequently fractions less than one, I have also done a square-root analysis of the multiplicative output. I did perform the same analysis using the raw scores for making a comparison. This explorative work was based on the fact that I had no *a priori* expectations about the degree to which gap should have impacted the results. I developed the following four models and conducted difference of means tests to assess the degree to which the assumed model represented the experimental outcomes.

1) Additive Model (Level Factor Scores & KAI Z-scores)
2) Multiplicative Model (Level Factor Scores & KAI Z-scores)
3) Square Root Model (Level Factor Scores & KAI Z-scores)
4) Raw Scores Model (Level = Educ + TotExp + Tenure + JobStat and KAI)

The difference of means tests factored for successful trials were conducted on the seven different measures as shown in Figure IV-6. The Gap A, etc., shown in the table refer to the gap parts indicated above in the Jablokow-Booth model.

I developed the four models as defined above and conducted rigorous comparison between the four and found that there were no statistically significant differences of means, really, for all four. And, since the multiplicative model and the square-root model were derivatives of the factor model, they tended to obfuscate the information further. I therefore dropped those two from the analysis and chose, instead, to report the cognitive gaps based on the factor scores as described above and on raw scores. In my subsequent discussion I have reported those and comment as appropriate. (I revisited this topic in Chapter VII during the discussion of my findings and the implications.)

Figure IV-6 is the template with which I will report cognitive gaps for each trial. Note each report will contain a row for the Additive Model (Add Model) and Raw Scores Model (Raw Model). Within each of those there are two additional subcategories: cognitive level

(level) and cognitive style (style). And within those two categories I report on the planner subteam (Pl) and the operator subteam (Op).

Figure IV-6 Cognitive Gap Computation Template

		Role	Subteam Gap A[a]	Subteam Gap B[b]	Team Gap C[c]	Subteam Gap D[d]	Subteam Gap A+B[e]	Subteam Gap A+B+D[f]	Team Gap= A+B+C+D[g]
Model	Level	Op	1.95	1.11	0.16	-2.66	3.06	0.41	17.04
		Pl	2.07	1.24	.	-2.02	3.32	1.30	
	Style	Op	3.92	2.38	1.17	1.08	6.30	7.38	
		Pl	0.56	0.33	.	5.75	0.89	6.63	

[a] Person-person cognitive gap within subteams (gap between individuals)
[b] Person-person cognitive gap within subteams (gap between individuals and subteam mean)
[c] Person-person cognitive gap between subteams (gap between subteam means)
[d] Person-problem cognitive gap within subteams (gap between individuals)
[e] Person-person cognitive gap subteam total
[f] Person-person AND person-problem cognitive gap for subteams
[g] Person-person AND person-problem cognitive gap for total team

7. Adaptation of the Critical Incident Technique and the Jablokow-Booth Gap Model

I developed a video analysis log for each trial which provided a structure for defining communicative acts during the deliberations of the planners and the operators. The video analysis log contained a column for idea/comment, time start, length, and description. During the first video review I recorded brief descriptions of communication which occurred during the discussions and gave them a time tag. Where unusual observations occurred I made special notes; e.g., where a person did not speak or contribute for considerable time or where the operations group barged in prior to the time they were supposed to. Following the initial viewing and compilation of video analysis log I made notes on the table about more critical incidents by asterisks at the specific time tag. This step enabled me to narrow the field of review for subsequent video reviews.

The next step in the process serendipitously became my adaptation of the critical incident technique. Prior to the exercise I committed to presenting a feedback educational session with all the participants of the experiment. After viewing the video it was clear that 12 hours of video recording was too voluminous for a reasonable feedback period. In fact, it was very clear that major contributions to success or failure during the problem solving exercise could be condensed into relatively small time segments. Thus, I embarked on creating an action movie which captured the critical incidents of decision making for the planners and operators. The planners' deliberations were typically reduced to roughly three minutes of critical incidents while the operators' deliberations were captured in about two minutes of critical incidents. My technique consisted of editing the film to convey critical communicative acts. I included some dialogue and non-verbal acts which may be considered non-critical for the purpose of conveying emotional and interpersonal relationships where they were judged to add richness to the final video. The final edited trial video clips were ultimately put together to make a movie report of the exercises. Lastly, the serendipity occurred when I realized that the dialogue in the final edited trial video clips was, in fact, critical incidents after the fashion of Flanagan (1954). In a few cases I included some additional dialogue in this written report that does not appear in the video simply because of the difficulty to convey the emotional tension adequately with abbreviated reports of the deliberations of planners and operators.

My careful reporting of critical incidents was intended to be replicable by other researchers viewing the same material. I am confident that any other trained observers would judge the same incidents as critical and, consequently, arrive at the same conclusions that I have regarding assigning meaning to communicative acts.

I have included information related to the Jablokow-Booth gap analysis model as discussed above. The Jablokow-Booth gap analysis model includes both style gap and level gap in its formulation. I have included both in my analysis however the central focus of my work has been on cognitive style and the extension into cognitive level is considerably more speculative than the discussion concerning cognitive style. In spite of the relatively superficial inclusion of cognitive level into this discussion I suggest that it does bring value to the conversation and raises new questions and possible avenues for additional research.

In the following sections of this chapter I will report on each of the 12 trials using the same presentation format. Each will begin with a table of information which reports on the subjects in the particular trial. That table will be followed by a companion table that contains the various combinations of cognitive gaps which will be used for additional qualitative evaluation. I will report the critical incidents, as discussed above, for the planning subteam and the operations subteam in turn. I will report on the ability of the team to solve the puzzle in the allotted time. In Section 7.1 I will elaborate on different parts of the table of information. These elaborations will be applicable to subsequent trial descriptions.

7.1 Fort Myers: FM-T1

This was the first trial and was conducted by Linda Vaughn in Fort Myers, Florida on December 1, 2009. All the participants arrived at 7:00 AM to participate and Vaughn provided breakfast snacks for them. When Vaughn asked the participants about video recording one dropped out—an option that was provided orally and in writing to all participants. Unfortunately one of the other volunteers was absent which meant there were only six participants for the team—two subteams of three each. Table IV-4 displays the information about participants and aggregated team statistics.

Note that FM-T1 is a non-role preferred trial where the relatively more innovative subteam plays the planner's role. Due to last minute changes which Vaughn had to deal with the code names were not assigned as the original plan called for. Thus, the code names were miss-assigned for the operators. Strictly speaking that has no meaning except as it relates to my reporting any specific behavior or comments made by one of the participants. To the extent that is significant I will address it.

In Table IV-4 I have recorded gender with the initials M or F. These were recoded as male = 1 and female = 0 when put into the SSPS format. On the pre-experiment questionnaire education was reported as high school, college, tech school, BS, MS, PhD or JD. I coded these as 12, 13, 14, 16, 18, or 21, respectively, to reflect the approximate number of years each educational level represented. Tenure meant for the host company and Other (experience) was for similar work with other companies. Total experience was recorded as Tot Exp. Map refers to an individual's preference when needing driving directions.

The choices provided on the questionnaire were written (W) or map (M). Some people answered the question with "both" and when that occurred I selected written (W) for that case. This was used as an indication of an individual's latent graphical and/or geometrical intelligence. Job Status was recorded for each individual. The Supplemental Questionnaire which participants filled out during the initial session asked for subjects to list their titles. I created a hierarchical scale for each of three divisions within this company which reflects the relative position of each participant relative to others. I also estimated an interdivisional hierarchical assignment of the job status positions for use in cognitive gap analysis tabulations. I have shown the Job Status Key in Table IV-5. Table IV-4 contains both individual and team information. Factor scores for Style (KAI) and Level are shown below the raw scores in the chart. Also, subteam means for both Style and Level are shown. These were the data used in the tabulation of cognitive gaps as shown in Table IV-4A below.

Table IV-4. Trial: FM-T1

Role	Operators				Planners			
Subteam	Relatively More Adaptive				Relatively More Innovative			
Code Name	Abe	Bo	Chris	Dale	Mel	Nat	Pat	Ray
Individual Attributes								
Age	27	49	30	-	41	25	40	-
Gender	M	F	M	-	M	M	M	-
Ed	12	12	13	-	16	13	12	-
Tenure	3	5	1	-	.2	4.5	4.5	-
Other Exp	0	0	0	-	15	1.5	13	-
Tot Exp	3	5	14	-	15.2	6	7.5	-
Map	W	W	M	-	M	M	M	-
Style (KAI)[a]	95 .04	67 -1.92	91 -.31	-	99 .32	100 .39	103 .60	-
Job Status [b]	S2 2	C1 2	S1 1	-	S4 4	S3 3	S3 3	-
Level [c]	35 -1.22	61 -.24	50 -.53		60.4 -.09	38.5 -1.13	65 -.29	
Subteam Attributes								
Mean Style	84.3 -.73				100.7 .44			
Mean Level	48.67 -.66				54.63 -.5			

[a] Style Proxy is KAI scores-Tot number is raw score and bottom number is standardized KAI Z-score
[b] Job Status numbers are taken from Table IV-5. Top numbers are Domain Specific Scores and bottom numbers are interval scores.
[c] Level Status proxy is based on Factor Analysis which loaded Age, Tenure, Total Experience, and Job Status. Top number is Age + Tenure + Total Experience + Job Status. The bottom number is the actual Factor Score produced in a Principal Components Analysis

The original plan called for the paired subteams to have mean KAI scores which were more than 1.5 standard deviations (S.D.) apart. In this case the total S.D. was 13.2 and, therefore, the desired difference between subteam mean KAI scores was 19.8. The difference between subteam mean KAI scores was only 16.3.

Table IV-4A. Cognitive Gaps: Trial FM-T1

(Gap Model Comparison)

		Role	Subteam Gap A[a]	Subteam Gap B[b]	Team Gap C[c]	Subteam Gap D[d]	Subteam Gap A+B[e]	Subteam Gap A+B+D[f]	Team Gap= A+B+C+D[g]
Add Model	Level	Op	1.95	1.11	0.16	-2.66	3.06	0.41	17.04
		Pl	2.07	1.24	.	-2.02	3.32	1.30	
	Style	Op	3.92	2.38	1.17	1.08	6.30	7.38	
		Pl	0.56	0.33	.	5.75	0.89	6.63	
Raw Model	Level	Op	52.00	27.33	5.97	-70.37	79.33	8.96	270.57
		Pl	53.00	32.27		-46.51	85.27	38.76	
	Style	Op	56.00	34.00	16.67	15.44	90.00	105.44	
		Pl	8.00	4.67		82.11	12.67	94.77	

[a] Person-person cognitive gap within subteams (gap between individuals)
[b] Person-person cognitive gap within subteams (gap between individuals and subteam mean)
[c] Person-person cognitive gap between subteams (gap between subteam means)
[d] Person-problem cognitive gap within subteams (gap between individuals)
[e] Person-person cognitive gap subteam total
[f] Person-person AND person-problem cognitive gap for subteams
[g] Person-person AND person-problem cognitive gap for total team

The relative job status determination as shown in Table IV-5 required some degree of subjectivity. It does, however, reflect perceived differences across divisional lines.

In reporting the following discourse I will, from time to time, indicate the factor score of the speaker on both the Level and Style as follows; e.g., Nat (-1.13, .39). The first factor is the Level score and the second is the Style score.

Table IV-5. Job Status Key [a]

Surveying Domain	Engineering Domain	Corporate Domain	Job Status
S1-Rodman/clerical	E1-Clerical/CAD		1
S2-I-man	E2-Engineer intern	C1-Clerical	2
S3-Party chief	E3-Professional engineer	C2-Professional	3
S4-Project manager	E4-Project manager		4
S5-Survey manager	E5-Group manager		5
S6-Survey executive	E6-Engineering executive	C3-Manager	6
			7
			8
			9
		C4-Corporate executive	10

[a] Surveying and Engineering Domain items S1, E1 through 6 have comparable Job Status numbers. Corporate Domain items rank higher as indicated

Trial FM-T1 was conducted in a conference room with two of the participants on one side of a table and one on the other. The table was relatively narrow and it appeared to be relatively cluttered during the assignment. Nat held a pen and appeared to be writing instructions during the entire planning period. Nat asked, “So we have enough pieces between all of us to assemble the key sheet, is that correct?” And before the facilitator could answer he continued, “So, can we combine all our pieces together right now?” The facilitator answered, “Everything you need is on the instructions.” Nat said, “All right” and continued reading the instructions. Nat also said, “Half the battle is just finding out what pieces we’ve got.” One of the unplanned situations that became evident in this trial was the problem with the instructions being written for four people. As Nat continued reading he could be heard reading, “Each of you has an envelope containing four cardboard pieces…” When the exercise was run with only three planners there was no modification of the instructions and no evidence of facilitator pointing out the nuance that occurs when only three planners are working. It is interesting that Nat (-1.13, .39) was more than one standard deviation below the problem degree of difficulty discussed above (PDD), which was assumed to be zero or the mean of the factor score for Level. Nat dominated the conversation and appeared to control the decision process with his writing of instructions.

All three planners appeared to read through the instructions taking turns to mention something aloud. They clearly fixated on different aspects of the instructions for example; Nat admonished the other participants with, "Don't touch my pieces" four times during the exercise period. It appeared that Pat never quite comprehended that part of the instruction prohibition.

I cannot be certain that there was substantive confusion over the number of pieces the three-person planning subteam had to deal with. However, Nat found another puzzle piece in his envelope after about five minutes of work and he asked Mel if he had more pieces. Mel looked and surprisingly said yes, "I'll be damn." He had two more puzzle pieces. This occurred well into the planning period. During this time Nat was writing the name of which planner had which puzzle pieces on the Hollow Square Key Sheet. This process consumed much of the planning period.

Mel (-.09, .32) [whose Level score was closest to the PDD] offered a solution to their task about 10 minutes into the planning period, "We could put the three together side by side together like they should look." But, Pat commented, "We can't assemble the puzzle" and that comment seemed to stop Mel from pursuing that solution concept. Pat and Nat carried on a dialogue about their task and how might they tell the operations subteam to assemble the puzzle. They displayed uncertainty as to what they could give the operations subteam. At one point Pat asked, "We can't write on anything…we cannot give them anything with paper written on it?" The facilitator replies, "Everything you can and can't do is on that sheet of paper." All the planners laughed and Nat said, "Read the paper." However, clearly the consensus of the planners by this time was that they could not provide any written instructions or graphical sketches to the operations subteam. Pat concluded that their task was to, "Plan to tell them how to put it together."

Much of the remainder of the planners' time was spent with Nat attempting to write instructions for the operations subteam. It appeared that the planners convinced themselves that they could not show even the "pattern sheet" which is a drawing of a square with a square opening in its center. Nat's written instructions (which are only going to be given orally) included a sentence that says, "All the pieces can be arranged to create a square with a small square one-sixth its size in the center." Mel offered, "You can draw it too to show," but Pat said, "No, we need to verbally tell them…" This seemed to settle that line of reasoning. Shortly after that Pat received a cell phone call that he took and said, "Can I call you back?"

As the planners' time limit grew close they did not appear to be aware of their deadline. For example, Pat was trying to help describe how the various pieces could go together and touched Nat's puzzle piece. Nat replied, "What did you not understand abut don't touch my pieces!" Pat replied, "Why?" as if he had not read the instructions at all. Nat replied, "I don't care, I'm just saying its right here in the instructions."

The relatively inconsequential discourse continued with Nat writing what he thought were instructions which, apparently, he was going to orally give to the operating subteam. As this dialogue continued Pat reinforced the belief that this planning subteam had established, "We can reiterate to them…they're not going to see what you are writing." The facilitator called out, "It's been 20 minutes" and the planners groaned, "Oh man…" Finally, the facilitator said, "You've got three minutes, you need to get them in here and give them some instructions." Pat looked at the facilitator and said, "Now we do?" and the facilitator said, “Yes.” Simultaneous with this discourse Nat said, “Oh my goodness” in apparent surprise. Pat arose and left the room to retrieve the operations subteam. Note that the facilitator was not supposed to intervene with the planners’ process to the degree she did in this instance. Strictly speaking the facilitator should have let the planners use their entire 25 minutes as they saw fit and call time at the 25 minute mark. Following that time the planners would not be permitted to provide any further instructions to the operating subteam.

There was no video record of the explanation period where the planners read their copious instructions to the operators. The facilitator wrote that the instructions were confusing and unclear to the operating subteam. The video record of the operating subteam showed the participants beginning the exercise by putting all the pieces in the center of the table and beginning a random movement of pieces in a vain attempt to assemble a puzzle that they were uncertain as to how it looked. The facilitator called time shortly after 20 minutes and asked, “Would you like for me to show you how it looks?” The operating team was frustrated and answered, “Yes.” Trial FM-T1 ended in the team not solving the puzzle.

Recall the cognitive gap analysis depicted in Table IV-4A above. I have conducted difference of means tests for each of the seven cases shown in this table. In all cases, the tests failed to rise to statistical significance. The quantitative results of those tests are shown in Table H-7 through Table H-20 found in Appendix H. Tables H-7 through H-13 are for the additive model using factor scores and Tables H-14 through H-20 are for the additive model using raw scores.

In the Ft Myers T-1 trial most of the video recorded was on the planners’ deliberation. The person-person cognitive gaps (A+B), again the numbers are ordered by level followed by style, for trial FT-T1 are (3.32, 0.89). Cognitive style and cognitive level combine in some unknown way to impact decision-making outcomes. Thus, it is reasonable to combine subteam person-person gaps with person-problem cognitive gaps to reveal the total cognitive gap within a subteam (A+B+D). The subteam total cognitive gap for FM-T1 was (1.3, 6.63). In a separate analysis I calculated the mean scores of successful planning subteams for both Level and Gap. I found those mean scores for Level and Style to be (9.41, 11.54) considerably different from the FM-T1 results.

The operator subteam for FM-T1 was a non-factor in the solution of the puzzle given the poor quality of their instructions. I should note that the person-person cognitive gap for the operator subteam was (3.06, 6.3). The person-person and person-problem cognitive gap for the operator subteam was (0.41, 7.38).

The total cognitive gap for trial FM-T1 was 17.04 (A+B+C+D). Note this combines both Level and Style into a single factor to be indicative of some interactive effect. The mean total cognitive gap score for successful trials was 41.76, considerably greater than the FM-T1 score.

7.2 Clearwater CW-T1

I administered trial CW-T1 on Dec 17, 2009 during the regular lunch period. Note that CW-T1 was a <u>role-preferred trial</u>; i.e., the relatively more adaptive subteam played the planning role. Owing to a subject's absence on the day of the trial I switched some team members around to make sure there were four planners since by this time I had become aware of the more critical nature of the planning team in comparison to the operating team. Table IV-6 contains the vital information about the individual participants and their team characteristics. Note that the difference in mean KAI scores between subteams was only 11.3

points, only slightly more than the standard deviation of KAI scores for all seven members of trial CW-T1. This is below the desired difference of 1.5 S.D. as earlier mentioned.

The video camera was positioned in one end of a room on a tripod and was turned on prior to the time the participants entered the room. No one appeared to notice or care about the video and it was not mentioned during the entire exercise. Tables were arranged to provide ample working space. And, participants were positioned in one of four spots around the table in order to maximize the camera shot in an unobtrusive way.

After I distributed the four envelopes to the planners they spent several minutes reading over the Planning Team Briefing Sheet before anyone spoke. They first got puzzle pieces on the table. Finally, Chris asked to no one in general, “Is there any reason we can’t write out the instructions and give it to the team?” To which Bo responded, “As I see it that is the only way we could do it.” The planners continue for some time arranging their pieces and talking about how to write instructions. Of the four planners I should note that Chris (1.06, 0.11) was considerably more senior in both age and job status than his subteam.

Dale (-0.69, 0.11) appeared to have an eureka[10] moment when she asked, “Oh, can we write down who has what…” And Chris interrupted with, “Yes.” Dale went on to say, “Okay, we do a drawing and put our names in the puzzle shapes.” By the comment *do a drawing* Dale was referring to sketching the puzzle piece shapes on the Pattern Sheet. The planners discussed this and concluded that there was nothing that prevents them from sketching the puzzle shapes on the pattern sheet. The planners continued getting puzzle pieces identified and laid on the table in some orientation like they would appear in the completed puzzle. Dale seemed to be missing a piece and looked in her envelope to discover

[10] I use this term to convey when a participant sees a solution or a part of a solution to their task. In the section above on Problem Solving, Creativity, Level, and Style the term “ah ha” moment was used to describe the same concept.

another piece—roughly 13 minutes into the allotted time period. Chris suggested that they name the puzzle pieces Abe 1, Bo 1, Chris 1, Dale 1, etc. and said, "And then we can write a descriptive legend…"

Table IV-6. Trial: CW-T1

Role	Planners				Operators			
Subteam	Relatively More Adaptive				Relatively More Innovative			
Code Name	Abe	Bo	Chris	Dale	Mel	Nat	Pat	Ray
Individual Attributes								
Age	27	45	48	38	47	47	48	-
Gender	M	M	M	F	M	M	M	-
Ed	16	16	16	16	16	16	16	-
Tenure	0.4	3.5	23	3.5	4	9	5	-
Other Exp	0	13	3	0	24	22	23	-
Tot Exp	.4	16.5	26	2.5	28	31	28	-
Map	W	W	M	M	M	M	M	-
Style (KAI)[a]	73 -1.50	87 -.52	96 .11	96 .11	96 .11	101 .46	101 .46	- -
Job Status [b]	E2 2	E4 4	E6 6	C2 3	E5 5	E5 5	E4 4	- -
Level [c]	29.8 -1.46	69 .15	103 1.06	48 -.69	84 .79	92 1.03	85 .87	- -
Subteam Attributes								
Mean Style	88.0 -.45				99.3 .34			
Mean Level	62.5 -.24				87.0 .90			

[a] Style Proxy is KAI scores-Tot number is raw score and bottom number is standardized KAI Z-score
[b] Job Status numbers are taken from Table IV-5. Top numbers are Domain Specific Scores and bottom numbers are interval scores.
[c] Level Status proxy is based on Factor Analysis which loaded Age, Tenure, Total Experience, and Job Status. Top number is Age + Tenure + Total Experience + Job Status. The bottom number is the actual Factor Score produced in a Principal Components Analysis

Dale ripped the Pattern Sheet from the stapled sheets and said she was going to trace the key sheet on the pattern sheet to which Chris said, "yes." As Dale began tracing the puzzle shapes onto the Pattern Sheet Chris said, “They don’t have to be that accurate…” to which Dale replied, “Well, you know, I like to do things perfect!”

Abe (-1.46, -1.5), who had been the least communicative in terms of times spoken, asked, “So I guess while we’re doing that shouldn’t one of us go and tell them what…I guess part of this time is we have to go instruct them on what to do…” Chris asked, “We’ve got to go instruct them and they come back in here?” Chris looked toward the facilitator for any visual cue that he has made a correct interpretation of the instructions. The facilitator was busily writing and did not make any eye contact which might convey a message. Abe said, “Yea, I think that’s it…” The planners concluded that they would leave written instructions and they were going to go brief the operating team. Chris and Abe rose to leave the room to go instruct the operating team and as they were leaving Dale said, “Just remember to tell them what our names are…” to which Chris replied, “I’m going to give them a map telling them where we were sitting…” A few minutes passed while Dale continued to refine her sketch of the puzzle pieces on the Pattern Sheet and to write notes about which group to start with, etc. Bo (0.15, -0.52) began gathering materials up and said, “We probably need to take this stuff with us so we don’t break the rules.”

The three-person operating subteam came in and quickly reviewed the Pattern Sheet key that was left. They reviewed the instructions and organized themselves with Pat and Nat telling which pieces went where and Mel took the pieces and assembled them. Mel (0.79, 0.11) expressed concern that they make sure they accurately assemble the puzzle asked, “Am I allowed to write on these,” [the puzzle pieces] and answered his own question with, “There’s no limitations, right?” The operations subteam very quickly assembled the puzzle. Trial CW-T1 was successful.

Table IV-6A contains all the person-person cognitive gaps and person-problem cognitive gap tabulations. The planner subteam provided excellent instructions for the operating team. In this case the planner subteam gaps (A+B) were (11.79, 7.7). Both scores were above the mean scores of successful trials (9.19, 6.51) by a relatively small amount.

Table IV-6A. Cognitive Gaps: Trial CW-T1

(Gap Model Comparison)

		Role	Subteam Gap A	Subteam Gap B	Team Gap C	Subteam Gap D	Subteam Gap A+B	Subteam Gap A+B+D	Total Team Gap= A+B+C+D
Add Model	Level	Op	0.47	0.26	.	3.59	0.73	4.32	33.84
		Pl	8.41	3.37	1.13	-1.18	11.79	10.61	
	Style	Op	0.70	0.47	.	5.37	1.17	6.54	
		Pl	5.46	2.24	0.79	2.75	7.70	10.45	
Raw Model	Level	Op	16.00	10.00		82.96	26.00	108.96	703.33
		Pl	240.60	94.20	24.55	-19.05	334.80	315.75	
	Style	Op	10.00	6.67		76.77	16.67	93.44	
		Pl	78.00	32.00	11.33	39.30	110.00	149.30	

The subteam total gap (A+B+D) was (10.61, 10.45) as compared to the successful planner subteam means of (9.41, 11.53), very nearly the same scores for both level and style. And, the total team cognitive gap was (33.84) versus the mean successful scores of (41.77). This indicates less cognitive gap, in total, than the mean successful outcomes.

Interestingly, the operator subteam gaps for this trial were somewhat less pronounced than for the planner subteam; i.e., person-person (A+B) gap (0.73, 1.17) and person-person with person-problem (A+B+D) gap (4.32, 6.54). The operator subteam exhibited no conflict during their solution as they had assigned a team leader prior to coming into the room for solving the puzzle.

7.3 Clearwater CW-T2

I conducted trial CW-T2 on Dec 18, 2009 beginning at 11:30 AM due to a schedule conflict with one of the participants. Unfortunately, by starting prior to noon one of the subjects was unable to participate as he was driving from another office. Fortunately that participant was scheduled to be on the operations subteam and, therefore it was less consequential. Note that CW-T2 was a non-role preferred trial with relatively more innovative subteam playing the planners' role. This trial was one of two where the entire planning subteam was female. See Table IV-7 for the vital information of participants and aggregated scores. Since the mean KAI scores for samples of female population in the US are 91 points it is worth noting that this all female planning subteam had a mean KAI score of 105.3, considerably higher than the population mean.

It was not known that one of the operating subteam would be unable to participate when the exercise began, consequently the pre-arranged code names resulted in Abe being unused.

This trial, like CW-T1, was administered in a conference room with ample table space and good orientation for the camera shot. Like with CW-T1, I turned the video recorder on prior to the time the participants entered the room. This seemed to work well in de-emphasizing the camera's presence.

The planners were relatively talkative during their deliberation period, reading some of the instructions aloud and commenting on the meaning of various things. They discussed where their pieces went in the puzzle. Planner Nat (0.46, 0.88) appeared to take over the reading of the instructions and was clearly more dominant in the formative stages of the planners' deliberation. The planners spent nearly 10 minutes discussing where their pieces went in the puzzle and approaching the problem by quadrants.

After about 12 minutes Ray (0.38, 1.86) began to examine the rules more closely. She said, "We can show them the pattern sheet." Nat continued to discuss how they would instruct the operating subteam to assemble the puzzle pieces to look like the pattern sheet. Pat

Table IV-7. Trial: CW-T2

Role	Operators				Planners			
Subteam	Relatively More Adaptive				Relatively More Innovative			
Code Name	Abe	Bo	Chris	Dale	Mel	Nat	Pat	Ray
Individual Attributes								
Age	-	35	42	59	29	44	40	54
Gender	-	M	M	M	F	F	F	F
Ed	-	16	14	18	16	13	17	14
Tenure	-	2	2	14	4.5	3	6	0.2
Other Exp	-	0	20	23	1.6	20	0	11
Tot Exp	-	2	22	37	6	23	6	11
Map	-	M	M	M	W	M	M	W
Style (KAI)[a]	-	92	95	99	100	107	109	121
	-	-.17	.04	.32	.39	.88	1.02	1.86
Job Status [b]	-	C2	E1	E3	E2	C2	E3	E1
	-	3	1	3	2	3	3	1
Level [c]	-	42	67	113	41.6	73	55	66.4
	-	-.94	.26	1.98	-.95	.46	-.41	.38
Subteam Attributes								
Mean Style	95.3				109.2			
	.06				1.04			
Mean Level	74.0				59.0			
	.40				-.13			

[a] Style Proxy is KAI scores-Tot number is raw score and bottom number is standardized KAI Z-score
[b] Job Status numbers are taken from Table IV-5. Top numbers are Domain Specific Scores and bottom numbers are interval scores.
[c] Level Status proxy is based on Factor Analysis which loaded Age, Tenure, Total Experience, and Job Status. Top number is Age + Tenure + Total Experience + Job Status. The bottom number is the actual Factor Score produced in a Principal Components Analysis

(-0.41, 1.02) pulled the Pattern Sheet from the stapled materials and laid it in front of her and appeared to have an eureka moment. She said, “If that’s the case can you put them [the puzzle pieces] on there [the pattern sheet]?” As Pat paused to move some papers from in front of her Ray almost simultaneously said, “Can you put them on there?” Pat began laying her puzzle pieces on the Pattern Sheet in the correct orientation. Ray looked toward the facilitator clearly looking for a visual clue about breaking the rules and, receiving none asked, “Would that be wrong?” and Nat replied, “No it’s not if we each put them on there.” The others pulled their Pattern Sheets loose and did likewise. Ray said, “It’s nothing exciting about it but it does give a good depiction and if you use the center square to come off of…” to which Nat interjected, “Yea, that’s exactly what I’m doing too.” After all the planners placed their pieces on their individual Pattern Sheets Nat said, “There we go, look at that; its funny you can see how the puzzle goes together now.” Nat chuckled and said, “Oh we’re good,” to which the relatively quiet Mel (-0.95, 0.39) responded, “Well, maybe.” The planners had the solution at roughly 14 minutes into the 25 minute planning period. In fact one mentioned, “I think we’re done.”

The planners used a considerable amount of time discussing who might instruct the operating subteam to assemble the puzzle. It was evident that they had no notion that they should go retrieve the operations team to provide them instructions. The planners sat for several minutes after they selected Mel to be the instructor. Suddenly, the operating subteam opened the door and asked, “Is it time?” about three minutes before the 25 minute planning period elapsed. All the planners turned to the facilitator for a visual cue. The facilitator shrugged as if to say “whatever.” Nat then turned to the operators still at the door and replied, “We’re ready.”

The operators entered and Nat said, “Hello Bo, Chris, and Dale, how are you?” Mel asked “Do we need to wait for the fourth—or the eighth?” And, Bo replied, “It looks like he’s not going to be here soon.” Following that, Mel began the oral instructions, “Okay, we have a puzzle for ya’ll to put together. Its going to make a hollow square pattern like you see here.” “We have mapped out where our pieces pretty much go on our own pieces of paper and they’re all facing the same orientation so you should be able to see where I have my square here…” I interrupted at this point with “Okay, time—its 25 minutes, now the planning team can provide no more instructions…” At this time the planning subteam left the room to have their lunch. As they were leaving Nat said, “I thought we had 10 minutes…”

The operations subteam took their place at the table and Dale (1.98, 0.32) said, “They are placed deliberately where they are so we should be aware of that.” Bo (-0.94, -0.17) suggested, “You take one [set of pieces] and place it in, and take the next and place it in, and take the next and place it in, and then the last piece and place it in.” The operators viewed the puzzle pieces for a while before they ever touched any piece. Finally they began assembling the puzzle and quickly completed the task. Trial CW-T2 was successful.

Table IV-7A shows the cognitive gaps for this trial. For the planner subteam person-person gaps (A+B) are (7.22, 6.19) as compared to the other successful planners subteam scores of (9.19, 6.5). The Style is right on the mean but the Level component is somewhat lower in this instance. The total planner subteam gap (A+B+D) is (6.57, 16.38) as compared to the successful planner mean scores of (9.41, 11.54). And the total team cognitive gap (A+B+C+D) is 40.43 as compared to the total team mean of 41.77.

Table IV-7A Cognitive Gaps: Trial CW-T2

(Gap Model Comparison)

		Role	Subteam Gap A	Subteam Gap B	Team Gap C	Subteam Gap D	Subteam Gap A+B	Subteam Gap A+B+D	Total Team Gap= A+B+C+D
Add Model	Level	Op	5.65	2.97	0.53	1.61	8.61	10.23	40.43
		Pl	5.02	2.20	.	-0.65	7.22	6.57	
	Style	Op	0.98	0.51	0.97	4.25	1.49	5.75	
		Pl	4.55	1.64	.	10.19	6.19	16.38	
Raw Model	Level	Op	142.00	78.00	15.00	30.96	220.00	250.96	708.13
		Pl	105.60	42.80		-36.30	148.40	112.10	
	Style	Op	14.00	7.33	13.92	60.77	21.33	82.11	
		Pl	65.00	23.50		145.55	88.50	234.05	

7.4 Wilmington WIL-T1

Wilmington trial WIL-T1 was conducted at noon on Dec 17, 2009 by research assistant Phyllis Elikai. Note that WIL-T1 was a role-preferred trial with relatively more adaptive subteam playing the planners' role and the more innovative subteam playing the operators' role. See Table IV-8 for vital information about team members. This trial was conducted in a conference room with ample table space. The video camera was mounted on a tripod and was started prior to the entry of the participants so as to minimize disruption potentially caused by the camera.

This planning session began with Abe and Dale reading and commenting on the instructions. At an early point Dale (2.12, -0.52) read aloud the statement that says after 25 minutes the planners can give no further instructions and interprets that as, "We can't tell them anything." For over six minutes Bo quietly read the instructions during which time Abe (-0.02, -1.01) and Dale discussed back and forth the various rules and prohibitions. Finally, after 6:50 minutes had elapsed Bo (1.99, -0.66) asked, "Did everybody keep the back of their nametags?" He obviously had had an eureka moment. Bo then asked Chris to lightly outline a square on the backing sheet from the nametags they put on when they entered the room. That was because Chris had a puzzle piece which was a square the size Bo needed for his solution suggestion. Bo then folded the small paper and created a 2 inch square—the size of the center opening in the hollow square. As the others sat and watched Bo create the small square he said, "So do it for everybody, everybody needs one of these squares." Abe replied in an inquisitive voice, "Everybody needs one of those squares…really?" Bo continued with his work of folding paper and creating the small squares. While Abe and Dale continued to make comments which have little contribution Bo said, "So then, you take the square [the template piece just created] and set it in the middle in front of you and then assemble your pieces around that square where they fit in the pattern. "My pieces go just like this and my other piece touches it just like this."

Chris (0.05, -0.59) began to use her puzzle piece as the center template and Bo said, "You got to get your square, you can't use that square." Chris then began to fold paper from the back of her nametag as Bo instructed. Dale struggled to get her pieces arranged and said, "Mine don't fit at all," to which Bo replied, "Yea they do." Bo then looked at Dale's pieces and told her where they go spread around the center template square. Bo continued to show the other planners where their puzzle pieces went with respect to the center square. Bo finally said, "We need to give them instructions," to which Abe replied, "I thought we couldn't talk at all." Bo said, "It says we are to give them instructions, and number two above says instruct the operating team how to implement your plan." Abe said, "Then we can't talk." She then said, "Are we sure we have all the pieces in the right place?" Bo then pauses, raises his right index finger and said, "A key is, [pointing to the top of his puzzle pieces] this is the top."

Table IV-8. Trial: WIL-T1

Role	Planners				Operators			
Subteam	Relatively More Adaptive				Relatively More Innovative			
Code Name	Abe	Bo	Chris	Dale	Mel	Nat	Pat	Ray
Individual Attributes								
Age	57	58	43	63	28	33	54	48
Gender	F	M	F	F	F	M	F	M
Ed	14	18	12	14	16	12	16	16
Tenure	2	31	2	18	4	10	13	23
Other Exp	0	4	15	20	0	1	7	0
Tot Exp	2	35	17	38	4	11	20	23
Map	W	M	W	W	M	M	M	M
Style (KAI)[a]	80 -1.01	85 -.66	86 -.59	87 -.52	98 .25	99 .32	104 .67	106 .81
Job Status [b]	C1 2	C4 10	C1 2	C1 2	E2 2	S2 2	E4 4	C3 6
Level [c]	63 -.02	134 1.99	64 .05	121 2.12	38 -1.01	57 -.47	91 .92	100 .97
Subteam Attributes								
Mean Style	84.5 -.70				101.8 .51			
Mean Level	95.5 1.04				71.5 .08			

[a] Style Proxy is KAI scores-Tot number is raw score and bottom number is standardized KAI Z-score
[b] Job Status numbers are taken from Table IV-5. Top numbers are Domain Specific Scores and bottom are interval scores.
[c] Level Status proxy is based on Factor Analysis which loaded Age, Tenure, Total Experience, and Job Status. Top number is Age + Tenure + Total Experience + Job Status. The bottom number is the actual Factor Score produced in a Principal Components Analysis

Finally Bo suggested that all four puzzle groups be oriented the same way so it would be easier for the operating team to assemble the puzzle. Bo took charge in directing how that should be done for the other participants. As that was completed the operating subteam entered the room without having been sent for.

Bo stood and explained to the operating subteam how all the puzzle pieces should be assembled. He explained that the square in the center is a representation of the center hollow square hole. The operating subteam asked very few questions and quickly began moving the puzzle pieces into one spot. After a few minutes the operating subteam had the puzzle assembled. It was positioned near one side of the table on which the work has been done. Operating subteam member Nat (-0.47, 0.32) said, “But he said it had to be put in the middle.” [In this trial the planning subteam stayed in the room and could be partly seen in the camera shot. Planner Bo could be seen shaking his head ‘no’ as he heard Nat’s comment.] Operating member Pat said, “He did?” “Okay.” Then the operating subteam moved the assembled puzzle to the center of the table. Operator Ray (0.97, 0.81) picked up the stack of square templates that were in the center of the puzzle. Nat said, “I don’t think those were supposed to be in there because the end result has a hole in the middle.” Pat said, “But he said those symbolize the hole.” Operator Ray hesitated with the small template pieces obviously unsure of what to do and said, “I’m sure it has something to do with our apparent lack of attention to minor detail like whether the pieces of paper should be stacked on top of each other which I thought they were.” As Ray wavered between putting the template pieces back in or leaving them out Mel said, “He said they represent the hole.” As Ray reached his hand out one more time to put the template pieces back in the center Nat said, “I’d leave it empty.” Ray stood up and said, “Darn, one last detail we can’t figure out…” to which everyone laughs. They Ray said, “Should we have asked some questions before we jumped right in to the activity?” The operators attempted to ask some additional question about leaving the square template piece in but they cannot ask additional questions since they had begun the assembly. While the debate about the template took several minutes in the end the puzzle was correctly assembled. Trial WIL-T1 was successful.

Table IV-8A Cognitive Gaps: Trial WIL-T1

(Gap Model Comparison)

		Role	Subteam Gap A	Subteam Gap B	Team Gap C	Subteam Gap D	Subteam Gap A+B	Subteam Gap A+B+D	Total Team Gap= A+B+C+D
Add Model	Level	Op	7.60	3.46	.	0.40	11.05	11.45	45.47
		Pl	8.38	4.09	0.96	5.19	12.47	17.66	
	Style	Op	2.03	0.91	.	7.56	2.94	10.50	
		Pl	1.54	0.63	1.21	1.52	2.17	3.69	
Raw Model	Level	Op	220.00	96.00		26.20	316.00	342.20	1130.50
		Pl	270.00	128.00	24.00	146.20	398.00	544.20	
	Style	Op	29.00	13.00		108.05	42.00	150.05	
		Pl	22.00	9.00	17.25	21.80	31.00	52.80	

Table IV-8A contains all the cognitive gap tabulations for WIL-T1. The planner subteam people-people cognitive gap (A+B) was (12.47, 2.17) as compared to the successful planner subteam scores of (9.18, 6.51). The total planner subteam cognitive gap (A+B+D) was (17.66, 3.69) as compared to the successful planner subteam of (9.41, 11.54). The team total cognitive gap (A+B+C+D) was 45.47 as compared to the total sample of 41.77.

7.5 Wilmington WIL-T2

Trial WIL-T2 was conducted on Dec 17, 2009 at 4:00 PM due to some schedule problems. Research assistant Phyllis Elikai conducted this trial. This was a role-preferred trial with the more adaptive subteam playing the planners role and the more innovative subteam playing the operators role. Vital information about this trial is shown in Table IV-9. A last minute schedule conflict eliminated one of the planners so the planning team had only three members. As it turned out all three planners were female. Like WIL-T1 this trial was held in a conference room with ample space.

The planners discussed assembling their pieces in a group such that they could be easily put together by the operating subteam. They worked to understand where all their pieces go in the puzzle. At roughly the six minute lapsed time mark, one of the operators (Ray (-0.85, 1.23)) appeared and knocked on the conference room door. The facilitator quickly went to the door and told her to go away [the facilitator should not have intervened in this situation]. The planners continued working and seemed oblivious as to the operators' attempt to enter the room. Abe (1.00, -1.64) suggested putting the pieces closer together and moving around the table so the pieces would "still be in front of us." There was some discussion about an assumption that they have to stay in their assigned seats. The three planners gathered close on one side of the table and placed their pieces relatively close together but still seemed baffled as to how to instruct the operators about what they need to do.

Bo (0.57, -0.87) suggested, "What if we write on here [meaning the pattern sheet] and put Abe, Bo, etc?" The others did not voice support for that idea. Dale (1.04, -0.10) seemed fixated on sliding the groups of pieces together in some fashion. Bo sketched on the pattern sheet—presumably the shape of the puzzle pieces. At approximately the 21 minute lapsed time mark the entire operations subteam entered the room (uninvited) and walked beside the table. (This time the facilitator said nothing, as appropriate). The planners did not acknowledge the operators and the operators walked back out of the room after less than a minute. Finally, at approximately the 25 minute mark the operators again barged in the door

Table IV-9. Trial: WIL-T2

Role	Planners				Operators			
Subteam	Relatively More Adaptive				Relatively More Innovative			
Code Name	Abe	Bo	Chris	Dale	Mel	Nat	Pat	Ray
Individual Attributes								
Age	50	51	-	52	23	39	27	29
Gender	F	F	-	F	M	F	F	F
Ed	16	16	-	12	12	12	12	18
Tenure	15	16	-	18	2	4	4	5
Other Exp	13	0	-	6	3	15	5	2
Tot Exp	28	16	-	24	5	19	9	7
Map	W	M	-	W	M	W	W	M
Style (KAI)[a]	71 -1.64	82 -.87	-	93 -.10	98 .25	105 .74	108 .95	112 1.23
Job Status [b]	C2 3	C2 3	- -	E1 1	S1 1	S1 1	C1 2	E3 3
Level [c]	99 1.00	86 .57	- -	95 1.04	31 -1.31	63 .07	42 -.89	44 -.85
Subteam Attributes								
Mean Style	82 -.87				105.8 .79			
Mean Level	92.3 .87				45.0 -.75			

[a] Style Proxy is KAI scores-Tot number is raw score and bottom number is standardized KAI Z-score
[b] Job Status numbers are taken from Table IV-5. Top numbers are Domain Specific Scores and bottom are interval scores.
[c] Level Status proxy is based on Factor Analysis which loaded Age, Tenure, Total Experience, and Job Status. Top number is Age + Tenure + Total Experience + Job Status. The bottom number is the actual Factor Score produced in a Principal Components Analysis

and Dale, who is in the middle of telling the other planners how they might tell the operators how to assemble the puzzle, turned to the operators, held her left index finger up and said, “Give us a second…” But as she is saying this the facilitator said, “Your time is up.” Dale and Abe, who were standing near one another at this time, both replied with “Okay.” But, Abe, looked down at the instructions sheet said, “We can’t give them any more instructions.” And, the facilitator said, “Okay, your time is up.” The facilitator said you guys need to get your stuff up. Abe asked, “Are we out of here?” The facilitator gave the planners the opportunity to stay and observe the operators. Bo asked two times during the shuffle of moving away from the table, “Did you say I couldn’t leave anything?” The facilitator answered, “Your time is up.” Bo interpreted that reply to mean no and, consequently, did not leave the sketch or any written instructions.

After several moments of getting settled into their seats operator Ray asked, “So what are our instructions?” All the operators looked inquisitively toward the facilitator during these first moments. After another awkward silence Nat (0.07, 0.74) said, “Well it appears that we have to assemble this puzzle into one puzzle.” As Nat finished that comment Ray picked up a puzzle piece from one of the piles and began attempting to solve the puzzle. Nat continued to say, “Let’s start to try to piece the puzzle together…right?” But the other operators seemed to ignore her. Ray turned to the operators and asked, “Did anyone leave any instructions?” and the planners who were still in the room giggled but did not speak. Mel (-1.31, 0.25) said, “We have the responsibility of carrying out a task but we don’t know what the task is…according to the instructions given by your planning team.” He goes on to say, “Who is the planning team.” The planning team, visible partially in the background of the video shot, held their hands up and said, “That would be us.” Mel then said, “Oh hey planning team, do you have instructions?” After a few moments pass and the planning team remained silent Nat said, “What are our instructions?” The facilitator said, “They can’t give you any more instructions, their time is up.”

Ray said, “What does it say, a hollow square, maybe it’s a hollow square…let’s put together a hollow square,” and commenced to move puzzle pieces closer together. As Ray was working with puzzle pieces Mel said, “So we were supposed to come in here and ask for instructions before the time was up?” to which Pat said, in a quizzical voice, “But we did that…I did that.” The remainder of the operators’ time was spent in a futile effort to assemble the hollow square. Wilmington trial WIL-T2 was unsuccessful.

Table IV-9A Cognitive Gaps: Trial WIL-T2

(Gap Model Comparison)

		Role	Subteam Gap A	Subteam Gap B	Team Gap C	Subteam Gap D	Subteam Gap A+B	Subteam Gap A+B+D	Total Team Gap= A+B+C+D
Add Model	Level	Op	4.17	1.63	.	-3.73	5.80	2.07	28.81
		Pl	0.93	0.60	1.62	3.49	1.53	5.02	
	Style	Op	3.15	1.19	.	8.96	4.34	13.30	
		Pl	3.08	1.54	1.66	0.52	4.62	5.14	
Raw Model	Level	Op	98.00	36.00		-106.30	134.00	27.70	499.23
		Pl	20.00	12.67	47.33	104.29	32.67	136.96	
	Style	Op	45.00	17.00		128.05	62.00	190.05	
		Pl	44.00	22.00	23.75	7.44	66.00	73.44	

Table IV-9A contains the cognitive gap tabulations for WIL-T2. The planner subteam person-person cognitive gaps (A+B) are (1.53, 4.62) compared to the successful planner subteams scores (9.19, 6.51). The planner total subteam person-person and person-problem cognitive gaps (A+B+C) are (5.02, 5.14) compared with the successful subteams (9.41, 11.54). And, the total team cognitive gap (A+B+C+D) is 28.81 as compared to successful teams of 41.77.

7.6 Charlotte CHL-T1

Trial CHL-T1 was conducted on Dec 15, 2009 at noon and administered by research assistant Phyllis Elikai. This was a role-preferred trial with relatively more adaptive subteam playing the planners’ role and the relatively more innovative subteam playing the operators’ role. Some last minute changes occurred due to absences caused by illness and client meetings. These resulted in a three person planning subteam and a three person operations subteam. The trial took place in a conference room with the video camera mounted on a tripod. The camera was turned on prior to the start of the exercise and seemed to have no effect on the participants. See Table IV-10 for vital information about the team members and aggregated scores. Note that the difference between mean KAI subscores is 18.3 points or slightly more than 1.5 standard deviations. Note also that the planners' average tenure was relatively low.

The three-person planning subteam began by quietly reading the instructions prior to getting the puzzle pieces out. They proceed to assemble their puzzle pieces in front of them in an orientation like they would appear in the final puzzle. Dale and Abe discussed the manner in which they may instruct the operators. Dale (-0.34, -0.17) said, "It says tell but it doesn't say it absolutely has to be verbal." The planners continued to tell each other how they might inform the operators to assemble the puzzle. They discussed a counterclockwise approach in which pieces are logically put into the puzzle. Abe (-0.29, 01.36) said, "When they come in we can have our pieces all lined up and in order and this is the base…" Abe also said, "So when we're ready for them to come in we set it up so [he points to other participants' puzzle piles] one, two...we need to insert that piece [again he points to another puzzle pile] in there, and we'll have them in a line right here. You need to follow it around…starting here and proceeding counterclockwise." It appeared that the planners visually understood what needed to be done but they did not write any instructions or make any sketches for the operators. Abe said, "But we can show them the pattern sheet." Abe asked, "Okay, are you ready?" to which Dale replied, "Yes." At that time Abe rose from his chair and went to retrieve the operations subteam. This was at approximately the 16:51 minute lapsed time mark.

Table IV-10. Trial: CHL-T1

Role	Planners				Operators			
Subteam	Relatively More Adaptive				Relatively More Innovative			
Code Name	Abe	Bo	Chris	Dale	Mel	Nat	Pat	Ray
Individual Attributes								
Age	42		25	47	25	37		32
Gender	M		M	F	M	M		M
Ed	16		16	16	16	13		18
Tenure	2		2.5	3	3	12.2		2
Other Exp	9		1	0	5	0		7
Tot Exp	11		3.5	3	8.5	12		9
Map	M		M	F	M	M		M
Style (KAI)[a]	75 -1.36		89 -.38	92 -.17	100 .39	100 .39		111 1.16
Job Status [b]	E4 4		E3 3	S5 5	S1 1	S1 1		E3 3
Level [c]	59 -.29		34 -1.31	58 -.34	38 -1.04	62 -.21		46 -.69
Subteam Attributes								
Mean Style	85.3 -.64				103.7 .65			
Mean Level	50.3 -.65				48.8 -.64			

[a] Style Proxy is KAI scores-Tot number is raw score and bottom number is standardized KAI Z-score
[b] Job Status numbers are taken from Table IV-5. Top numbers are Domain Specific Scores and bottom are interval scores.
[c] Level Status proxy is based on Factor Analysis which loaded Age, Tenure, Total Experience, and Job Status. Top number is Age + Tenure + Total Experience + Job Status. The bottom number is the actual Factor Score produced in a Principal Components Analysis

After the operating subteam got into the room Abe began, “What you’re tasked to do is to create a hollow square…okay…out of the 16 figures…okay, and if you start with this shape [Abe pointed to the partially assembled puzzle group in front of him], specifically this rectangle and work around counterclockwise back to the top and you follow the order of these shapes [Abe continued to point with his index finger to various puzzle pieces arranged on the table] it will form that hollow square. As soon as Abe finished this last remark Ray (-0.69, 1.16) asked, “What are the dimensions?” to which Dale replied, “That is irrelevant” while some minor chuckles occurred, Ray said, “I think it is relevant.” Abe said, “All sides are equal” and Ray said, “So it is a square.” Ray asked, “So, you want us to start here [he pointed to the largest group of puzzle pieces] and work…with what…just anything?” Abe and Dale are casually answering the questions posed by Ray. Dale restated Abe’s comments, “If you start here [he made a hand gesture toward the largest group of puzzle pieces] and work your way down and look at the shapes that are needed…” Abe also offered, “And they are essentially in somewhat of an order.” At that time the other two operators, both of whom had thus far been quiet, positioned themselves closer to the table. At that time Dale said, “Now once ya’ll start we can’t talk to you.” Operator Nat (-0.21,0.39) in an effort to be funny said, “Zip” and made a hand gesture across his lips as to suggest the planners needed to shut up.

Very shortly the operators began moving the puzzle pieces into the large group. The first three pieces appear to fit as the planners had said but when they were moved over one of the triangles was too big for the space provided. This appeared to disrupt the thought flow. The operators continued as best they could with their memory of the instructions. The planners had provided no written or graphical instructions and ultimately the operators ran out of time before the puzzle was assembled. Charlotte trial CH-T1 was unsuccessful.

Table IV-10A contains the cognitive gap tabulations for the CH-T1 trial. The planner subteam person-person cognitive gaps (A+B) are (3.36, 3.83) as compared to the successful trials (9.19, 6.51). The planner subteam total person-person and person-problem cognitive gaps (A+B+D) are (0.76, 5.28) compared to the successful subteams scores (9.41, 11.54). Lastly, the total team cognitive gap (A+B+C+D) is 16.44 as compared to the successful team’s gap of 41.77.

Table IV-10A Cognitive Gaps: Trial CHL-T1

(Gap Model Comparison)

		Role	Subteam Gap A	Subteam Gap B	Team Gap C	Subteam Gap D	Subteam Gap A+B	Subteam Gap A+B+D	Total Team Gap= A+B+C+D
Add Model	Level	Op	1.66	0.87	.	-2.57	2.53	-0.04	16.44
		Pl	2.04	1.32	0.01	-2.60	3.36	0.76	
	Style	Op	1.54	1.03	.	6.59	2.57	9.15	
		Pl	2.38	1.45	1.28	1.45	3.83	5.28	
Raw Model	Level	Op	48.80	27.20		-69.84	76.00	6.16	251.20
		Pl	50.00	32.67	1.53	-63.71	82.67	18.96	
	Style	Op	22.00	14.67		94.11	36.67	130.77	
		Pl	34.00	20.67	18.33	20.77	54.67	75.44	

7.7 Charlotte CHL-T2

Trial CHL-T2 was conducted on Dec 14, 2009 at 12:30 PM and was administered by research assistant Phyllis Elikai. This was a role-preferred trial with relatively more adaptive subteam playing the planners' role and the relatively more innovative subteam playing the operators' role. One last minute change occurred due to an absence. There was no material change in the subteam make-up as a result of the change. The trial took place in a conference room with the video camera mounted on a tripod. The camera was turned on prior to the start of the exercise and seemed to have no effect on the participants. Table IV-11 contains vital information about trial CHL-T2.

Note that the difference between subteam mean KAI scores was slightly more than 1.5 standard deviations of the total group KAI scores. Note also that this was a full eight person group.

This trial began with the planners reading for over two minutes without any dialogue. Chris (-1.36, -0.10) asked, "When do they come back in" at the nearly three minute mark and Abe (-0.82,-1.36) replied, "After 25 minutes." After another few minutes Chris observed that the pattern sheet might be sketched on. He said, “That’s not a key sheet, but we can make a key sheet that will tell them how to do it.” Chris persisted, “Can we just draw out how to do it and give it to them?” Bo (-1.05,-0.66) asked, “Is that cheating?” and Abe added, “I think that’s cheating.” Abe was clearly uneasy with what she thought was a violation of the rules. Bo held the pattern sheet up toward Abe and said, “This is gonna be their key sheet” to which

Table IV-11. Trial: CHL-T2

Role	Planners				Operators			
Subteam	Relatively More Adaptive				Relatively More Innovative			
Code Name	Abe	Bo	Chris	Dale	Mel	Nat	Pat	Ray
Individual Attributes								
Age	31	31	25	32	39	26	34	30
Gender	F	F	M	M	M	M	M	M
Ed	13	13	16	13	16	13	16	16
Tenure	2.5	3.5	2	4.5	5	3.5	9	2
Other Exp	7.5	0	.3	6	8	3.5	0	7
Tot Exp	10	3.5	2.3	10.5	13	7	9	9
Map	M	W	M	M	M	M	M	W
Style (KAI)[a]	75 -1.36	85 -.66	93 -.10	71 -1.64	99 .32	99 .32	103 .60	110 1.09
Job Status [b]	S1 1	C1 2	E3 3	S4 4	S4 4	E3 3	E3 3	E3 3
Level [c]	44.5 -.82	40 -1.05	32.3 -1.36	51 -.73	61 -.19	39.5 -1.06	55 -.51	44 -.78
Subteam Attributes								
Mean Style	81 -.94				102.8 .58			
Mean Level	42 -.99				49.9 -.64			

[a] Style Proxy is KAI scores-Tot number is raw score and bottom number is standardized KAI Z-score
[b] Job Status numbers are taken from Table IV-5. Top numbers are Domain Specific Scores and bottom are interval scores.
[c] Level Status proxy is based on Factor Analysis which loaded Age, Tenure, Total Experience, and Job Status. Top number is Age + Tenure + Total Experience + Job Status. The bottom number is the actual Factor Score produced in a Principal Components Analysis

Abe replied, “Are you sure,” and Bo said, “Maybe.” The question of sketching the key sheet on the pattern sheet obviously created a moral dilemma for Abe. She continued working on how to instruct the operators to assemble the puzzle based on the location of where different chairs were setting.

In spite of Abe's evidenced objection to doing any kind of sketch of the puzzle shapes on the pattern sheet, Bo persisted, "So what would be wrong with tracing it, wouldn't that be their instructions?" [She looked at Abe and directed her question to her. after which she laughed uncertainly…] Chris also laughed and said, "I think so…" Abe, to whom the previous question was addressed did not respond but continued with her work on some kind of sequential instructions for assembling the puzzle. Several minutes passed with Abe writing instructions and finally Bo said in a moderately frustrated voice, "This is the pattern sheet, not the key sheet" to which Chris replied, "I know." Chris continued, "It doesn't say they can't see the pattern sheet." Dale (-0.73,-1.64) who had been relatively quiet until then, and Bo simultaneously say, "Why don't we trace it…" Bo [after she began tracing the shapes of the puzzle into the pattern sheet] said, "I'll trace it" as she laughed softly, then said "I'll be the bad one." Abe watched Bo sketch the puzzle shapes on the pattern sheet smiled and said, "I don't know, I kinda think if she's making another key SHEET…" to which Bo interjected, "But this is the pattern…this is the hollow square pattern sheet." Abe responded, "Right…?" And Bo shot back, "That's not the key sheet."

Abe continued her effort to write some instructions to the operators which would tell them which group of puzzle pieces to start with and how to proceed. Chris assisted her in formulating some basic instructions. Abe offered, relatively light heartedly, "And we've got Becky's cheat sheet just in case." [Note that Abe used Bo's real name in the video here.] Bo, who is busily sketching on the pattern sheet, and Chris say, "Yea" in unison and Abe giggled as if they had done something wrong. Shortly after that the facilitator said, "Your 25 minutes is up…” and the planners leave the room without having provided any oral instructions to the operating subteam.

The operating subteam entered the room and sat around the table. Mel (-0.19,0.32) picked up one of the larger triangle pieces from his group of puzzle pieces and held it up with one hand and thumped it like a football to the operator sitting across the table from him. They all laughed. A couple of minutes went by with the operators looking first at each other and then all looked directly at the facilitator. The facilitator said, “I’m not going to tell you anything.” Pat (-0.51,0.60) said, “Oh you are waiting…” and Mel looked around near his end of the table and found the written instructions that Abe had worked on during the planning session. Mel pulled the instructions closer to him and said, almost matter of factly, “Okay, here’s our objective. Combine all twelve puzzle pieces into a hollow square pattern…or sheet…or pattern sheet.” Ray (-0.78,1.09), looked startled and said, “Where did you get that from?” And, Mel replied, “This was left on the table…” Mel continued reading, “Directions…have each team member sit in one of four chairs, beginning with seat closest to Andy’s door, closest to TV, and on side of exit door—that is one set.” Mel reiterated, “Okay, have each team member sit in one of four chairs…” Over the next few minutes the operating subteam members, other than Mel who continued sitting in his seat and reading the instructions Abe had prepared, moved up and out of the camera shot to far corners of the room as if on a scavenger hunt. Finally the planners came back to the table. Mel also spotted the sketched pattern sheet (also called Bo’s cheat sheet) and said, “Okay, here are some answers we can use.” When they all gathered back around the table Mel continued reading the instructions about seating arrangements and Pat (-0.51,0.60) began piecing the puzzle together based on the sketches shown on the pattern sheet. Ray and Nat have sat and listened to Mel reading and re-reading the seating instructions. Finally, Ray asked Mel, “What does any of that got to do with solving this puzzle?” Mel replied, “It’s telling us who needs to do it first…that is set one…” Pat, who had been assembling the puzzle based on the sketch of the puzzle pieces on the pattern sheet, said, “Well I started…” Mel continued reading for a moment and looked at his cell phone and said, “I’m sorry guys, I’ve got to take this.” He answered his cell and began a conversation with a client about some expense vouchers sent on a recent invoice. From this point forward Mel talked on the cell phone and made no further contributions to the subteam.

Pat continued to put the puzzle pieces together with Ray and Nat helping to put pieces in place. Pat commented, “Not exactly like that…” due to a solid square being located in a spot that is supposed to have two triangles making up the square. Nat (-1.06,0.32) said, “Take that square out,” and switched locations of the two triangles and the square. Nat, Pat, and Ray solved the puzzle while Mel continued his telephone conversation. Trial Charlotte CHL-T2 was successful.

Table IV-11A contains the tabulated cognitive gap information for CH-T2 trial.

Table IV-11A Cognitive Gaps: Trial CHL-T2

(Gap Model Comparison)

		Role	Subteam Gap A	Subteam Gap B	Team Gap C	Subteam Gap D	Subteam Gap A+B	Subteam Gap A+B+D	Total Team Gap= A+B+C+D
Add Model	Level	Op	2.85	1.12	.	-3.18	3.97	0.79	20.11
		Pl	2.12	0.86	0.35	-4.94	2.98	-1.96	
	Style	Op	2.59	1.05	.	7.91	3.64	11.55	
		Pl	5.32	2.24	1.52	0.30	7.56	7.86	
Raw Model	Level	Op	75.50	32.50		-81.93	108.00	26.08	295.35
		Pl	60.60	23.20	7.93	-121.55	83.80	-37.75	
	Style	Op	37.00	15.00		113.05	52.00	165.05	
		Pl	76.00	32.00	21.75	4.30	108.00	112.30	

The planner subteam person-person cognitive gaps (A+B) are (2.98, 7.56) as compared to the successful subteams mean score of (9.19, 6.51). The planner subteam total cognitive gaps (A+B+D) are (9.41, 11.54). And, the total team cognitive gap is 20.11 versus the successful trials mean score of 41.77.

7.8 Raleigh RAL-T1

I administered Trial RAL-T1 on Dec 8, 2009 at noon. This was a non role-preferred trial with relatively more innovative subteam playing the planners' role and the relatively more adaptive subteam playing the operators' role. One last minute change occurred due to an absence. In this case one of the planners was absent and I moved the most innovative of the adaptive group to the innovative-planners subteam. The trial took place in a conference room with the video camera mounted on a tripod. The camera was turned on prior to the start of the exercise and seemed to have no effect on the participants. Table IV-12 contains vital information about trial RAL-T1.

Note that the difference between mean KAI scores for subteams was slightly more than 1.5 standard deviations. Owing to the last minute change of participants there was a 30 point range of KAI scores within the planning subteam.

After a relatively quiet time during which the planners reviewed the instructions they began generally discussing the placement of their individual pieces in the puzzle. For the initial period Mel (1.34, -0.45) took the vocal lead pointing out where everyone's puzzle pieces were located in the puzzle. Mel wrote the planner's code name on the puzzle key sheet so that he knew who had which pieces and where they were located. Ray (0.76, 1.65) placed one of his puzzle pieces beside Nat's piece to compare the size of the pieces as Mel and Pat continued a directionless discussion about how they were going to tell the operating team to complete the puzzle. Pat said, "We can't give them any further instructions once they start," to which Mel added, "Once they start…"

Mel suggested grouping the pieces together, "With A, B, C, and D…if that makes sense" while moving his hands to suggest sequential groupings of puzzle pieces. Pat appeared to not register that suggestion and offered another direction. He said, "Let's think about if we were to say…for example if we gave them a starting piece and we'll have to

Table IV-12. Trial: RAL-T1

Role	Operators				Planners			
Subteam	Relatively More Adaptive				Relatively More Innovative			
Code Name	Abe	Bo	Chris	Dale	Mel	Nat	Pat	Ray
Individual Attributes								
Age	58	43	48	-	53	30	44	45
Gender	M	M	F	-	M	F	M	M
Ed	16	16	14	-	16	16	16	18
Tenure	19	2.5	2.5	-	18	3	4	4
Other Exp	18	21	25	-	12	4.5	20	23
Tot Exp	37	23.5	27.5	-	30	7.5	24	27
Map	M	M	W	-	M	M	W	W
Style (KAI)[a]	76 -1.23	79 -1.08	82 -.87	- -	88 -.45	98 .25	108 .94	118 1.65
Job Status [b]	E4 4	E5 5	C3 6	- -	E5 5	E3 3	E5 5	C4 10
Level [c]	118 1.84	74 .33	84 .74	- -	106 1.34	43.5 -.87	77 .53	86 .76
Subteam Attributes								
Mean Style	79 -1.08				103 .60			
Mean Level	92 .97				78 .44			

[a] Style Proxy is KAI scores-Tot number is raw score and bottom number is standardized KAI Z-score
[b] Job Status numbers are taken from Table IV-5. Top numbers are Domain Specific Scores and bottom are interval scores.
[c] Level Status proxy is based on Factor Analysis which loaded Age, Tenure, Total Experience, and Job Status. Top number is Age + Tenure + Total Experience + Job Status. The bottom number is the actual Factor Score produced in a Principal Components Analysis

describe very carefully what they were going to create…and we say the pieces that are together stay together." Nat (-0.87, 0.25) replied in support of Pat's comment, "Yea, that's good." Pat continued, "This is your bottom left corner…" and Mel broke into the discussion and said, "I would put the pieces of the puzzle together just the way the puzzle is put together, lay them out exactly like that" using hand gestures for emphasis. As Mel was completing his statement Nat said, "They should be standing on that end of the table" and gestured toward the far end of the table, obviously understanding that all the groups of puzzle pieces needed to be oriented the same or otherwise be quite confusing.

Three of the planners rose and grouped themselves near the end of the table while Pat continued sitting in his chair. Ray had been relatively quiet until this time and he began suggesting placements for the individual pieces. He began, "Let's all get on one side of the table." The solution concept that the group had generally followed was to arrange each persons' puzzle pieces in front of where the person sat or stood in four rows of four. The first row was the top row meaning the four pieces in the puzzle which were at or near the top. Pat (0.53, 0.94), who had been watching and listening, said, "But they are not going to be able to see that." And Mel agreed, "They are not going to be able to see that because they are not in order…" The planners continued moving pieces around and created four rows of puzzle pieces but they were not equally numbered with puzzle pieces. One row had several pieces and another row had fewer. They had settled on placing the pieces which were near the top on the top row, the pieces just below the top in the second row, etc. Considerably late in the exercise Pat said, "So we better think about how we are going to give them instructions." After several moments of silence all three of the other planners begin talking about how all the pieces go together—again. The additional discussion produced no written plan or sketch to present to the operating team. After 25 minutes I called time and directed the planners to go to the next room for their lunch. Mel said, “I thought we were supposed to give them instructions,” to which I replied, “You’ve got 25 minutes to do that, your time is up.” Both Mel and Pat make exasperated sighs and as Pat is walking out he said, “We didn’t write anything down.”

The operating subteam entered and sat on the end of the table where all the puzzle pieces were positioned. They sat their pizza down on the table in the midst of the puzzle pieces. Abe (1.84, -1.23) said, “We are to create a hollow square.” Bo (0.33, -1.08) said, “We are waiting on directions from others?” And, Abe said, “Well we will receive no further directions so that is the directions…to make a hollow square. “So whether we use all the pieces or not, it really doesn’t matter because we haven’t been told…” After their initial frustrated comments the operators made a futile attempt to assemble the puzzle. But with nothing to go on they did not succeed. Trial RAL-T1 was unsuccessful.

Table IV-12A contains the tabulated cognitive gaps for trial RAL-T1.

Table IV-12A Cognitive Gaps: Trial RAL-T1

(Gap Model Comparison)

		Role	Subteam Gap A	Subteam Gap B	Team Gap C	Subteam Gap D	Subteam Gap A+B	Subteam Gap A+B+D	Total Team Gap= A+B+C+D
Add Model	Level	Op	3.02	1.74	0.53	3.88	4.76	8.64	41.29
		Pl	6.88	2.63	.	2.20	9.50	11.71	
	Style	Op	0.84	0.42	1.68	-0.32	1.26	0.94	
		Pl	7.00	2.80	.	8.00	9.80	17.80	
Raw Model	Level	Op	88.00	52.00	13.88	102.96	140.00	242.96	1200.46
		Pl	196.50	71.50		59.33	268.00	327.33	
	Style	Op	12.00	6.00	24.00	320.00	18.00	338.00	
		Pl	100.00	40.00		114.30	140.00	254.30	

The planner subteam person-person cognitive gaps (A+B) are (9.5, 9.8) as compared to the successful planner subteam mean scores of (9.18, 6.51). The planner subteam person-person and person-problem cognitive gaps (A+B+D) are (11.71, 17.8) as compared to the successful planner subteam scores of (9.41, 11.54). The total team person-person and person-problem cognitive gap score is 41.29 versus the mean scores for successful trials at 41.77, remarkably close for this to be a failed trial.

7.9 Raleigh RAL-T2

I administered Trial RAL-T2 on Dec 14, 2009 at noon. This was a role-preferred trial with relatively more adaptive subteam playing the planners' role and the relatively more innovative subteam playing the operators' role. The trial took place in a conference room with the video camera mounted on a tripod. The camera was turned on prior to the start of the exercise and seemed to have no effect on the participants. Table IV-13 contains vital information about trial RAL-T2. The difference between subteam mean KAI scores was over 1.5 standard deviations. The range of planners subteam KAI scores was less than 20 points.

This trial began with discussion about where the various puzzle pieces should go and which person had which pieces. Abe (-0.61, -1.92) was very quiet early during the reading of the instructions. Each person arranged his or her pieces in front of them like they were supposed to be arranged in the puzzle. They discussed how to explain the objective to the operators. Dale (-1.27, -0.73) asked, "Do we have to put the puzzle pieces back in the envelope?" Abe said, "It doesn't say how long we have to instruct them" and someone said, "How about a written plan?" They then debated the fact that the instructions do not prohibit a written plan.

Table IV-13. Trial: RAL-T2

Role	Planners				Operators			
Subteam	Relatively More Adaptive				Relatively More Innovative			
Code Name	Abe	Bo	Chris	Dale	Mel	Nat	Pat	Ray
Individual Attributes								
Age	32	44	37	27	60	43	28	28
Gender	M	M	M	F	F	M	M	M
Ed	13	14	16	18	16	16	16	18
Tenure	11	17	4	1	.9	14	3	3.5
Other Exp	0	4	3.5	2.5	25	0	4	2
Tot Exp	11	21	7.5	3.5	25.9	14	7	5.5
Map	W	M	W	W	W	W	M	M
Style (KAI)[a]	67 -1.92	70 -1.71	82 -.87	84 -.73	95 .04	100 .39	107 .87	115 1.44
Job Status [b]	C3 6	E1 1	E3 3	C2 3	C1 2	E4 4	E2 2	E2 2
Level [c]	60 -.61	83 .45	51.5 -.61	34.5 -1.27	88.8 1.21	75 .17	40 -.95	39 -.98
Subteam Attributes								
Mean Style	75.8 -1.31				104.3 .69			
Mean Level	57.3 -.51				60.7 -.14			

[a] Style Proxy is KAI scores-Tot number is raw score and bottom number is standardized KAI Z-score
[b] Job Status numbers are taken from Table IV-5. Top numbers are Domain Specific Scores and bottom are interval scores.
[c] Level proxy is based on Factor Analysis which loaded Age, Tenure, Total Experience, and Job Status. Top number is Age + Tenure + Total Experience + Job Status. The bottom number is the actual Factor Score produced in a Principal Components Analysis

At 14:20 minutes into the exercise Abe appeared to have an idea. He suggested, "We can't show them the key, but…" at which time Chris (-0.61, -0.87) interrupted and said, "We can show them the pattern sheet." Abe went on, "But we could also un-staple these things and put a piece on each side of our puzzle…framing it." Dale said, that's a good idea…and you could even use your envelope…" Abe said, "Right, as the fourth piece. "And, so they would have a good picture or view of what it…" Chris, who had been staring intently at Abe during this exchange said, “Say that again…” and Abe reiterated his concept of creating a perimeter template which would frame the puzzle.

Chris said, “I say we show them the pattern sheet as well.” Also one of the four pieces of paper that would be used to frame the puzzle happened to be the key sheet. Chris said, “We can write on the paper, don’t turn over.” By this time Abe is busily writing instructions for the operating team with other planners offering several suggestions for necessary or helpful information to be included in the directions. Chris had an idea about using the pattern sheet for a graphical instructions sheet. He said, “Like re-create the key sheet but just show them our pieces…you know what I mean? “Like, if I draw my pieces in here [he pointed to the pattern sheet]…would that be showing them?” Dale said, “Yea…I think that would be showing them the key…” They all laughed and Abe, paused from writing his instructions for the operating team said, “Yea, I did wonder that.”

Chris, however, persisted in pushing the question of key sheet and asked, “Bo, do you think that would be giving them the key sheet if in your pattern sheet just draw out where your pieces go?” To which Bo (0.45, -1.71) quickly replied, “Yes…” and Chris said, “You do, okay.” But Bo continued with the thought and said, “Just *your* pieces?” And, Chris said, “Yes…so you are not giving them the whole key sheet, you’re just giving them part of it…your pieces.” Bo said, “It doesn’t say that though…” And, Chris said, “Exactly, it said don’t show them the key sheet…the key sheet is the entire thing…” Chris lifts one of the key sheets from its place on the table and holds it face up for emphasis. Bo, now an accomplice in this interpretation said, “Yea, we can sketch our pieces.” Chris still was not convinced that the sketch idea was legal and turned and asked me, “Mike, would you tell us if it was cheating?” to which I replied, “Everything you need to know is on the instruction sheet.”

After which all the planners laughed and Chris said, “He’s got the same response to everything.” All the planners completed their sketches of their pieces on their pattern sheets while Abe completed the instructions. I called time after 25 minutes and instructed them to go to the next room and told them that they had no more time to provide oral instructions to the operators. As the planners rose to leave the room Abe said, amidst laughter, “Okay, I’m glad I wrote down some instructions.”

The operations team entered the room and took their places around the table. Nat (0.17, 0.39) happened to take the seat in which Abe had sat and, therefore, had the instructions in front of him. He began reading, “The goal is to take the pieces for forming a square with an empty small square centered in the middle.” He asked the other operators, “Do you see this picture here?” And, Ray (-0.98, 1.44) said, “Okay…” Nat continued, “All the pieces are oriented and positioned properly…” The operators had little trouble following the very precise instructions which included a specific order of which puzzle groups went into the base puzzle first. In addition, the operators had the sketches of the puzzle pieces on the pattern sheets. The operators quickly assembled the puzzle. Trial RAL-T2 was successful.

Table IV-13A contains the tabulated cognitive gaps for RAL-T2. The planner subteam person-person cognitive gaps (A+B) are (7.09, 6.44) compared to the successful trials mean scores of (9.19, 6.51). The planner subteam person-person and person-problem cognitive gaps are (4.55, 4.9) compared to the successful trials mean scores of (9.41, 11.54). And, the total team cognitive gap (A+B+C+D) is 37.13 versus the successful teams mean scores of (41.77).

Table IV-13A Cognitive Gaps: Trial RAL-T2

(Gap Model Comparison)

		Role	Subteam Gap A	Subteam Gap B	Team Gap C	Subteam Gap D	Subteam Gap A+B	Subteam Gap A+B+D	Total Team Gap= A+B+C+D
Add Model	Level	Op	7.68	3.31	.	-0.69	10.99	10.31	37.13
		Pl	5.16	1.92	0.37	-2.54	7.09	4.55	
	Style	Op	4.69	1.89	.	8.44	6.58	15.01	
		Pl	4.41	2.03	1.99	-1.54	6.44	4.90	
Raw Model	Level	Op	184.40	84.80		-27.80	269.20	241.40	723.90
		Pl	154.00	57.00	3.45	-45.05	211.00	165.95	
	Style	Op	67.00	27.00		120.55	94.00	214.55	
		Pl	63.00	29.00	28.50	-21.95	92.00	70.05	

The planner subteam person-person cognitive gaps (A+B) are (7.09, 6.44) compared to the successful trials mean scores of (9.19, 6.51). The planner subteam person-person and person-problem cognitive gaps are (4.55, 4.9) compared to the successful trials mean scores of (9.41, 11.54). And, the total team cognitive gap (A+B+C+D) is 37.13 versus the successful teams mean scores of (41.77).

7.10 Raleigh RAL-T3

I administered Trial RAL-T3 on Dec 10, 2009 at noon. This was a non role-preferred trial with relatively more innovative subteam playing the planners' role and the relatively more adaptive subteam playing the operators' role. The trial took place in a training room with the video camera mounted on a tripod. The camera was turned on prior to the start of the exercise and seemed to have no effect on the participants. Table IV-14 contains vital information about trial RAL-T3. The difference between subteam mean KAI scores was over 1.5 standard deviations. The range of planners subteam KAI scores was less than 20 points.

This trial began with nearly eight minutes of discussion about who has which puzzle pieces and how they are oriented. Nat (1.71, 0.11) suggested a “key-stone” concept at about the 3:00 minute mark but the idea floated off to no avail. They discussed a clockwise rotation of assembling the puzzle. They discussed quadrants. They started numbering the puzzle pieces in a counterclockwise fashion with Ray (0.79, 1.51) marking the pieces on her key sheet.

Pat (-0.05, 0.74) suggested grouping the pieces into four piles and using the dial of a clock as a key with which to provide instructions. The nature of instructions had not yet been discussed. Nat offered another idea or variation on the concept of instructing the operators to assemble the puzzle in a circular fashion. Mel (1.69, 0.04) picked up the pattern sheet and said, “The pattern sheet, I’m gonna start at 12-o’clock…they’ll have to physically have to figure out how does that…” Ray began agreeing with Mel before he finished talking and said, “Okay, okay, let’s do that…line ‘em up…yea, we’re all on the same side.” Ray gathered her pieces and began moving to the other side of the table and said, “Why not, let’s try it and see if we can do it…” Pat remained seated on the left side of the table while the other three gathered on the right side and lined all 16 puzzle pieces up in the order which they planned to instruct the operators to assemble the puzzle. Ray had previously written the code names and a number one through four on the key sheet. During the time they were lining all 16 pieces up on one side of the table Ray was calling out the next piece name, e.g., Mel #3, etc. After the puzzle pieces were lined up Mel turned and asked how much time was left and I responded that they had about five minutes. Mel then made a “time-out” gesture and very softly asked, “Why couldn’t you just space them around so…” He made hand gestures indicating how the pieces would be positioned in a sort of exploded arrangement so that the

Table IV-14. Trial: RAL-T3

Role	Operators				Planners			
Subteam	Relatively More Adaptive				Relatively More Innovative			
Code Name	Abe	Bo	Chris	Dale	Mel	Nat	Pat	Ray
Individual Attributes								
Age	57	48	25	34	49	64	40	53
Gender	M	M	M	F	M	M	M	F
Ed	13	18	16	18	14	14	16	16
Tenure	18.5	1.5	2.5	4	13	2.5	4	5
Other Exp	19.5	23	0	2	30	30	11	15
Tot Exp	38	24.5	2.5	6	43	32.5	15	20
Map	M	M	W	M	M	M	M	M
Style (KAI)[a]	63 -2.19	84 -.73	86 -.59	87 -.52	95 .04	96 .11	105 .74	116 1.51
Job Status [b]	S4 4	E4 4	E4 4	E3 3	S6 6	C2 3	S4 4	E4 4
Level [c]	117.5 1.78	78 .59	34 -1.36	47 -.79	111 1.69	102 1.71	63 -.05	82 .79
Subteam Attributes								
Mean Style	80 -1.01				103 .60			
Mean Level	69 .06				89.5 1.03			

[a] Style Proxy is KAI scores-Tot number is raw score and bottom number is standardized KAI Z-score
[b] Job Status numbers are taken from Table IV-5. Top numbers are Domain Specific Scores and bottom are interval scores.
[c] Level proxy is based on Factor Analysis which loaded Age, Tenure, Total Experience, and Job Status. Top number is Age + Tenure + Total Experience + Job Status. The bottom number is the actual Factor Score produced in a Principal Components Analysis

operators would only have to push the pieces in to make the puzzle. As Mel was suggesting that Pat voiced his agreement saying, “We have all that table…those two tables to do that…” Ray listened and said, “All you have to do is just push them together…okay, yes…go right ahead…absolutely.” As Ray and Mel began moving the puzzle pieces into the exploded position Nat reminded them, “We can’t touch each others’ pieces…” All the planners moved pieces around with lots of touching violations. Ray appeared to circumvent that problem in her mind by using her pen to actually touch pieces that were not hers. After all the pieces were in position Mel said, “They are not touching, they are in front of everybody, and now we can simply instruct them to make that…” [He held up the pattern sheet as he spoke.] The planners pause and Mel said, “That’s a lot easier…” to which everyone laughed. Mel asked to no one in general, “Have we broken rules? I don’t know.” As the planning team stood around the table the operations team barged in uninvited.

Mel began instructions, “Your task is to assemble these puzzle pieces in this hollow square pattern sheet…the part in the middle ends up empty, its hollow…so these pieces will go together to make that pattern. Mel and Ray exchanged ideas and laughed. At that point I called time and sent the planners out of the room.

The operators quickly moved into position around the puzzle and moved the pieces into place with little trouble. They took some time after the puzzle pieces were put together worrying about tightness of fit and wondering if they had missed something. In the end, the operators were successful. Trial RAL-T3 was successful.

Table IV-14A Cognitive Gaps: Trial RAL-T3

(Gap Model Comparison)

		Role	Subteam Gap A	Subteam Gap B	Team Gap C	Subteam Gap D	Subteam Gap A+B	Subteam Gap A+B+D	Total Team Gap= A+B+C+D
Add Model	Level	Op	10.82	4.53	0.98	0.28	15.35	15.63	54.89
		Pl	6.19	2.66	.	5.17	8.86	14.03	
	Style	Op	5.18	2.38	1.61	-0.05	7.56	7.51	
		Pl	5.04	2.10	.	8.00	7.14	15.14	
Raw Model	Level	Op	281.50	114.50	20.38	14.33	396.00	410.33	1125.50
		Pl	164.00	68.00		116.20	232.00	348.20	
	Style	Op	74.00	34.00	23.00	-0.70	108.00	107.30	
		Pl	72.00	30.00		114.30	102.00	216.30	

Table IV-14A contains the tabulated cognitive gaps for trial RAL-T3. The planner subteam person-person gaps (A+B) are (8.86, 7.14) compared to the successful planner subteams scores of (9.19, 6.51). The planner subteam person-person and person-problem cognitive gaps (A+B+D) are (14.03, 15.14) as compared to the other successful planner subteam scores of (9.41, 11.54). And, the total team person-person and person-problem cognitive gap is 54.89 as compared to the other successful planner subteam mean score of 41.77.

7.11 Raleigh RAL-T4

I administered Trial RAL-T4 on Dec 7, 2009 at noon. This was a <u>non role-preferred trial</u> with relatively more innovative subteam playing the planners' role and the relatively more adaptive subteam playing the operators' role. The trial took place in a conference room with the video camera mounted on a tripod. The camera was turned on prior to the start of the exercise and seemed to have no effect on the participants. Table IV-15 contains vital information about trial RAL-T4. The difference between subteam mean KAI scores was well over 1.5 standard deviations. The range of planners subteam KAI scores exceeded 20 points.

This planning group discussed whether or not the puzzle pieces would be left on the table for the operations subteam and concluded they would. They discussed who had which pieces of the puzzle. At roughly 3:40 minutes into the trial period Ray (1.56, 2.63) quietly began to fold and tear a piece of paper that would become a center template. He explained that everyone should have one and orient their pieces around the template as they should be oriented in the total puzzle. There was considerable discussion about the correct orientation of the puzzle pieces since the planners were sitting on opposite sides of the table. Finally, Ray suggested that the template [hole] could be the orientation and they wrote an orientation on the piece of paper that they made for the template.

Ray asked if the instructions could be written or oral and the planners concluded that they should do a written plan. Pat (-1.01, 2.21) began writing instructions at that point. One asked about reproducing the key sheet and labeling their pieces as to whose went where. Ray asked, “Is that working the margins?” Nat (0.82, 1.37) suggested that Pat read over what she

Table IV-15. Trial: RAL-T4

Role	Operators				Planners			
Subteam	Relatively More Adaptive				Relatively More Innovative			
Code Name	Abe	Bo	Chris	Dale	Mel	Nat	Pat	Ray
Individual Attributes								
Age	37	42	57	36	27	48	27	53
Gender	M	M	M	M	M	M	F	M
Ed	16	16	16	16	16	16	16	16
Tenure	4.5	8	21	6	1.8	2	3	18
Other Exp	7	9	10	3	5	25	2	13
Tot Exp	11.5	17	31	9	6.75	27	5	31
Map	M	M	M	M	M	M	W	M
Style (KAI)[a]	73 -1.50	78 -1.15	91 -.24	98 .25	108 .95	114 1.37	126 2.21	132 2.63
Job Status [b]	E3 3	E3 3	E4 4	S4 4	E3 3	E3 3	C2 3	E6 6
Level [c]	56 -.46	70 .08	113 1.62	55 -.49	38.5 -1.02	80 .82	38 -1.01	108 1.56
Subteam Attributes								
Mean Style	85 -.66				120 1.79			
Mean Level	73.5 .19				66.1 .09			

[a] Style Proxy is KAI scores-Tot number is raw score and bottom number is standardized KAI Z-score
[b] Job Status numbers are taken from Table IV-5. Top numbers are Domain Specific Scores and bottom are interval scores.
[c] Level proxy is based on Factor Analysis which loaded Age, Tenure, Total Experience, and Job Status. Top number is Age + Tenure + Total Experience + Job Status. The bottom number is the actual Factor Score produced in a Principal Components Analysis

had written to make sure everything was covered. Ray said, “I don’t know how much time we have” and picked up the instruction sheet and started reading. After a few moments he looked at his watch and said, “We need to call them in right now…it says during a period of 25 minutes you are to do the following…that includes the instructions…” Ray then exited to retrieve the operators.

After the operators were in the room Ray began, “This is a puzzle…a hollow square and otherwise it’s just a square. “There are four pieces at each station. “All of these are correct, location wise, if you are standing like you are now with your back to the window facing that way.” Mel (-1.02, 0.95) added, “And we have written directions too.” Abe (-0.46, -1.50) asked, “And it has got to fit inside that” [he pointed to the pattern sheet that Pat held up.] to which all the planners answered at once “No.” The planners offered different comments or directions sometimes interpreting others. Operator Chris (1.62, -0.24) asked, “Can we ask questions…can we take notes real quick before we start our task?” to which Ray replied, “Right quick, we only have a couple minutes left in our 25 minutes.” Chris said to the other operators, “I suggest everybody diagram…we’ve got four people…” Abe asked, “It’s being kept just like this, right?” Ray answered, “You’ll need to put them together…we’re going to leave.” Finally, Abe asked, “What’s the end state?” and “Does it have to be in a particular location?” Pat and Ray answered no. The planners’ time has lapsed and they leave the room.

The operators take every precaution about moving the puzzle pieces prematurely. They discussed how the pieces go together. Three of the operators begin discussing how simple it looked and appeared to be ready to move pieces around on the table. Chris said, “Make notes before you move them.” After that, Abe pulled out his cell phone and began taking photographs of the four sets of puzzle pieces. As Abe took pictures Chris picked up the written instructions and began reading. Following the reading of the instructions the operators quickly assembled the puzzle. Trial RAL-T4 is successful.

Table IV-15A contains cognitive gap tabulations for trial RAL-T4. The planner subteam person-person cognitive gaps (A+B) are (13.97, 8.4) compared to the mean scores of successful planner subteam of (9.19, 6.51). The planner subteam person-person and person problem cognitive gaps (A+B+D) are (14.42, 22.34) compared to all successful planner subteam trials of (9.41, 11.54). And, the total team cognitive gap is 60.50 as compared to the mean score of all successful teams of 41.77.

Table IV-15A Cognitive Gaps: Trial RAL-T4

(Gap Model Comparison)

		Role	Subteam Gap A	Subteam Gap B	Team Gap C	Subteam Gap D	Subteam Gap A+B	Subteam Gap A+B+D	Total Team Gap= A+B+C+D
Add Model	Level	Op	6.87	2.87	0.10	0.93	9.74	10.67	60.50
		Pl	9.56	4.41	.	0.44	13.97	14.42	
	Style	Op	6.16	2.66	2.45	1.70	8.82	10.52	
		Pl	5.88	2.52	.	13.95	8.40	22.34	
Raw Model	Level	Op	188.00	79.00	7.38	36.20	267.00	303.20	1177.50
		Pl	251.50	111.50		-0.68	363.00	362.33	
	Style	Op	88.00	38.00	35.00	24.30	126.00	150.30	
		Pl	84.00	36.00		199.30	120.00	319.30	

7.12 Raleigh RAL-T5

I administered Trial RAL-T5 on Dec 11, 2009 at noon. This was a non role-preferred trial with relatively more innovative subteam playing the planners' role and the relatively more adaptive subteam playing the operators' role. The trial took place in a training room with the video camera mounted on a tripod. The camera was turned on prior to the start of the exercise and seemed to have no effect on the participants. Table IV-16 contains vital information about trial RAL-T5. The difference between subteam mean KAI scores was over 1.5 standard deviations. The range of planners subteam KAI scores was less than 20 points.

This trial commenced with the planners discussing the puzzle pieces they had and how they could fit together. Ray (1.9, 1.65), focused on the rules and said, “We have to keep our pieces in front of us.” The group spent considerable time talking about triangles and how they would be arranged. They discussed quadrants and approaching the puzzle from a

Table IV-16. Trial: RAL-T5

Role	Operators				Planners			
Subteam	Relatively More Adaptive				Relatively More Innovative			
Code Name	Abe	Bo	Chris	Dale	Mel	Nat	Pat	Ray
Individual Attributes								
Age	61	49	46	36	29	28	25	63
Gender	M	M	M	F	M	F	M	M
Ed	18	21	16	16	16	16	18	21
Tenure	3.5	1.5	8	4	1.5	3.5	3	5
Other Exp	31	1.5	15	3	5	2.5	0	32
Tot Exp	34.5	3	23	7	6.5	6	3	35
Map	M	M	M	M	M	W	M	M
Style (KAI)[a]	72 -1.57	81 -.94	83 -.80	84 -.73	100 .39	101 .45	107 .88	118 1.65
Job Status [b]	E4 4	C2 3	S5 5	E3 3	E3 3	E1 1	E2 2	E3 3
Level [c]	103 1.59	56.5 -.32	82 .54	50 -.67	40 -.98	38.5 -1.01	33 -1.26	106 1.90
Subteam Attributes								
Mean Style	-1.01 80				.84 106.5			
Mean Level	72.9 .28				54.4 -.34			

[a] Style Proxy is KAI scores-Tot number is raw score and bottom number is standardized KAI Z-score
[b] Job Status numbers are taken from Table IV-5. Top numbers are Domain Specific Scores and bottom are interval scores.
[c] Level proxy is based on Factor Analysis which loaded Age, Tenure, Total Experience, and Job Status. Top number is Age + Tenure + Total Experience + Job Status. The bottom number is the actual Factor Score produced in a Principal Components Analysis

quadrant perspective but Ray said, “They are not really quadrants.” They appeared to go down a path of instruction for four quadrants where they would start with a base. Pat (-1.26, 0.88) said, “I think first is to identify what their task is…” Pat, a few minutes later, asked, “How long do we have to instruct…” Ray offered, “I think we need to have AN instructor rather than everybody yelling…”

Pat, who had been reading the instruction sheet during the last few moments read aloud and commented, “We may not show the key sheet to the operating team…” Ray and Mel replied “Alright” in unison. Pat continued while looking at Ray, “Alright…If we sketch a schematic on the back of the instruction sheet that is not the key sheet.” Ray utters an audible sigh and says, “That may be stretching it…” At that point Pat and the others appear to let that idea pass but after a few minutes Pat again addressed Ray and said, “Would you think that is allowable?” Ray said, in a matter of fact tone, “You’re showing them.” Nat (-1.01, 0.45), supporting Pat’s idea said, “The instructions say you may not show the key sheet…I say we go for it.” She continued, “It does not say anywhere that you cannot draw out…” Ray said, “That seems to be stretching it but I think that is a generational difference.” After a few minutes of minor debate Ray offered, “It doesn’t say you can’t sketch stuff, but to me that’s kinda pushing it.” Pat again addressed Ray and asked, “So we’re going to call that cheating?” and Ray said, “I would…but I come from a different generation…” After a few moments Ray’s words appeared to sink in and Pat said, “Okay, we’ll call that cheating then.” At this point the discussion returns to the four groups of puzzle pieces and general discussion about how the operating subteam could assemble the pieces.

The operations subteam barged in about two minutes before the planners’ time expired. The four operators gathered at the far end of the table and the planners gathered at the near end. Planner Pat began giving oral instructions about how the operating team should assemble the puzzle. Pat asked, “Operations team, first we would like to know what your task is?” Chris (0.54, -0.80) responded, “To satisfy the needs of the planning group.” After that Pat asked the operators to gather near the puzzle pieces on the table. He then said, “We are gonna start with Bo” [pointing at one of the members] “moving his shapes…” At that point I called time and sent the planning group to another room. The planners did not show the operating team the hollow square pattern sheet. At the time I stopped the instructions there had been little substantive information given.

The planners left the room and the operators began discussing a hollow square. It was clear that they did not have any idea as to what the hollow square looked like. Because they had not been instructed that the puzzle pieces were arranged in a pattern and they could be brought together the operators did not realize they should not move the pieces apart from each other. Unfortunately they quickly moved pieces around and lost any chance of ever solving the puzzle. Trial RAL-T5 was unsuccessful.

Table IV-16A contains cognitive gap tabulations for trial RAL-T5. The planner subteam person-person cognitive gaps (A+B) are (13.98, 5.88) as compared to the successful planner subteam cognitive gaps of (9.19, 6.51). The planner subteam person-person and person-problem cognitive gaps (A+B+D) are (12.29, 15.10) compared to the successful planner cognitive gaps of (9.41, 11.54). And, the total team cognitive gap score is 45.82 as compared to the successful total team score of 41.77, no substantive difference.

Table IV-16A Cognitive Gaps: Trial RAL-T5

(Gap Model Comparison)

		Role	Subteam Gap A	Subteam Gap B	Team Gap C	Subteam Gap D	Subteam Gap A+B	Subteam Gap A+B+D	Total Team Gap= A+B+C+D
Add Model	Level	Op	7.66	3.14	0.62	1.42	10.80	12.22	45.82
		Pl	9.51	4.47	.	-1.69	13.98	12.29	
	Style	Op	2.66	1.12	1.85	-0.05	3.78	3.73	
		Pl	4.20	1.68	.	9.22	5.88	15.10	
Raw Model	Level	Op	184.50	78.50	18.50	33.08	263.00	296.08	874.50
		Pl	220.50	103.25		-59.43	323.75	264.33	
	Style	Op	38.00	16.00	26.50	-0.70	54.00	53.30	
		Pl	60.00	24.00		131.80	84.00	215.80	

8. Critical Evaluation

This chapter has chronicled the research process, introduced a technique for analyzing the communicative interaction of the groups, offered additional theoretical and empirical work illuminating this type of study, and reported the critical communicative acts of the trials without attempt at explication. I have also developed and explained the concept of cognitive gaps and shown both cognitive level and cognitive style gaps for each of the trials. The next two chapters will include evaluation of qualitative and quantitative findings respectively. The final chapter will present implications of this work and recommendations for application and future research.

CHAPTER V QUALITATIVE FINDINGS

1. Overview

There are two classes of trials which will be reported on in this chapter: 1) successful trials and 2) unsuccessful trials. Successful trials were the ones in which the planners and operators collaborated to assemble the hollow-square puzzle within the prescribed time. Conversely, unsuccessful trials were ones in which the planners and operators failed to assemble the puzzle in the prescribed time. The initial focus of this work was on the interaction of high adaptors and high innovators collaborating to solve a non-trivial problem. In the previous chapter I have extended that focus to include some consideration of cognitive level along with cognitive style.

There were some observed difficulties in communication based on problem-solving styles between some planner and some operator groups. However, in most cases the planner groups were largely responsible for the failed trials to a much greater degree than were the operators. In the way this exercise played out, the planners' role emerged as the more challenging and more critical of the two role types. For example, in all five unsuccessful trials the planners failed to present a coherent solution concept to the operators. Consequently, the operators had almost no chance to solve the puzzle. There were 16 pieces to the puzzle. Mathematically, there are 16-factorial (16!) combinations in which the puzzle pieces might be arranged and absent a reasonable set of instructions from the planners, failure was virtually a certainty.

This chapter will extend the critical incident technique adaptation I introduced in the previous chapter by aggregating individual incidents into defined behaviors and their consequences with respect to either positive or negative contribution toward the solution of the puzzle. To each behavior and consequence I have assigned causal attributions based on two aspects of observed behavior: 1) cognitive style and 2) knowledge-in-action. Cognitive style is based on Kirton's A-I theory and its terminology consistent with my earlier discussion for consistency. Knowledge-in-action is drawn from Carlile's formulation of how knowledge is localized, embedded, and invested and the processes by which it crosses boundaries. The manifestations of Carlile's knowledge-in-action are one of three levels of communicative action and I will use those as a proxy for cognitive level and the degree to which they contribute to solving the puzzle.

Drawing from Carlile's (2002) work on boundary objects discussed in the previous chapter I will examine the critical incidents with respect to the three facets of knowledge boundaries to the extent one was evident in a critical incident. Recall that there are three hierarchical types of knowledge boundaries: syntactical, semantic, and pragmatic. For my purposes I call these *words, meaning, and understanding*. The implication of this is that for the lower level, *words*, a language is needed and used for outgoing communication. This is independent of the hearer. An example of how words can be spoken to no avail of problem solving is when someone speaks and her words go unacknowledged. The next level, *meaning*, implies that some words have been uttered, a listener has received them, and there is an interpretation of the words spoken. This enables a two-way dialogue. However, this does not insure intersubjectivity. Considerable exchange of words and clarification of meanings further enables possible mutual understanding. This is obviously a prerequisite for the final stage, *understanding*. At this highest level, *understanding* implies knowing something after a communicative transaction that was unknown (or not believed) prior to the transaction. This highest stage may more accurately be called *synergizing*. In Carlile's terms, only synergizing can lead to transformational knowledge. I will apply these categories to the observed critical incidents for the purpose of determining where important contributions to the outcome occurred during the exercise. Those contributions could be negative (restricting new knowledge) or they might be synergistic (enabling new knowledge). Of course the domain in which Carlile proposed his knowledge boundary conceptualization was an applied new product development. In that case new knowledge often truly requires major paradigm shifts for cross functional teams to reach synergy. I would argue, however, that even in more modest knowledge-in-action situations such as the Hollow-Square puzzle in this research, significant examples of boundary problems will be prevalent. Thus, carrying forth the Jablokow-Booth model concepts from the previous chapter in which I discussed *gaps* in cognitive style and cognitive level, I will offer some observations about the facets of boundary spanning mechanisms which impacted these outcomes, either positively or negatively.

The knowledge domain for this exercise is that contained in the instructions for the exercise. They include one page of written instructions which specify things the planners can and cannot do. Also, a puzzle pattern sheet and a separate puzzle solution sheet are included in the knowledge domain. The boundary for this problem is a strict prohibition against showing the puzzle solution sheet to the operators or assembling the total puzzle. Anything short of those is not strictly forbidden. For example, showing the pattern sheet is acceptable. And, there is no prohibition against sketching the puzzle piece shapes in the pattern sheet. A synergistic boundary spanning group would be one that explored the boundaries; e.g., what can we do and what can we specifically not do? Examples of exchanges which remain at the lowest level (talking) are those in which a subject speaks and no one makes a constructive reply. Another example is when a subject speaks and another participant rejects his comment immediately without further reflection. This is a negative example of the second level or meaning; i.e., the responder cuts off further exploration by the original speaker by virtue of his/her assertive refutation of the initial suggestion.

2. Classification Scheme for Critical Incidents Consequences

The critical incident technique is often used to assign classes or categories to major groups of critical incidents during the review of the small group dialogue, an example of which was presented by the Buffinton et al. (2002) research above. Recall that in the Buffinton et al. work journals of participants were reviewed for important impressions (critical incidents) and classified based on number of instances of particular types of journal entries. This could be said to be an inductive use of the technique. In my case I have identified a classification scheme based in Kirton's A-I theory and Carlile's (2002) knowledge-in-action concepts and will apply them to the critical incident technique in a deductive fashion.

In the previous chapter I presented my suggested depiction of cognitive schema as viewed through the lens of A-I theory (See Figure IV-3). Also, I expanded on Carlile's conceptualization of how information crosses boundaries for the purpose of collaborating across knowledge domains. I will use Kirton's schema of cognitive functioning and combine Carlile's heuristic of knowledge transfer for ascribing causation to manifest style or manifest level. In the case of cognitive style I will draw from Kirton's behavior descriptions shown earlier in Table I-1. The terms I will employ in the cognitive style classification will be as follows (See Table I-1, p.15):

1. Manifest cognitive style traits common to adaptors include: precision, reliability, efficiency, prudence, discipline, conformity, problem resolver, tried and true solutions, improvement, safe, dependable, maybe too focused, impervious to boredom, domain authority, risk averse, rule-keeper, group cohesion, high self doubt, and compliant.
2. Manifest cognitive style traits common to innovators include: undisciplined, disregard to details, different, probes novelty, outside box, problem finder, irreverent, impractical, shocking, ends justify means, disregard for means, abrasive, dissonant, low self doubt, proliferates ideas, tangential, and challenges status quo.

In the case of cognitive level I will use terms discussed above to identify three levels of communicative intelligence and knowledge transfer which I will use as a proxy for cognitive level:

1. Words-(syntax) basic declarative statements which have no measurable impact.
2. Meanings-(semantic) declarative and interrogative statements which explore the boundary of the problem.
3. Synergy-(pragmatic)-objects, models, and maps which are created through discourse which enable learning and transformative knowledge.

The first two manifestations of cognitive level have the possibility of both positive and negative valence; i.e., they could contribute positively to synergy or, conversely, they could block learning and synergy. In the subsequent presentation of critical incidents and their classification I will enumerate valence as positive (+) or negative (-) to indicate the nature of those acts. Also, I will discuss particular positive or negative contributions to cognitive level as necessary to illuminate the quality of problem-solving observed.

Again, referring to Figure IV-3, the cognitive style and cognitive level shown there interact with cognitive resource. In the Kirton schema cognitive resource is the sum total of accumulated knowledge and skills which enable and support cognitive style and cognitive level. Kirton used cognitive level as the power of the CPU, not the size of the hard drive—to employ a computer analogy. In the sense that I am using cognitive level in the subsequent discussion I am adopting the Carlile (2002) definition of manifest capacity as knowledge that is localized, embedded, and invested in a practice area. The application of Carlile's terms requires some blurring of Kirton's schema. But, for the purposes of this presentation the cognitive level variable is much more speculative than is the cognitive style variable. However, the manifest level shown below has useful application in problem solving as will be shown.

Where other aspects of Kirton's schema come into play which are outside the two classes of cognitive functioning I will make suitable footnotes for their identification.

3. Unsuccessful Trials

There were five unsuccessful trials during this research program. There were three unsuccessful trials with non preferred roles assigned to planners and there were two unsuccessful trials with preferred roles assigned to planners. The only particular characteristic worthy of note for the unsuccessful trials was that all three of the three-person planners' subteam failed.

Hare (2003) opined that groups sometimes outperform individuals during puzzle solving activity by virtue of the fact that the group has more people working on the problem. In my case where the three-person planning subteams were all unsuccessful I could make the argument that, *ceteris paribus*, the three-person subteam was only 75% capacity to the full four person subteam. Hare (2003:132) offered, “When groups are compared with individuals on the same task, groups are generally found to be better than the average individual but seldom better than the best.” Thus, the larger the group the more likely it will contain a person with skills beneficial to the problem. I will return to the three-person planning subteam performance discussion in the final chapter of this report.

The following presentation includes tables of observations of behaviors, consequence of the behavior, and a causal attribution of the behavior based on the classificatory scheme presented above. Some additional discussion will be included as appropriate.

3.1 Fort Myers FM-T1

Critical consequential behaviors observed during the Fort Myers Trial FM-T1 are shown in Table V-1. It is noteworthy that FM-T1 had a three-person planners’ subteam. Recall from the earlier presentation of trial summaries that this was a non role preferred trial.

This trial was administered by one of my research associates and was the first trial run during this experiment. Consequently, there were a couple of instances of facilitation variation that were not present in subsequent trials. Specifically, the facilitator told the group that they only had three minutes left and they should get the operators in and tell them something. This did not affect the outcome.

I noted two classes of behaviors in the presentation table and have extended that same format into all the subsequent tables which contain critical incidents and their classifications. First, *manifest style* refers to the observed behaviors which demonstrate aspects of problem-solving style represented by the critical incident indicated. As mentioned above, those manifest styles are described in terms used in Kirton's typology of adaptive-innovative behaviors found in Table I-1 above and as presented earlier in this chapter. Second, *manifest level* refers to the observed behaviors which are indicative of the qualitative value of communicative acts pursuant to knowledge transfer. It should be clear that both style and level are inextricably linked *in the way I am measuring them for this study*. That is, I am making both style and level inferences from some of the same utterances. However, the commonly held view today is that cognitive style and cognitive level are independent (Kirton 2003 and Jablokow and Booth 2006). I would argue that the "independent" level refers to the power of the CPU (or capacity) versus to the knowledge-in-action which is local, embedded, and invested and is observed by boundary objects as discussed herein. The latter cognitive level combines cognitive resource, and cognitive affect. That version of cognitive level influences and impacts cognitive style, hence is not totally independent in this situation.

In trial FM-T1 the three planners were modestly innovative. They were reported to be somewhat distracted by the fact that they were scheduled to depart the office for their field assignment as soon as their exercise was complete. Also, the planners were relatively similar in relative job status. I have footnoted the significance of both those items in the table of critical incidents for consideration.

The facilitator of this trial noted that this group appeared to be relatively lackadaisical toward their task. And, I noted that this planner group appeared to be weak in graphical/spatial resource, a trait I ascribed to the planners' disregard for details.

Table V-1 Trial: FM-T1. Group Decision-Process Effects and Causes [a]

Observed Behavior	Consequence	Cognitive Causal Attribution [b]	
		Manifest Style [c]	Manifest Level [d]
Poor effort to grasp instructions [e]	Repeated requests for interpretations about instructions with more stringent assumptions being made that necessary	undisciplined	words(-)
Casual conversation unrelated to task	Waste of valuable time and not carrying fair share of mental workload	undisciplined	-
Poor comprehension of written and oral communication	Repeated questions to the facilitator which all received the same unhelpful answer	disregard to details	meaning (-)
Poor work space organization	Table space was too small to enable planners to adequately spread out puzzle and grasp problem	disregard for means	-
Taking a phone call during activity	Distraction of others and demonstrated relative disregard of others working	dissonant	-
Suggestions receive poor/no support	Valuable suggestion about how to arrange pieces went for naught due to false interpretation of instructions	low self doubt	words (-)
Leaderless collective decision process [f]	Failure to converge ideas or understandings for the benefit of all	undisciplined	words (-)
Relative lack of intensity [e]	Most of time was expended talking about how to help operators solve problem but not doing so	probes novelty	meaning (-)
Failure to grasp appropriate boundaries of instructions	Group failed to produce understandable instructions for operators	disregard to details	meaning (-)
Poor graphical/spatial dexterity	Inability to conceive an instruction approach which could be understood by the operators	disregard to details	meaning (-)
Miscommunication with operators during instruction period	Operators were left with no written or graphical instructions and little ability to complete the puzzle	undisciplined	words (-)

[a] The examples of behaviors and their consequences are based on the most significant of the observations made of the recorded experiments following the critical incidents technique.
[b] The classification scheme used in the causal attribution of behavior is divided into two categories: Cognitive Style from Kirton's A-I theory and Cognitive Level using Carlile's boundary-spanning objects.
[c] The itemized traits in cognitive style come from the abbreviated list of behavior descriptions of adaptors and innovators shown in Table I-1 above.
[d] The valence indications (-) and (+) indicate the directional impact of the communicative act
[e] The facilitator observed that the subjects were impatient to get to their field assignments and displayed low motivation.
[f] All three planners had similar Relative Job Status which seemed to work against convergence of ideas

The words or phrases used to classify a critical incident (observed behavior and its consequence) as to its manifest style relate to typical behaviors along the adaption-innovation bipolar continuum. Words used to classify manifest level should be considered in conjunction with the stylistic description. In the case of the first critical incident the planners asked what they could do and were told to read the answer sheet. The words they used did not build toward rising to a new knowledge level. I consequently indicated a negative valence (-) to describe unconstructive facets of cognitive level. Because multiple questions were asked to the facilitator and to which the same reply was always given (everything you need to know is on the instructions) I deemed that series of interchanges to be indicative of a lower cognitive level, as indicated by the lowest level of communicative act or boundary object (words) with a negative valence. My view is that there was no substantive meaning acquired by the words spoken, hence the negative valence. In a later query planner Pat asked yet another question about writing instructions for the operators in which he interpreted the response much more severely than he should have; I scored this as *meaning (-)* to imply some level of understand was achieved during the discourse but, unfortunately, it was non-constructive. One critical incident which could have changed this outcome involved a suggestion by planner Mel when he said they could place the three puzzle groups side by side so as to provide a clue to the puzzle for the operators. This was dismissively rejected by planner Pat who displayed low self doubt in his assertion that, “We can’t assemble the puzzle,” as if the suggestion implied that. I considered that an indication of a low manifest level in action; i.e., words (-).

The critical consequential behaviors for the operators’ subteam in this trial are relatively moot since the facilitator did not video the actual instructions that the planners gave to the operators. Consequently, it was difficult to assess the quality of communication that occurred there. However, the operators were recorded during their deliberations. They were slow to move but made a critical error by the suggestion of pushing the three groups together and mixing the pieces up. Due to the poor quality of instructions received by the operators it was virtually impossible for them to have assembled the puzzle.

3.2 Wilmington WIL-T2

Critical consequential behaviors for the Wilmington Trial WIL-T2 are shown below in Table V-2. This trial also had a three-person planning subteam. This was a role preferred trial. The planners in this case were relatively more adaptive.

This planner group had a KAI mean score of only 82 points, a moderately adaptive team. However, the KAI scores ranged from 72 to 93 points, a significant 21 points. KAI score differences of over 10 points can contribute to difficulty in communication and differences of over 15 points can lead to serious communication and trust difficulties. Challenges in group problem solving when significant diversity is present were demonstrated in this trial. In addition to the style challenge, this group had three planners who are at the same relative hierarchical level in the organization. In addition to the problem of relative job status, this planner group was relatively long tenured in the organization (14, 18, and 12 years). This fact coupled with the relative job status worked to suppress anyone's willingness to step up to assume the leader role.

In the initial critical incidents listed in Table V-2 it was interesting to note that these three planners read considerable more prohibitions and restrictions into the instructions sheet than were actually there. In this case I can see how the style, which I called *compliant* and which might also reflect significant *risk-aversion*, clouded the meaning of information conveyed by the instructions. Additionally, I recorded a critical incident at the end of the planner deliberations where they left no instructions either written or oral for the operators. I

Table V-2 Trial: WIL-T2. Group Decision-Process Effects and Causes [a]

Observed Behavior	Consequence	Cognitive Causal Attribution [b]	
		Manifest Style [c]	Manifest Level [d]
Poor effectiveness in reading instructions	Did not build a collective understanding of rules	compliant	meaning (-)
Laser focus on a single solution concept	Missed other possible solution techniques	too focused	-
Ignoring good suggestion about sketching pieces on pattern sheet	Idea went unused	safe	meaning (-)
Lack of assertiveness by idea creator	Idea went unused	high self doubt	-
Poor listening by members	Non-convergent collaboration	problem resolver	words (-)
Lack of confidence by idea creator	Failed to leave sketch that would have been a valuable instruction tool for the operators	high self doubt	meaning (-)
Leaderless collective decision process	Failure to converge ideas or understandings for the benefit of all	makes goals of means	words (-)
Failure to establish boundaries	Did not push enough to the limits of rules	risk averse	-
Failure to comprehend boundaries of instructions	Group failed to communicate to operators even when operators barged in two times	makes goals of means	meaning (-)
Poor graphical/spatial dexterity	Inability to conceive an understandable instruction approach	too focused	-
Perceived prohibitions vastly exceeded actual instructions	Neither written nor graphical instructions was prepared	safe	meaning (-)
Operators knocked on door and asked to come in	Planners ignored them	too focused	words (-)
Operators entered room while planners were working	Planners ignored them again and operators left with no information	makes goals of means	-

[a] The examples of behaviors and their consequences are based on the most significant of the observations made of the recorded experiments following the critical incidents technique.
[b] The classification scheme used in the causal attribution of behavior is divided into two categories: Cognitive Style from Kirton's A-I theory and Cognitive Level using Carlile's boundary-spanning objects.
[c] The itemized traits in cognitive style come from the abbreviated list of behavior descriptions of adaptors and innovators shown in Table I-1 above.
[d] The valence indications (-) and (+) indicate the directional impact of the communicative act

attributed this to a *safe* style since the planners did not venture to push the instructions envelope. Hence, in both these cases I scored manifest level as *meaning (-)* to indicate meaning was conveyed (or understood) but in an inappropriate way.

This planner subteam displayed classic high adapter (style) behavior in its laser focus on a single solution. The two more vocal planners (this too was a three-person planner subteam) appeared to fixate on the only logical approach being creation of three groupings of puzzle pieces which would enable the operators to solve the puzzle. There was little dialogue pertaining to this aspect of the work so I did not ascribe a manifest level for this critical incident. The dominant dyad in this planner group failed to hear (comprehend) planner Bo who suggested marking on the pattern sheet to provide a key for the operators. The dominant dyad did not acknowledge planner Bo's idea. And, planner Bo displayed considerable *self doubt* in ceasing further argument. I judged the initial missed communication as *words (-)* to imply there was no indication that the dominant dyad even heard let alone understood the suggestion. Also, I ascribed a manifest level of *meaning (-)* for planner Bo who failed to make the dominant dyad understand the idea.

The dialogue reported in the previous chapter recounts interesting interaction between the relatively more innovative operations subteam and the relatively more adaptive planning subteam. I noted a critical incident when, very early during the planners' deliberations, one member of the operating subteam knocked on the door. The facilitator quickly went to the door and sent the operators away—inappropriately. Interestingly, the planners seemed to be oblivious to the incident. I considered the manifest style attribute *too focused*, a potential pitfall for higher adaptors. Additionally, I noted a second critical incident in which the operators actually entered the room and stood beside the table. The planners did not acknowledge the operators' presence and after about 90 seconds the operators left again. This time the facilitator said nothing. I called this manifest style attribute *makes goals of means*.

3.3 Charlotte CHL-T1

This trial was similar to WIL-T2 in that the three planners were at roughly the same hierarchical level in the organization. However, unlike WIL-T2, these three planners were relatively low tenured. Being relatively adaptive (KAI mean 85), these planners displayed little assertiveness in pushing each other to find the best solution, a common trait of adaptors who prefer to maintain group cohesion and cooperation. Thus, as A-I theory would predict, they were very polite to each other. This planner group viewed the instructions as particularly restrictive and, consequently, prepared no written or graphical instructions. I called this manifest style attribute *compliant* in that they dutifully read the instructions but seemed to have little grasp of the meaning, hence I considered the manifest level *words (-).*

Like the trial WIL-T2, this planner subteam quickly fixated on creating groupings of puzzle pieces and telling the operators how to assemble the puzzle based on those three groups. I called this manifest style *too focused* and assigned manifest level *meaning (-).* The relative equality in tenure and relative job status may have contributed to the critical incident I called tentative leadership. This relates to the *compliant* nature I mentioned in the first critical incident but I have ascribed the style attribute to be rule keeper and the level attribute *meaning (-)*.

This planner subteam mistakenly imputed considerably more prohibitions into the instructions sheet than were actually there. I ascribed this manifest style attribute to *conformity* and the corresponding level attribute *words (-)*.

Table V-3 Trial: CHL-T1. Group Decision-Process Effects and Causes [a]

Observed Behavior	Consequence	Cognitive Causal Attribution [b]: Manifest Style [c]	Cognitive Causal Attribution [b]: Manifest Level [d]
Poor effectiveness in reading instructions	Did not build a collective understanding of rules	compliant	words (-)
Laser focus on a single solution concept	Missed other possible solution techniques	too focused	meaning (-)
Tentative leadership	No challenges to collective assumptions and suggestions	rule keeper	meaning (-)
Poor graphical/spatial dexterity	Inability to conceive an understandable instruction approach	too focused	meaning (-)
Perceived prohibitions vastly exceeded actual instructions	Neither written nor graphical instructions was prepared	conformity	words (-)
Ineffective and incomplete communication with operators	Operators jumped in too quickly and the possibility of further assistance was lost	disregard to details	meaning (-)
Failure to establish boundaries	Did not push enough to the limits of rules and therefore limited the form of instruction	rule keeper	words (-)

[a] The examples of behaviors and their consequences are based on the most significant of the observations made of the recorded experiments following the critical incidents technique.
[b] The classification scheme used in the causal attribution of behavior is divided into two categories: Cognitive Style from Kirton's A-I theory and Cognitive Level using Carlile's boundary-spanning objects.
[c] The itemized traits in cognitive style come from the abbreviated list of behavior descriptions of adaptors and innovators shown in Table I-1 above.
[d] The valence indications (-) and (+) indicate the directional impact of the communicative act

One of the critical incidents which contributed significantly to the failure of this trial was the planners' instructions to the operators. This was a puzzling observation given the relatively adaptive nature of the planners subteam. Clearly the planners thought they had an understandable solution prepared. But, the mental images they held were not effectively conveyed. This is a good example of an attempt at *objects, models, and maps* in communicating boundary spanning knowledge in Carlile's terms. However, the planners failed to write or sketch anything for the operators. Thus, when the operators began their work there was no additional communication possible. I attributed the style attribute as *disregard to details*, a trait usually associated with more innovative styles. Also, I attributed the level attribute as *meaning (-)*. If the operating subteam had not started their work so quickly perhaps the planners could have orally depicted the solution so that the operators might have been successful. It was not certain, however, that with more instruction time the planners would have been successful in informing the operators. But, when the operators began their work they moved the first set of pieces together as the planners had instructed and found one piece was slightly too large, unbeknownst by the planners. This surprise resulted in the operators essentially regrouping and pursuing unsuccessful solution paths. Unfortunately the operators could not ask further questions once they began assembling the puzzle, a point they apparently did not consider before they began, an example of the innovative style of the operator subteam.

3.4 Raleigh RAL-T1

Critical consequential behaviors for trial RAL-T1 are shown in Table V-4 below. This was a non role preferred trial. On the day of trial there was an absence in the original randomly selected planners subteam. I rearranged the teams such that the least adaptive member of the operations subteam was moved to the planners subteam. The mean KAI score was 103 points, slightly innovative. However, the range of scores increased by 10 points due to the last minute change; i.e., from 88 to 118 points. Additionally, this group had three alpha-type males who were also relatively highly ranked in the organization.

Behaviors within this trial were indicative of those predicted by A-I theory. The three alpha-type males serve in leadership roles in the organization, but in different divisions. Consequently, when one would appear to be taking charge the others would push in a different direction. Unfortunately none of the solution paths was effective in reaching a successful solution.

Table V-4 Trial: RAL-T1. Group Decision-Process Effects and Causes [a]

Observed Behavior	Consequence	Cognitive Causal Attribution [b]	
		Manifest Style [c]	Manifest Level [d]
Poor effectiveness in reading instructions	Did not build a collective understanding of rules	disregard to details	words (-)
Too many ideas and too little agreement	No single idea was developed enough to provide adequate instructions	proliferates ideas	words (-)
Large number of ideas but narrowly focused	Only concept involved placing piles on table and instructing about procedure	proliferates ideas	meaning (-)
Relatively casual approach	Planners lacked intensity as if they would easily solve problem	irreverent	words (-)
Three alpha-types dominated discussion but no one led	Large blocks of time were consumed discussing one concept after another	dissonant	words (-)
Leaderless collective decision process	Failure to converge ideas or understandings for the benefit of all	probes novelty	meaning (-)
Failure to comprehend boundaries of instructions	Planners missed all possible forms of instruction except oral	disregard to details	words (-)
Poor graphical/spatial dexterity	Inability to conceive an understandable instruction approach	proliferates ideas	meaning (-)
Complete failure to understand schedule requirements	Planners used all available time in discussion and left none for instructing operators	undisciplined	words (-)
Operators tried to assemble the puzzle without assistance	Operators moved the puzzle pieces together and failed to solve	conformity	words (-)

[a] The examples of behaviors and their consequences are based on the most significant of the observations made of the recorded experiments following the critical incidents technique.
[b] The classification scheme used in the causal attribution of behavior is divided into two categories: Cognitive Style from Kirton's A-I theory and Cognitive Level using Carlile's boundary-spanning objects.
[c] The itemized traits in cognitive style come from the abbreviated list of behavior descriptions of adaptors and innovators shown in Table I-1 above.
[d] The valence indications (-) and (+) indicate the directional impact of the communicative act

The planners in trial RAL-T1 never seemed to grasp the instructions in spite of their relative collective intellect. I called a critical incident their poor effectiveness in reading the instructions which resulted in no collective understanding of the problem boundaries and requirements. I ascribed the manifest style *disregard to details*, a surprising observation for at least one of the planners (Planner Mel KAI 88 is well known for his attention to detail). And I ascribed the manifest level *words (-)* since many words were spoken but there was little observable *shared meaning* that made a positive contribution to the problem. This was particularly evident between planner Mel (KAI 88) and planner Ray (KAI 118), as a 30 point KAI score difference would predict.

I identified three critical incidents which were caused by the relative high innovative trait of proliferation of ideas. Interestingly, the ideas all centered on different combinations of the same solution approach; i.e., arranging the puzzle pieces in some kind of systematic orientation which would make the solution obvious. I ascribed the manifest level for these as *words (-)* once and *meaning (-)* twice. The two incidents during which some degree of meaning was attained involved the planners' agreement of a spatial arrangement of the pieces. While agreement was reached, the planners were unable to push to a solution of how to instruct the operators to use their spatial arrangement, thus I scored a negative valence.

Two other critical incidents in this trial occurred as a direct result of cognitive style gaps, both of which had to do with understanding the details of the instructions. I classified the manifest styles for these two as disregard to details and undisciplined, both classic behaviors for more innovative people. And, I ascribed the manifest level words (-) for these since it seemed that words were spoken but not really understood.

I identified only one critical incident for the operators during the solution period. In this trial the planners ran out of time prior to writing any instructions for the operators or prior to providing any oral instructions to the operators. Consequently, the operators had little chance of successfully solving the puzzle. The planners had left the puzzle pieces grouped across the table but the operators, not knowing the intention of the planners, pulled the pieces together in a random grouping and made an effort to solve the puzzle. I ascribed the manifest style for this incident as *conformity*. The operators knew the name of the exercise was the Hollow Square and, consequently attempted assemble a hollow square but with no success.

The three-person operations team exhibited some degree of frustration concerning the position that the planning subteam had put them in. The operators made several comments which I ascribed to manifest level as *words (-)* but they really contributed no help toward solving the puzzle.

3.5 Raleigh RAL-T5

Critical consequential behaviors for trial RAL-T5 are shown in Table V-5 below. This was a non role preferred trial. The planners were moderately innovative, KAI mean of 106.5. The range of KAI scores varied only 20 points but there were other factors at play in this trial which appeared to influence the outcome.

Planner Ray was a 63 year old retired college professor. Coincidentally, he was one of the professors for planner Pat. However there was a considerable age difference. In fact, the average age of Mel, Nat, and Pat was 27.3, roughly 35 years junior to planner Ray. When the idea of sketching the puzzle shapes on the pattern sheet arose Ray called it cheating and said it was a generational thing. This dampened any additional pursuit of that solution idea and the group was unsuccessful. In Table V-5 above I attributed the cause of that moral dilemma to *dissonant* which is a result of abrasive behavior, whether intentional or not. Clearly an emotional edge was created by Ray’s comment and with his relatively senior status of both age and education the other members made little effective rebuttal and contribution. I ascribed the manifest level attribute meaning (-) since clearly a shared meaning occurred vis-à-vis the moral dilemma. Unfortunately planner Ray perceived his

Table V-5 Trial: RAL-T5. Group Decision-Process Effects and Causes [a]

Observed Behavior	Consequence	Cognitive Causal Attribution [b]	
		Manifest Style [c]	Manifest Level [d]
Poor effectiveness in reading instructions	Did not build a collective understanding of rules	disregard to details	words (-)
Many ideas and suggestion	Little convergence on a workable method to instruct operators	proliferates ideas	words (-)
Pushed to limits of rules but was overruled by alpha-type planner	A moral dilemma was raised which prevented the idea from being used	dissonant	meaning (-)
Lack of confidence by idea creator	Idea went unused due to excessive influence by one planner	abrasive	meaning (-)
Relatively casual approach	Time nearly expired but operators barged in only to receive very poor and incomplete instructions	disregard to details	words (-)
Two alpha-types dominated discussion but no one led	Failure to converge ideas or understandings for the benefit of all	problem finder	meaning (-)
Poor graphical/spatial dexterity	Inability to conceive an understandable instruction approach	disregard to details	words (-)
Perceived prohibitions vastly exceeded actual instructions	Neither written nor graphical instructions was prepared	disregard to details	meaning (-)
Operators tried to solve puzzle without a visual guide	Operators abandoned the marginal oral instructions too quickly	resolving problems	meaning (-)

[a] The examples of behaviors and their consequences are based on the most significant of the observations made of the recorded experiments following the critical incidents technique.
[b] The classification scheme used in the causal attribution of behavior is divided into two categories: Cognitive Style from Kirton's A-I theory and Cognitive Level using Carlile's boundary-spanning objects.
[c] The itemized traits in cognitive style come from the abbreviated list of behavior descriptions of adaptors and innovators shown in Table I-1 above.
[d] The valence indications (-) and (+) indicate the directional impact of the communicative act

remarks as objective opinion and the other three planners perceived his remarks as negative judgment. Other critical incidents occurred which are noted in Table V-5 which contributed to the overall outcome. However, the moral dilemma which played out in this group proved to be the dominant critical incident which influenced the outcome.

The operators barged into the room prior to being summonsed. Their roughly two minutes of oral instructions left them with a marginal understanding of the intention of the planners. The planners, as noted in the critical incident concerning perceived prohibitions vastly exceeding actual rules, left no written or drawing information for the operators. This was an important observation leading to the next critical incident involving the operators in which they tried to solve the puzzle without a visual guide. The operators came close to solving the puzzle based on limited instructions but because one of the triangle pieces was in the wrong location they abandoned the solution and started from scratch. I ascribed the valiant effort by the operators to the manifest style attribute *resolving problems*, a classic adaptor behavior. I ascribed the communication that occurred between the operators to the manifest level attribute *meaning (-)* to indicate the fact that some shared understanding occurred but not constructive.

4. Successful Trials: Critical Observations

There were seven successful trials in this experimental program. Behaviors observed during these trials were revealing in terms of group interaction and good decision processes. There were instances of behaviors which A-I theory would predict and some surprising deviations. Also, in contrast to the manifest level observations made in the unsuccessful trials there were many more synergistic examples in the successful trials, not unexpectedly. I will note both manifest style attributes and manifest level attributes in tables similar to those used with the unsuccessful trials. Again, I will classify critical consequential behaviors with the same scheme introduced above. And, I will comment on some of the more instructional or outstanding examples of manifest style and manifest level.

4.1 Clearwater CW-T1

Critical consequential behaviors for the Clearwater trial CW-T1 are shown in Table V-6. This trial consisted of a four-person planner subteam. This was a role preferred trial.

These planners had a KAI mean score of 88 points, slightly adaptive. The range of KAI scores, however, was 23 points. The range of KAI scores could have resulted in communication and style difficulties but none was observed. A contributing factor to the relative harmony in such a diverse group can be attributed to the natural hierarchy that this group enjoyed. A 23 year veteran who is also a high ranking leader in the company was accompanied by a fairly high ranking professional and two lower ranking professionals. This group's problem-solving behavior exemplifies successful group behavior. The group made ample plans and instructions for their operating team and the operating team successfully completed the puzzle in a few minutes.

Table V-6 Trial: CW-T1. Group Decision-Process Effects and Causes [a]

Observed Behavior	Consequence	Cognitive Causal Attribution [b]	
		Manifest Style [c]	Manifest Level [d]
Thorough reading of instructions	Quickly developed and resolved questions	precision	synergy
Natural group leader probed the boundaries of the problem	A safe condition was created for pushing ideas	domain authority	meaning (+)
A near-boundary idea was floated and the natural leader quickly affirmed it	A solution concept was developed	rarely challenges rules	meaning (+)
All planners made suggestions supporting the solution	No communication problems which diverted creative energy—convergent solution	dependable	synergy
Group determined that they must go instruct the operators	Operators had necessary and sufficient instructions	efficiency	meaning (+)
Group divided itself into sketchers and instructors	Wise allocation of resources	discipline	synergy
Clearing of table before operators return over concern of rule breaking	Demonstrated concern about right and wrong	rule keeper	meaning (+)
Operators assumed they could write on the puzzle pieces	Operators were able to easily solve the puzzle and keep up with the pieces which were placed	takes control	synergy

[a] The examples of behaviors and their consequences are based on the most significant of the observations made of the recorded experiments following the critical incidents technique.
[b] The classification scheme used in the causal attribution of behavior is divided into two categories: Cognitive Style from Kirton's A-I theory and Cognitive Level using Carlile's boundary-spanning objects.
[c] The itemized traits in cognitive style come from the abbreviated list of behavior descriptions of adaptors and innovators shown in Table I-1 above.
[d] The valence indications (-) and (+) indicate the directional impact of the communicative act

For illustrative purposes I will discuss a few of the critical incidents which were most important to the successful execution of this trial. Firstly, I observed the planners thoroughly reading and discussing the instructions, a manifest style attribute I called *precision*. The discourse in which the planners engaged included both questions and answers. They probed the boundaries of the problem and affirmed other's opinions, a manifest level attribute I called *synergy*. Similar to the hierarchical conception of Carlile's three knowledge boundaries and processes, this served as both the syntactical (a language structure was hammered out by the planners) and the semantic (shared meaning in which differences and dependencies were illuminated) were achieved. I ascribed this to manifest level attribute *meaning (+)*.

A second critical incident which proved important was the natural group leader emergence and his subsequent probing the boundary of instructions. I noted the consequence of this as making the other planners feel comfortable in their ideation, a manifest style attribute I called domain authority. The corresponding manifest level attribute was meaning (+) as the planners collectively developed constructive interpretation of the instructions in such a way as to lead toward the successful solution of the puzzle.

The last critical incident observed during the planners' deliberation involved the idea in which planner Dale suggested sketching the puzzle shapes on the back of the pattern sheet. Such an idea had been rejected by other trials but the natural leader, as mentioned in the previous paragraph, supported the idea thereby allowing it to fully blossom into the solution concept. I ascribed this manifest style attribute as *rarely challenges rules* unless assured of strong support which the natural team leader provided. The manifest level attribute was called *meaning (+)* as the planner group achieved shared understanding about their solution following this exchange of questions and answers.

I noted the operators' critical incident concerning their assumption of "there are no rules" and writing on the puzzle pieces. Consequently the operators were able to keep up with the pieces as they placed them and solve the puzzle quickly. This operators' subteam was very slightly innovative and demonstrated that in their behavior concerning the question of writing on the puzzle pieces, a manifest style attribute I called *takes control*. They worked well together in discussing how to solve the puzzle and make it fit exactly correctly. I ascribed a manifest level attribute of *synergy* to this operators subteam activity. The operators displayed some adaptive tendencies in their meticulous assembly of the puzzle, perhaps because of their modest KAI score (mean 99.3).

4.2 Clearwater CW-T2

Critical consequential behaviors for the Clearwater trial CW-T2 are shown in Table V-7. This was a four person planning subteam. The planners had a mean KAI score of 105.3 points, moderately innovative. The range of KAI scores, however, was 21 points. This was a non role preferred trial. This trial was one of two all-female planning subteams. Since this was an all-female group the mean KAI score of 105.3 means this was somewhat more innovative in natural problem solving preferences than had it been composed of all men—population samples in the US indicate mean KAI scores for women are about 91 points—nearly one standard deviation below the mean score for this planning group.

These planners read parts of the instructions aloud as if they might better understand if they heard the words spoken. I reported this critical incident as all members orally

Table V-7 Trial: CW-T2. Group Decision-Process Effects and Causes [a]

Observed Behavior	Consequence	Cognitive Causal Attribution [b]	
		Manifest Style [c]	Manifest Level [d]
Casual reading of instructions	Developed a partial understanding of boundary	disregard to details	meaning (+)
All members orally contributed	Group quickly began working together	probes novelty	synergy
A creative idea was suggested and the members debated its appropriateness	A solution concept was developed	outside box	synergy
All planners made suggestions supporting the solution	No communication problems which diverted creative energy—convergent solution	confident	synergy
Planners discussed who would be best able to communicate with operators	An engineer was selected since the operators were all engineers	problem finder	meaning (+)
Planners sit and idly chat after finding a solution	Planners did not prepare a written plan and were lucky to have time for oral instructions to operators	disregard to details	meaning (-)
Planners provided oral instructions to operators	Operators had just sufficient instructions to complete the task	undisciplined	meaning (+)
Operators carefully considered their task prior to beginning	The four keys were kept undisturbed prior to the total assembly	precision	synergy

[a] The examples of behaviors and their consequences are based on the most significant of the observations made of the recorded experiments following the critical incidents technique.
[b] The classification scheme used in the causal attribution of behavior is divided into two categories: Cognitive Style from Kirton's A-I theory and Cognitive Level using Carlile's boundary-spanning objects.
[c] The itemized traits in cognitive style come from the abbreviated list of behavior descriptions of adaptors and innovators shown in Table I-1 above.
[d] The valence indications (-) and (+) indicate the directional impact of the communicative act

contributed. I ascribed this manifest style to the attribute *probes novelty*. Also, the collective dialogue when ensued during this time was an example of manifest level that I termed *synergy*. This occurrence was the foundation for the next critical incident, which I called a creative idea suggested. Based on the novel idea, which I termed the manifest style attribute *outside box* a solution was formulated. The planners contributed oral support and encouragement for this novel solution thereby demonstrating the manifest level attribute *synergy*.

A less positive critical incident occurred after planners conceived the solution. They sat idly and chatted for several minutes, apparently unaware of their responsibility to summons the operators and instruct them on how to assemble the puzzle. I called the manifest style attribute in this instance *disregard to details*, a common pitfall for innovators. The planners had developed some sense of understanding about the rules unfortunately they were incomplete. I viewed the manifest level attribute *meaning (-)* in this case.

I noted a critical incident involving planners barging into the room early. I ascribed a manifest style attribute of *conformity* to the operators in consideration of their zeal to be productive. There was no particular manifest level displayed in this but the operators' effort saved the planners from self-destructing. Had the planners sat another two or three minutes they would have been unable to provide oral instruction to the operators. And there was no indication that the planners were going to act to retrieve the operators. After the operators entered the room there was an awkward moment before the designated planner provided relatively complete instructions.

I observed a critical incident involving the operators during their portion of the exercise. The operators were very careful to not move all the pieces around but to take considerable time prior to moving even the first piece. I considered the manifest style attribute in this instance to be *precision*. And, the manifest level attribute was *synergy*. In this case the operators were very helpful to solving the puzzle, in spite of the relatively simple solution concept.

4.3 Charlotte CHL-T2

Critical consequential behaviors for the Charlotte trial CHL-T2 are shown in Table V-8. This was a four person planning subteam and was role preferred. The planners had a mean KAI score of 81 points, medium adaptive. The range of KAI scores, however, was 22 points slightly over the prescription of 20 points. The planners were similar in hierarchical position within the company. I should note that the metric used as a proxy for cognitive level, as shown earlier in Table IV-11 was -0.99, or about one standard deviation below the mean of the factor scores. I will comment on a few of the critical incidents for illumination beyond what is presented in the chart.

This trial demonstrated two parallel solution concepts, one successful and one unsuccessful. The high adaptor who wrestled with a moral dilemma as to the ability of her team to present a sketch of the puzzle pieces pursued a completely different solution. She wrote a lengthy description of how the operators might assemble the four groups of puzzle pieces by sliding them together in a certain sequence. I cited this occurrence as a critical incident as moral issues with solution by the most adaptive of the planners. I ascribed this manifest style to *rule keeper*, a common challenge for high adaptors. The corresponding manifest level attribute was *meaning (-)* as I inferred that the planner had understood instructions but, unfortunately, incorrectly or more restrictively than necessary.

The other planners, whom I will call a triad, worked together to draw the puzzle pieces on the pattern sheet, an option that they were free to pursue. I should note that this solution technique was a boundary edge solution, implying that it required pushing the rules to the limit. In this case I cited two critical incidents involving this boundary edge work by

Table V-8 Trial: CHL-T2. Group Decision-Process Effects and Causes [a]

Observed Behavior	Consequence	Cognitive Causal Attribution [b]	
		Manifest Style [c]	Manifest Level [d]
Casual reading of instructions	Developed a partial understanding of boundary	disregard to details	meaning (-)
All members orally contributed	Group quickly began working together	efficiency	meaning (+)
Three members supported a boundary pushing idea	A solution concept was determined	rarely challenges rules	meaning (+)
Most adaptive planner displays moral issues with solution	Pursues an independent solution concept	rule keeper	meaning (-)
Boundary pushing planners persist argument of legitimacy	Objector acquiesces but with some doubt	challenged rules cautiously	synergy
Operators received no oral instructions from planners	Operator took control with misleading instructions	low self doubt	words (-)
Controlling operator took phone call	Other operators found sketch solution and solved puzzle	challenge status quo	synergy

[a] The examples of behaviors and their consequences are based on the most significant of the observations made of the recorded experiments following the critical incidents technique.
[b] The classification scheme used in the causal attribution of behavior is divided into two categories: Cognitive Style from Kirton's A-I theory and Cognitive Level using Carlile's boundary-spanning objects.
[c] The itemized traits in cognitive style come from the abbreviated list of behavior descriptions of adaptors and innovators shown in Table I-1 above.
[d] The valence indications (-) and (+) indicate the directional impact of the communicative act

the triad: first the triad supporting the boundary pushing idea and second the triad argues for legitimacy of solution. I ascribed the manifest style attribute in both cases to be *challenge rules rarely*. Adaptors only challenge rules when they have strong support, which they received from the triad. Note that they had considerable argument with the planner with the moral dilemma concerning the appropriateness of that solution. I ascribed a manifest level attribute of *synergy* for both these critical incidents as they demonstrate dialogue and probing the limits of a question.

Due to the planner subteam using all the 25 minute period deliberating there was no time left for instructions to the operators. I noted a critical incident for the operators that they received no oral instructions. As a result the operators took seats at the table and ultimately found the instructions written by the moral dilemma planner which were no help. I noted that one operator began to read these instructions and dominated the operators' activity. I called this manifest style to be *low self doubt*, particularly for the dominating operator. I ascribed the manifest level attribute to *words (-)* to capture the fact that while words were spoken they contributed nothing positive toward the solution.

I noted another critical incident when the dominating operator took a cell phone call and, thereby, was not able to continue reading the meaningless instructions. It was during that cell phone call that the other operators found the sketch solution produced by the triad and commenced to solve the puzzle immediately. This manifest style was a *challenge to status quo* (of the dominating operator and his written instructions) and I called the corresponding manifest level attribute *synergy*.

4.4 Wilmington WIL-T1

Critical consequential behaviors for the Wilmington trial WIL-T1 are shown in Table V-9. This was a four person planning subteam and was role preferred. The planners had a mean KAI score of 84.5 points, medium adaptive. The range of KAI scores was only 7 points, therefore they were quite similar in preferred cognitive style. One of the planners was the co-founder of the organization and was significantly separated from the other planners hierarchically. The proxy for cognitive level factor score was about one standard deviation above the mean.

I have cited the creative idea solution by planner Bo as a critical incident. Its consequence was the ending of debate and random conversation about how to solve the problem. I ascribe the manifest style to *domain authority* and the corresponding manifest level attribute to *meaning (+)* for this incident. The second, but related, critical incident concerning the selection of the solution was the extensive explanation that planner Bo provided for the other planners. Several questions were asked and it was clear that the other planners did not immediately catch on to the idea until much exchange. The outcome of this extensive explanation was shared understanding. I ascribed the manifest style attribute compliant to capture the behavior of the adaptive planning team. I also ascribed the manifest level attribute synergy for the collective exchange and learning that was evidenced at this trial. Planner Bo was individually responsible for conceiving the solution concept for this trial, helping the other planners understand it, preparing the puzzle pieces, and instructing

Table V-9 Trial: WIL-T1. Group Decision-Process Effects and Causes [a]

Observed Behavior	Consequence	Cognitive Causal Attribution [b]	
		Manifest Style [c]	Manifest Level [d]
Thorough reading of instructions	Developed a solid understanding of boundary	precision	meaning (+)
One planner conceived creative idea after considerable thought	A very good solution ended debate about different alternatives	domain authority	meaning (+)
Senior executive led the planners to understand his solution	Other planners soon understood and contributed	compliant	synergy
Senior executive observed that orientation of groups needed attention	Simplified the ultimate instructions for the operators	problem resolver	synergy
Planners allocated time to fully inform operators how to solve puzzle	Operators had adequate instructions for solution	efficiency	meaning (+)
Operators asked few questions prior to beginning task	Some confusion occurred as a result of misperceptions about final location of puzzle	disregard to details	words (-)

[a] The examples of behaviors and their consequences are based on the most significant of the observations made of the recorded experiments following the critical incidents technique.
[b] The classification scheme used in the causal attribution of behavior is divided into two categories: Cognitive Style from Kirton's A-I theory and Cognitive Level using Carlile's boundary-spanning objects.
[c] The itemized traits in cognitive style come from the abbreviated list of behavior descriptions of adaptors and innovators shown in Table I-1 above.
[d] The valence indications (-) and (+) indicate the directional impact of the communicative act

the operators as to the proper assembly. This is a good example of when subject-matter expertise and managerial position combine for a positive outcome.

Because of the excellent solution instructions prepared and delivered to the operators there were few incidents which rise to a level of criticality in the operators' deliberations. However, one critical event was noted involving the placement of the puzzle after its assembly. I noted that the operators asked few questions prior to beginning assembly. That resulted in some confusion as to where the assembled puzzle should be placed on the table. I ascribed the manifest style attribute for this incident to *disregard to details*. I ascribed the manifest level attribute for this case to be *meaning (-)*. Clearly words were spoken and heard by the different operators. But also it was clear that there were different interpretations of those words.

Another example, also not reported as a critical incident but descriptive of typical innovator behaviors, occurred with respect to the small square templates that were in the center of the puzzle. One of the operators understood the instructions to say leave the small paper squares in place in the completed puzzle and some heard otherwise. As this operations' subteam was relatively more innovative it was in keeping with expected behaviors that one of them asked, "…do you think we should have asked more questions before we jumped right in," a comment which revealed the operators' innovative problem solving style. This was a successful trial.

4.5 Raleigh RAL-T2

Critical consequential behaviors for the Raleigh trial RAL-T2 are shown in Table V-10. This was a four person planning subteam and was role preferred. The planners had a mean KAI score of 75.8 points, or about 1.3 standard deviations below the mean. The planners' range of KAI scores was 17 points. The planners' relative job status did not appear to influence any outcome. The operators KAI raw score mean was 104, or +0.69 factor score. The cognitive level proxy was -0.51 for the planners and -0.14 for the operators.

This planning subteam actually presented two different but completely sufficient solutions. While they were a relatively high adaptor group they did not limit their idea generation to just one. In addition, the second idea was sufficiently close to the instruction boundary that they wrestled with the appropriateness of the approach for creative idea number two.

In spite of considerable study of the instructions the planners missed their responsibility to fetch the operators and provide them instructions. Fortunately for this planning group they provided abundant written and graphical instructions for the operators so no additional oral instructions were necessary. I will briefly expand on several of the noted critical incidents and corresponding cognitive styles and levels.

Planner Abe (KAI 67) conceived solution concept number one and was considered a critical incident. This solution was explained with great detail by planner Abe and it strictly fit well within the bounds of the instructions. I considered this incident to demonstrate manifest style as compliant, as would be expected by a relatively high adaptor. The adaptor was successful in explaining his solution to the other planners. I ascribed the manifest level attribute meaning (+) in this incident.

Table V-10 Trial: RAL-T2. Group Decision-Process Effects and Causes [a]

Observed Behavior	Consequence	Cognitive Causal Attribution [b]	
		Manifest Style [c]	Manifest Level [d]
Relatively thorough reading of instructions	Developed a partial understanding of boundary	precision	meaning (-)
All members orally contributed	Group quickly began working together	group cohesion	words (+)
Creative idea number one offered by a member	A solution concept was determined	compliant	meaning (+)
Detailed written instructions were developed for idea number one	Solution was sufficient by itself	conformity	synergy
Creative idea number two was advanced and supported by others	Another solution concept was determined	probes novelty	synergy
Other three planners worked on second creative idea	A second solution concept was fully developed	rule challenge support	synergy
Only written and graphical instructions were provided for operators	Operators looked for instructions prior to moving puzzle pieces	discover problem	meaning (+)
Operator called the north arrows "nerdy"	Demonstrated disregard of Planner's means of communication	irreverent	meaning (+)

[a] The examples of behaviors and their consequences are based on the most significant of the observations made of the recorded experiments following the critical incidents technique.
[b] The classification scheme used in the causal attribution of behavior is divided into two categories: Cognitive Style from Kirton's A-I theory and Cognitive Level using Carlile's boundary-spanning objects.
[c] The itemized traits in cognitive style come from the abbreviated list of behavior descriptions of adaptors and innovators shown in Table I-1 above.
[d] The valence indications (-) and (+) indicate the directional impact of the communicative act

The other planners understood solution one but were unsatisfied as to its sufficiency. Thus, the other three planners, a triad, developed a creative idea that I dubbed creative idea number two and identified it as a critical incident. I ascribed their manifest style as *probes novelty*, a behavior that is more usually descriptive of innovators. I ascribed their manifest level as *synergy*; clearly the triad worked hard to provide this second solution.

Another critical incident related to creative solution number two had to do with building a consensus as to the propriety of solution number two. This considerable dialogue demonstrated how ideas opened minds and how minds were changed during the discourse. I ascribed the manifest style attribute *rule challenge support.*. As mentioned above, adaptors require strong support for decisions that are near the boundary. Also, I ascribed the manifest level attribute as *synergy*, a good example of how dialogue enabled learning.

Due to the major mistake by the planners on the time requirements the operators were not given any oral instructions. I noted a critical incident where only written and graphical instructions were provided for operators. The consequence of that was the operators had to figure out what they were tasked to do with only written and graphical material. The relatively more innovative operators exhibited surprising restraint as they approached the problem and carefully read over the detailed instructions that planner Abe had prepared while the planner triad was creating its second solution. I ascribed this manifest style as *discover problem* to capture the operators' behavior upon entering the room. Also, the operators had constructive dialogue that built consensus as to what they needed to do. I ascribed the manifest level as *meaning (+)* to capture the obvious shared understanding.

I identified an interesting but not necessarily critical incident involving an operator calling part of the planners' written instructions nerdy. The comment demonstrated a relative distain of the planners' means of communication. This was a manifest style I called irreverent, a behavior typical of innovators. Interestingly, this comment was made by operator Ray (KAI 115) and the written instructions in question were produced by planner Abe (KAI 67). This represents a KAI range of nearly 50 points and explains the wide variation such cognitive style differences exhibit. In spite of the fact that the nerdy comment was somewhat derisive, it was humorous and contributed to the understanding of what the planners were trying to convey. Thus, I ascribed a manifest level attribute meaning (+) to this incident.

Although the dialogue shown in the previous chapter did not report it I was puzzled by the relatively high adaptive planner group missing the time constraints. During the post exercise discussion I asked the planners why they did not retrieve the operators and provide them oral instructions. Planner Abe (KAI 67) said, "Well…you're everybody's boss and when you send somebody away to a room I expect they will stay there until you send for them back." This is an example of unwitting influence during administration of experiments that should be considered for future experiments. In spite of the problems with the prescribed time, Trial RAL-T2 was successful.

4.6 Raleigh RAL-T3

Critical consequential behaviors for the Raleigh trial RAL-T3 are shown in Table V-11. This was a four person planning subteam and was non role preferred. The planners had a mean KAI score of 106.7 points, slightly innovative. The range of planner KAI scores was 21 points. The range of KAI mean scores between the planners and the operators was 27 points. Relative job status did not appear to influence the outcome. The level proxy for the planner subteam was about one standard deviation above the mean. The level proxy for the operators was right at the mean factor score.

The planners for this trial pushed the limits of the instructions more than any other group. They moved quickly from one concept to another with no hesitation, an attribute that I ascribe to the relative innovativeness of the group. The female member of the group had a KAI score of 116 making her considerably innovative. She was quite vocal during the discussion and was quick to say, "Yes, let's do it…" for almost any suggestion that was made. I will elaborate on a few of the critical incidents depicted in Table V-11 to illuminate both manifest styles and manifest levels observed.

Table V-11 Trial: RAL-T3. Group Decision-Process Effects and Causes [a]

Observed Behavior	Consequence	Cognitive Causal Attribution [b]	
		Manifest Style [c]	Manifest Level [d]
Relatively casual reading of instructions	Developed a partial understanding of boundary	disregard to details	words (+)
All members orally contributed	Group quickly began working together	proliferates ideas	words (+)
Idea offered by a member	Group rallied behind	problem finder	meaning (+)
Alternative idea offered by a member	Group changes almost immediately	proliferates ideas	synergy
Brief oral instructions were provided to operators	Due to simple solution planners provided, limited oral instructions were sufficient	undisciplined	meaning (+)
Operators very cautious about apparent solution	It took longer for the operators to assemble the puzzle that expected	compliant	-

[a] The examples of behaviors and their consequences are based on the most significant of the observations made of the recorded experiments following the critical incidents technique.
[b] The classification scheme used in the causal attribution of behavior is divided into two categories: Cognitive Style from Kirton's A-I theory and Cognitive Level using Carlile's boundary-spanning objects.
[c] The itemized traits in cognitive style come from the abbreviated list of behavior descriptions of adaptors and innovators shown in Table I-1 above.
[d] The valence indications (-) and (+) indicate the directional impact of the communicative act

One incident that proved critical was the relatively casual reading of the instructions. The consequence of that was only a partial understanding of the instructions. The obvious manifest level attribute was *disregard to details*, a common trait of innovators. There were considerable words spoken during the reading of the instructions. However there was scant evidence of meaningful understanding. I will ascribe manifest level as *words (+)* to give the planners credit for comprehending a few of the rules, not that they rigidly adhered to them.

I noted two examples of planners collaborating with new ideas. I ascribed this manifest style to *proliferates ideas* as would be expected with an innovative planner subteam. The first occasion of that I deemed to be superficial in manifest level and classified it *words (+)* for similar reasons I mentioned with the causal reading of instructions above. The second occasion of manifest style being *proliferates ideas* included a more constructive dialogue which resulted in the successful solution. Thus, I ascribed a manifest level attribute *synergy* for this incident.

This planner subteam missed the time constraints imposed by the instructions as might be expected by innovators. I called the brief oral instructions to the operators a critical incident. The consequence of those oral instructions resulted in the operators being able to solve the puzzle. The fact of the limited time remaining for the oral instructions (actually the operators barged into the room about three minutes before the planners' time lapsed) led me to ascribe this manifest style *undisciplined* in consideration of the planners' obliviousness to the time constraints. I did, however ascribe manifest level as *meaning (+)* by virtue that sufficient instructions were conveyed to enable the operators to solve the puzzle.

Except for the prohibition against touching other's pieces the planners seemed relatively oblivious to the rules. Their final solution idea, the exploded puzzle, was simple enough that the operators could easily assemble the puzzle.

The operators were very cautious about the apparent solution, which I cited as a critical incident. The consequence of that was the operators took considerably longer to solve the puzzle than would have otherwise been expected. I ascribed the operators' manifest style as *compliant* to capture the very concerted effort by the operator to complete the puzzle correctly. I ascribed the dialogue that transpired during the operators' deliberations as manifest level *meaning (+)*.

4.7 Raleigh RAL-T4

Critical consequential behaviors for the Raleigh trial RAL-T4 are shown in Table V-12. This was a four person planning subteam and was non role preferred. The planners had a mean KAI score of 120 points or about 1.8 standard deviations above the mean; i.e., somewhat innovative. Conversely, the operators mean KAI score was 85 points or about 0.7 standard deviations below the mean. The range of planners' KAI scores was 24 points. The most innovative of the four planners was also the most senior in terms of relative job status.

This trial was almost a carbon copy of the Wilmington WIL-T1 trial except for role reversal; i.e., this one was a non role preferred planning team and a non role preferred operating team. The interesting difference was the WIL-T1 planners' mean KAI score was 84.5 versus RAL-T4 whose planners' mean KAI score was 120. This difference would suggest considerable difference in problem-solving style. As it turned out, a senior executive in RAL-T4 had the same idea that a senior executive in WIL-T1 had—making a center 2-inch square template around which to position all the puzzle pieces. The other three planners for RAL-T4 contributed more to the solution than those for WIL-T1; e.g., one of the younger, less tenured planners raised the point about the orientation of the puzzle pieces.

Table V-12 Trial: RAL-T4. Group Decision-Process Effects and Causes [a]

Observed Behavior	Consequence	Cognitive Causal Attribution [b]	
		Manifest Style [c]	Manifest Level [d]
Thorough reading of instructions	Developed a solid understanding of boundary	precision	synergy
One planner conceived creative idea after reading instructions	A very good solution ended debate about different alternatives	probes novelty	synergy
Senior executive led the planners to understand his solution	Other planners soon understood and contributed	confident	meaning (+)
Planners observed that orientation of groups needed attention	Simplified the ultimate instructions for the operators	problem finder	synergy
Planners had time to fully inform operators how to solve puzzle	Operators had ample time to query Planners	efficiency	synergy
Operators asked important boundary-seeking questions	Operators did not begin until puzzle piece locations were documented	prudence	synergy
Operators questioned each puzzle piece move prior to the move	Abundance of caution resulted in flawless solution in relatively short time period	discipline	synergy

[a] The examples of behaviors and their consequences are based on the most significant of the observations made of the recorded experiments following the critical incidents technique.
[b] The classification scheme used in the causal attribution of behavior is divided into two categories: Cognitive Style from Kirton's A-I theory and Cognitive Level using Carlile's boundary-spanning objects.
[c] The itemized traits in cognitive style come from the abbreviated list of behavior descriptions of adaptors and innovators shown in Table I-1 above.
[d] The valence indications (-) and (+) indicate the directional impact of the communicative act

Some differences in overall implementation of the planners' task were evident and were as predicted by A-I theory. I will elaborate on a few of the critical incidents defined in Table V-12 to help illustrate the manifest style and manifest level demonstrated in this trial.

The initial critical incident which bears reporting was a thorough reading of the instructions. The obvious consequence of that was the development of a relatively solid understanding of the problem boundaries. I ascribed this manifest style as *precision*. And, I ascribed the corresponding manifest level as *synergy*. The dialogue which accompanied this portion of the deliberations was constructive and demonstrated the building of common understanding. I should note that it was uncharacteristic of a relatively high innovative planner subteam to demonstrate such adaptive traits in this instance.

The second critical incident worth noting concerned the conception of a creative solution by the senior planner. As mentioned, this was the same solution that was observed in the WIL-T1 trial. This solution was developed by planner Ray during which time the other planners were debating different approaches. The consequence of Ray's idea ended discussion about the different alternatives to a solution. I ascribed a manifest style attribute *probes novelty* to capture the ideation which this trial exhibited. And, I ascribed a manifest level *synergy* to capture the fact that all the planners participated in making Ray's solution be successful. This is a great example of the fact that all people are creative but with different styles and different levels. Recall planner Bo in WIL-T1 who conceived the same solution. Bo's KAI score was 85 and his level factor score was 1.99. In contrast, for trial RAL-T4, planner Ray conceived the same solution and his KAI score was 132 or 47 points more innovative that Bo's. Ray's level factor score was 1.56, a comparable score to Bo's.

Another critical incident that warranted attention was the planners taking time to fully inform the operators about solving the puzzle. The consequence was that the operators had ample time to solve the puzzle. What was not mentioned in this particular description was the fact that after the planners determined their solution technique they sat for quite a while until they realized that they had to also bring the operators back into the room and inform them how to assemble the puzzle during the 25 minute time limit. This was discovered about 20 minutes into the process and to the credit of the planners they brought the operators in and explained their task. I ascribed the manifest style as *efficiency* in spite of the relative haphazard nature of the decision process. However, I would suggest that this innovative planner subteam was relatively tangential or non-linear in its approach, a trait common with high innovators. Also, I ascribed the manifest level as *synergy* since the planners successfully agreed to the necessary actions within the prescribed time limit.

A critical incident associated with the operators involved the important boundary-seeking questions the operators asked of the planners before they began solving the puzzle. The consequence of that query was that the operators documented all the puzzle piece locations prior to the commencement of solution. Since the operators were high adaptors this behavior was expected. I ascribed the manifest style as *prudence*, a common characteristic of adaptors. I ascribed the manifest level attribute *synergy* to reflect the fact that all the operators participated actively in asking questions and making careful decisions before acting. One example of the relatively extreme degree of adaptive behavior the operators exhibited was in the operators' action to photograph the location of the puzzle pieces prior to any movement of pieces. This was, perhaps, the most extreme example of adaptive behavior during these experiments.

5. Summation

I have coalesced fragments of critical incidents reported in the previous chapter into larger units of meaningful consequential behavior as presented in this chapter. By so doing I am confident that this method would produce substantially similar findings if performed by other trained observers. This is a necessary perquisite for any scientific endeavor to be considered valid. In spite of my effort to make objective observations concerning critical incidents this process includes considerable subjectivity, a fact I readily admit.

The following chapter reports quantitative findings and, consequently, is decidedly objective. In the last chapter I will blend the two sets of findings for fuller understanding of the implications of this research program.

CHAPTER VI QUANTITATIVE FINDINGS

1. Overview

This research was conducted in a professional services organization and participants were employees of the organization. I called the small groups formed for the experiment *intact* groups. This contrasts with the prior research which, in both cases, was set in a university context. Hammerschmidt's (1996) work was with mid-career managers who were participating in a leadership training program. For the most part these people were unfamiliar with each other and groups which were assembled with them were classified as ad hoc. Similarly, Scott (2007) conducted her experiment with undergraduate students who had no prior working relationship and likewise those groups which were formed for Scott's experiment were deemed ad hoc. A fundamental premise of my hypotheses is the integrative effect that an organization (institution) has for its participants. That integrating effect may be observed by the graphical depiction of cognitive schema occurring within an organization (or institution) as shown in Figure IV-3. The five boxes inside the dotted line represent an individual decision maker. Inside the dotted line note the term climate. This follows the early work of Lewin et al. (1939) and significant later work led by Schneider (1975, 1983a+b, 1983b, 1987, and 1990) and others. That led me to hypothesize better decision outcomes from intact groups versus ad hoc groups, *ceteris paribus*. This chapter will report significant quantitative findings from this research and from the comparative research, will summarize the hypothesis testing, and will present other findings from information recorded during this research.

The hypothesis testing which follows was formulated as a comparative analysis with other similar work. All of the prior work was focused only on cognitive style and was silent on cognitive level. Additionally, the cognitive style differences which were previously analyzed were not based on the Jablokow-Booth cognitive gap theory introduced and extended in Chapter IV.

2. Quantitative Findings

The results of my experiments considering cognitive style are shown in tabular form in Table VI-1. I have discussed some of the issues related to KAI scores and other differences previously. The format used in Table VI-1 is chosen based on the comparative studies that I will use for hypothesis testing. Note that the three bottom rows of information

Table VI-1. Creed Findings

Team Category	Description	KAI mean	s.d.	Success Proportion Successes/Trials
Adaptive Planners Innovative Operators	Role Preferred	92.99	1.96	67% 4/6
Innovative Planners Adaptive Operators	Non Role Preferred	95.93	5.43	50% 3/6
Total	Mixed	94.46	4.18	58% 7/12
Adaptive Planners Innovative Operators (Trimmed)	Role Preferred	91.67	1.58	100% 4/4
Innovative Planners Adaptive Operators (Trimmed)	Non Role Preferred	96.65	5.74	60% 3/5
Total (Trimmed)	Mixed	94.78	5.11	78% 7/9

contained the term “trimmed.” This is based on considerable evidence that the three, three-person planning subteams in my research should be removed from the analysis.

I conducted two series of tests to evaluate the impact of the three three-person planning subteams on the outcomes in my experimental field work. As it turned out, all three of the three-person planning subteams failed to produce sufficient guidance for their operations subteams to solve the puzzle. On an individual level, the number of planners was a statistically significant indicator of likelihood of success in solving the puzzle. These results are shown in Appendix Table I-1 Person Success Dependence on Number of Planners. Supporting information is shown in associated tables marked Table I-1A, Table I-1B, and Table I-1C. This resulted in $\chi^2=38.48$, $p<.001$ (1-tailed test), N-88 in the predicted direction. However, the trials were by team and, consequently, it could be argued that N should be 12—the actual number of trials conducted during this experiment. I also conducted an analysis of team success based on the number of planners and found that even with the reduced number of subjects the number of planners was a statistically significant indicator of likelihood of success in solving the puzzle. These results are shown in Appendix Table I-2, Table I-2A, Table I-2B, and Table I-2C. This resulted in $\chi^2=5.6$, $p<.05$ (1-tailed test), N-12 in the predicted direction. I would also mention the suggestions by Hare (2003) concerning the probability the increased number of people participating in a problem solving activity will provide someone who is skilled at the problem type.

I presented the issues relating to three-person planning teams first so as to highlight the possible impact on my findings. However, during the subsequent presentation I will present my quantitative findings for both the full (N=12) and trimmed (N=9) trials. I will only deviate from that approach with the presentation of a binary logistic regression model following presentation of hypothesis test results. In that case I only included the nine four-person planning teams in the model.

I will compare my findings with similar findings from previous research. The earlier previous research was conducted by Hammerschmidt (1996) in the early 1990s. Hammerschmidt's research is presented in Appendix Table I-3 Hammerschmidt Findings. While I have discussed some of Hammerschmidt's research protocol earlier I think it would be worthwhile to recall some of the significant aspects of his work here.

Hammerschmidt asserted that the planner role in the Hollow Square Experiment is more adaptive in style and, therefore, would be more compatible with planners who are more adaptive. Conversely, he suggested that the operator role is less restrictive and, therefore, more compatible with operators who are more innovative. He called the conditions where participants are assigned roles in their KAI comfort zone, role preferred and the case where participants are assigned roles outside their KAI comfort zone, non role preferred. Hammerschmidt also assembled his research teams based on having similar KAI mean scores (range < 15.7 points) and dissimilar KAI mean scores (range > 15.7 points). Note that the Category 5 was random selection. For the first 50 trials the teams were assembled with no forethought concerning KAI scores. Although Hammerschmidt did not report his total findings as a unit of measure, I added it (Category 6) for purposes which will become apparent.

Referring to Appendix Table I-3 the most successful category for Hammerschmidt's work was Category 2 with relatively adaptive planners assembled with dissimilar sister subteams (defined as the KAI mean score ranged > 15.7 points between subteams). Owing to small number of trials in my research program I did not differentiate between ranges of sister subteam KAI mean scores during my experiment. I should also comment on Hammerschmidt's use of the term σ for the standard deviation of the various groups. He made no mention of populations versus samples in the report of his research so I recorded his findings exactly as he published it. I would assume that the factor shown is, in fact, the sample standard deviation and should appropriately be shown as "s".

Scott's (2007) findings are shown in Appendix Table I-4 Scott Findings. Scott's research interest was about the degree to which knowledge about one's problem solving style would influence his/her behavior during a problem solving exercise. She assembled all her teams with each total team having a KAI mean score near the theoretical mean. She arranged the total teams into two groups, those with similar approaches (defined as the range of team KAI mean scores < 15 points) and those with dissimilar approaches (defined as the range of team KAI mean scores > 15 points). Scott's experimental group was exposed to a one-hour lecture on KAI theory and style preferences while her control group did not get the education on KAI. Notice that the standard deviation (s.d.) of the dissimilar approach teams was much larger than the similar approach groups, as should be expected. Also notice that Scott, unlike Hammerschmidt, had relatively balanced teams centered on the midrange of KAI scores. She did not record the mean KAI scores of the subteams and, therefore, subteam performance cannot be included in my hypothesis testing concerning intact teams outperforming ad hoc teams even in non role preferred task situations. Scott, like Hammerschmidt, did not report her findings in aggregate. I computed that for purposes of discussing total findings. For the purposes of establishing a clear record of information which will be included in my comparative analysis and hypothesis testing I have consolidated all three research findings into Table VI-2 Experiment Comparative Results.

3. Research Objectives and Hypothesis Testing

Earlier I indicated that my essential interest is in helping improve group problem solving. I proposed three hypotheses with which to answer my research questions. I will address each in turn.

3.1 Hypothesis Testing Method

The results of all three research programs are reported in terms of the percentage of successful trials relative to the total trials; i.e., a proportion. My test parameter will be the difference between two independent proportions. If proportions are indicated by p, then my test statistic is shown by the quantity $p_1 - p_2$. This results in the following formulation for hypothesis testing in this research program:

The null hypothesis is: H_0: $p_1 - p_2 = 0$;

The test hypothesis is: H_1: $p_1 - p_2 > 0$.

It is assumed that all three sets of findings are population samples. I will employ a procedure for comparing population proportions which Kachigan (1986) proposed. And, for purposes of outlining the test procedure employed here I will summarize the main points.

The only known about the populations (ad hoc groups versus intact groups) are the sample data. Kachigan suggested using a weighted average of the sample proportions which are from two populations, represented by the proportion p_1 and p_2. The sample estimates p^ are assumed and are the values recorded from the trials in the two experiments which are being used for comparison. The weighted average of p^ is as follows:

$$p_w = \frac{n_1 p_1 + n_2 p_2}{n_1 + n_2}.$$

Table VI-2. Experiment Comparative Results

Team Category	Task Preferences	Success Proportion Successes/Trials
Hammerschmidt Cat 1 & 2 (H1) N=33	Subteam Role Preferred Tasks	84.8% 28/33
Hammerschmidt Cat 3 & 4 (H2) N=36	Subteam Non Role Preferred Tasks	63.8% 23/36
Hammerschmidt Cat 5 (H3) N=50	Unknown	52% 26/50
Hammerschmidt All Cat (H4) N=119	Mixed	64.7% 77/119
Scott All Cat (S1) N=40	Mixed	65% 26/40
Creed Cat 1 (C1) N=6	Subteam Role Preferred Tasks	67% 4/6
Creed Cat 2 (C2) N=6	Subteam Non Role Preferred Tasks	50% 3/6
Creed All Cat (C3) N=12	Mixed	7/12 58%
Creed Cat 1' (C4) N=4	Subteam Role Preferred Tasks	100% 4/4
Creed Cat 2' (C5) N=5	Subteam Non Role Preferred Tasks	60% 3/5
Creed All Cat' (C6) N=9	Mixed	78% 7/9

It logically follows that q_w is $(1-p_w)$. This is used in the following tabulation to estimate the standard error of the difference:

$$s_{p_1-p_2} = \sqrt{p_w q_w \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}$$

The null hypothesis, in my research, says ad hoc groups and intact groups are not statistically different; i.e., $p_1 - p_2 = 0$. Thus, using a student's t distribution due to small sample size, the formula for testing the difference of proportions is:

$$t = \frac{(p\hat{}_1 - p\hat{}_2) - (p_1 - p_2)}{s_{p\hat{}_1 - p\hat{}_2}}.$$

Additionally, under the assumption that the populations are not statistically different[11], then $p_1 - p_2 = 0$, and for the null hypothesis the t-test becomes:

$$t = \frac{(p\hat{}_1 - p\hat{}_2)}{s_{p_1 - p_2}}.$$

This will be approximately normally distributed if values of $n_1 p_1\hat{}, n_1 q_1\hat{}, n_2 p_2\hat{}, n_2 q_2\hat{}$ all exceed five (Kachigan 1986:183).

The hypothesis test information is contained in Table VI-3. The companion table showing the formula for development of the standard error of the difference between proportions in identical populations is shown in Appendix Table I-5.

[11] I have assumed that for the problem under consideration (the Hollow Square Puzzle) the three populations considered in this work are not statistically different. The problem requires little more than a basic understanding of geometric forms and high school reading comprehension. Lack of supplemental information on the Hammerschmidt population and the Scott population limit the ability to further defend the assumption concerning no statistical differences.

Table VI-3 Difference Between Two Independent Proportions

Comparison Categories	N_1 / N_2	$Solve_1$ / $Solve_2$	Not $Solve_1$ / Not $Solve_2$	p_w	q_w	$t = \frac{(p\hat{}_1 - p\hat{}_2)}{s_{p_1 - p_2}}$	p (1-tailed)
H4 v. C3	12 / 119	7 / 77	5 / 42	0.6412	0.3588	-0.4387[a]	>.05
H1 v. C2[b]	6 / 33	3 / 28	3 / 5	0.7949	0.2051	-1.9446	<.05
H1 v. C5[b]	5 / 33	3 / 28	2 / 5	0.8158	0.1842	-1.3357	>.05
H4 v. C6[b]	9 / 119	7 / 77	2 / 42	0.6562	0.3437	-0.7961	>.05
S1 v. C3	12 / 40	7 / 26	5 / 14	0.6346	0.3654	-0.4206	>.05

a. The negative signs in the t-test column reflect the hypothesis that intact groups will out perform ad hoc groups.
b. The prescription concerning approximate normality was violated in this case.

3.2 Hypothesis H1

Hypothesis H1 says intact groups will perform better at problem solving than ad hoc groups, *ceteris paribus*. Since this hypothesis offered no specification as to the nature of role preference among the planners or operators I will use the total results as presented in Table VI-2 and shown as Hammerschmidt's H4 and Scott S1 (both of which were ad hoc groups) against Creed C3 (intact groups).

Hammerschmidt's H4 contains all 119 trials and are mixed in terms of role preferred tasks. Creed's C3 is also mixed and contains all 12 trials. The t-test value shown in Table VI-3 (H4 versus C3) was below statistical significance and, hence the null hypothesis cannot be rejected. <u>Thus, there is no statistically significant difference between Hammerschmidt's ad hoc groups and Creed's intact groups in executing the hollow square experiment according to these findings</u>. However, the prescription in which $n_1 p_1\hat{}, n_1 q_1\hat{}, n_2 p_2\hat{}, n_2 q_2\hat{}$ are all required to exceed five is marginally violated in this test (i.e., 7.0, 5.0, 77.0, and 42.0).

Recall my earlier discussion concerning the significance of the three-person planning teams in my research. I included "trimmed" findings whereby I eliminated the three three-person planning teams from the data set and tabulated t-tests for comparison using those data. These data are reported in Table VI-2 as Creed C6. The t-test value shown in Table IV-3 is below statistical significance. <u>Even with the trimmed data we cannot reject the null hypothesis that there is no statistical difference between the intact groups' and ad hoc groups' performance.</u> These findings are tempered by the requirements that $n_1 p_1 \hat{}, n_1 q_1 \hat{}, n_2 p_2 \hat{}, n_2 q_2 \hat{}$ are all required to exceed five are grossly violated (i.e., 7.0, 2.0, 77.0, and 42.0) and therefore of questionable validity.

Scott's S1 contained 40 trials, all of which were mixed in a fashion not reported. Again, I use Creed's C3 for the comparison. The t-test value shown in Table VI-3 (S1 versus C3) was below statistical significance therefore the null hypothesis cannot be rejected. <u>There is no statistical difference between Scott's ad hoc groups' performance and Creed's intact groups' performance according to these data</u>. Again, the requirements that $n_1 p_1 \hat{}, n_1 q_1 \hat{}, n_2 p_2 \hat{}, n_2 q_2 \hat{}$ are all required to exceed five are modestly violated in this test (i.e., 7.0, 5.0, 26.0 and 14.0).

In summary, the tests performed during my research failed to support Hypothesis H1, that intact groups will out perform ad hoc groups.

3.3 Hypothesis H2

Hypothesis H2 says intact groups will perform better at problem solving even when performing non role preferred tasks in comparison to ad hoc groups performing role preferred tasks, for limited periods of time. Creed's C2, N=6, contains results from subteams performing non role preferred tasks. I will test that against Hammerschmidt's H1, N=33. Since Scott did not investigate role preference in her work there is no test available here. The t-test shown in Table VI-3 (H1 versus C2) is statistically significant at the $p<.05$ level, however in the opposite direction from my hypothesis. According to these data ad hoc groups doing role preferred tasks out perform intact groups in non role preferred tasks. Note the small sample size for the Creed trials (N=6). This significantly violates the requirement for approximate normal distribution given by $n_1 p_1\wedge, n_1 q_1\wedge, n_2 p_2\wedge, n_2 q_2\wedge$ (i.e., 3.0, 3.0, 28.0, and 5.0). Therefore, I would consider this a suspect finding.

I included "trimmed" findings whereby I eliminated the three three-person planning teams from the data set and tabulated t-tests for comparison using those data. Again, hypothesis H2 holds that intact groups in non role preferred tasks will out perform ad hoc groups in role preferred tasks for a short period of time. The t-test shown in Table VI-3 (H1 versus C5) is below statistical significance. Thus, even with the trimmed data set for C5 I cannot reject the null hypothesis. In addition, the small number contributes to a significant violation of the assumptions required for an approximately normal distribution given by $n_1 p_1\wedge, n_1 q_1\wedge, n_2 p_2\wedge, n_2 q_2\wedge$ (i.e., 3.0, 2.0, 28.0, and 5.0). Therefore, I would also consider this a suspect finding.

3.4 Hypothesis H3

Hypothesis H3 asserts that the degree of congruence between formal organization and informal organization may be approximated by the degree to which intact groups out perform ad hoc groups on the same tasks. <u>Since the trials comprising my research did not support the assertions about intact groups versus ad hoc groups this hypothesis is logically rejected.</u> However, the prior theoretical and empirical work upon which this hypothesis was based may provide some explication concerning my specification of critical variables; i.e., *intact* groups.

3.5 Additional Quantitative Findings

My research program included two important items: 1) supplemental information as shown in Appendix C and, 2) a post exercise attitudinal survey shown in Appendix D. The information stemming from those items gave me access to some information which Hammerschmidt (1996) and Scott (2007) did not report in their findings. The absence of reporting does not mean the data do not exist but rather that it is not available for comparative analysis. I will discuss the supplemental information and its contribution to understanding the outcomes. Important items from that information will be used to develop a binary logistic regression model which provides some interpretation of my research findings. Finally, I will present the attitudinal survey information.

3.6 Supplemental Information

The Supplemental Information form shown in Appendix C and the KAI Inventory form asked for several pieces of demographic information which proved useful in evaluating behaviors and outcomes. I used those data earlier in Chapter IV in my development of factors for use in my adaptation of the Jablokow-Booth cognitive gap model. In this presentation I will evaluate those data with respect to their individual and collective contribution to successful problem solving. This is yet another application of the same data in my effort to understand different outcomes and causative factors. In the following evaluation of those data I will comment on each item collected from participants with respect to *a priori* thinking. Each of these items has little meaning standing alone. A major view of this research is that people interact during problem solving exercises in relation to others so their individual characteristics only matter in a comparative and interactive way. The Jablokow-Booth gap model is based on this interactivity between problem solvers. I will come back to the gap model later. For this consideration I was more interested in simple individual differences and aggregated team differences.

I recorded subject's age, education, tenure inside this organization, and tenure with other similar firms. I believed, *a priori*, that these factors would combine to make the teams with the highest combination of education and tenure inside this organization more likely to successfully guide their teams toward a correct solution of the puzzle. The subject's age generally should be positively related to tenure; i.e., the more tenure one has the older one is, *ceteris paribus*. Tenure outside this organization could also be an important variable which could have an influence on the other team members depending on how that outside tenure is viewed by the participants.

I conducted one way analysis of variance tests with these four variables comparing participants who successfully solved the puzzle (solve) and those who were not successful (fail). These variables are presented in tabular form in Appendix Table I-6. Information shown in Appendix Table I-7 shows that *education* failed the homogeneity of variances assumption at the $p<.001$ level and *tenure* was relatively close ($p<.10$) to violating the homogeneity of variance criterion. A more robust difference of means test will therefore be employed for those two variables. Welch and Brown-Forsythe tests are robust to different variances and produce a test statistic similar to the F-test. Appendix Table I-7A indicates that neither of the means of education nor tenure is statistically different in the categories *solve* versus *fail*. See Appendix Table I-8 for difference of means tests for individual participants. Note that both education and tenure are shown in Appendix Table I-8 although their statistics were calculated using the more robust test. The significance numbers are similar between the two tests. In Appendix Table I-8, none of the F-tests rises to statistical significance at the $p<.05$ level. Recall that these are individual measurements placed into two categories, solve and fail. I next present some possible interaction and/or group variables for consideration.

Because teams solve problems rather than individuals it is appropriate to evaluate some combinations of group statistics. I considered both average team statistics and cumulative team statistics during this investigation. I termed these variables *constructed variables*. I evaluated average education and cumulative education by team (N=12). Note that in both cases these data were tabulated for the planners subteam only. As I said above, planners' subteams were significantly more responsible for either successful or unsuccessful trials, based on empirical observations in this research. Hence, I considered the make-up of their respective teams for this analysis. Again, I conducted one way analysis of variance on these variables and the descriptive statistics are shown in Appendix Table I-9. Appendix Table I-10 indicates that the equality of variance assumption is violated for variable *cumulative education planners*. I therefore conducted a robust test of equality of means for *cumulative education planners* as shown in Appendix Table I-10A. Appendix Table I-11 shows difference of means tests for *average education planners* is not statistically significant in solving the puzzle based on simply evaluating the team; i.e., N=12. Likewise, Appendix Table I-10A shows that *cumulative education planners* is not statistically significant for the N=12 case.

I also considered the variables *average education teams*, *average education planners*, and *cumulative education planners* in the sense of multilevel modeling and, therefore, tabulated their impact for the full N=88 data set. Appendix Table I-12 shows descriptive statistics for those variables. Appendix Table I-13 shows the Levene test which indicates the equality of variances assumption between groups is violated for all three variables. Another test was performed for the condition of unequal variances and is shown in Appendix Table I-13A. Appendix Table I-14 shows the difference of means tests based on assumption of equal variances. Of course this is suspect since the variances are unequal. However, for purposes of contrasting, both the robust tests shown in Appendix Table I-13A and the tests shown in Appendix Table I-14 indicate an insignificant statistical difference between the two groups. I have retained these variables in the discussion on *a priori* grounds that they should have an important effect on the functioning of the teams.

I considered possible interaction variables including the following *tenure* X *education, tenure* X *average education*, tenure X *cumulative education*, *total experience* (summation of in-firm tenure and outside tenure), and *education* X *total experience*.

These variables were evaluated by one way analysis of variance based on successful versus unsuccessful trials. Table I-15 shows descriptive statistics for those variables. These are a mixture of individual and group characteristics applied to individuals, N=88. The

Levene tests shown in Appendix Table I-16 indicate *tenure* X *education*, *tenure* X *average education* and *tenure* X *cumulative education* violate the equality of variance assumption. I conducted robust tests of these three variables and found them to be not statistically different as shown in Appendix Table I-16A. Also, the difference-of-means tests for these five variables are shown in Appendix Table I-17. None of these variables indicates statistically significant differences between means for successful versus unsuccessful groups.

The primary individual differences used for the comparative portion of this research was KAI scores. It, therefore, is appropriate that one way analysis of variance was conducted with these data. Appendix Table I-18 displays KAI Scores Descriptive Statistics for the primary and its three factor scores. The Levene tests shown in Appendix Table I-19 reveal that the homogeneity of variance assumption was not violated by these data. And Appendix Table I-20 indicates there is no statistically significant difference between individuals participating in successful versus unsuccessful trials, according to individual KAI scores. (Although I have not reported the output in the Appendix, I evaluated the same information using team as the unit of measurement (N=12) and obtained the same result. I will return to the question of KAI scores and their predictive ability during problem solving activity later.

There were two categorical variables recorded during this research, gender and a control variable (map). During the formulation of this research I wanted to provide some means of assessing whether some people have a greater natural cognitive talent for graphical (puzzle) problem solving. I asked the question:

> Please select the answer that best describes your preference: When I am driving to a location that I am unfamiliar with I prefer:
>
> _____Written directions
>
> _____A map

There were several responses with both options checked. During the recording of these data when someone checked both options I only recorded written directions. I wanted to evaluate whether either of these was statistically significant in regards to successfully solving the puzzle.

I created a joint frequency distribution of map preference and solve puzzle to determine if there were statistically significant associations between individuals who preferred maps with people who solved the puzzle. I found that there was no statistical difference between successful and unsuccessful individuals with respect to map preference. This is shown in Appendix Table I-21 and companion Appendix Table I-21A and Appendix Table I-21B.

I created a joint frequency distribution with *gender* and *solve* in order to determine if there were statistically significant associations between genders regarding successfully solving the puzzle. I found no statistically significant associations between genders on solving the puzzle. This information is shown in Appendix Table I-22 and companion Appendix Table I-22A and Appendix Table I-22B.

While there were no *a priori* assertions regarding the topic, I was interested in gender differences on map preference versus written directions. I created a joint frequency distribution of gender and map preferences as shown in Appendix Table I-23 and found a statistically significant difference between men and women on this consideration, $\chi^2=13.65$, $p<.001$ (2-tailed test). Appendix Table I-23A and Appendix Table I-23B show the supporting tests of statistical differences. I will comment further on this finding later.

3.7 Model Building

The variables described in the previous pages were studied with respect to their potential to contribute to a predictive model for successfully solving the hollow-square puzzle. The dependent variable in this case happens to be dichotomous or binary; i.e., either solve (=1) or fail (=0). Binary logistic regression is a statistical method which enables the researcher to construct an appropriate model given the nature of the dependent variable. There were 12 trials in five offices involving 88 participants in this research program. I view this as a multilevel model with a binary dependent variable. Multilevel analysis can be used to evaluate both individual statistics and groups statistics; e.g., students across an entire school district and schools within that district. The students are "nested" within specific schools and, hence, multilevel modeling can help understand the effect a school has on student performance (Bickle 2007). The present research is similar; i.e., teams impact individuals and consequently I am employing both individual statistics and group (or team) statistics to simulate multilevel modeling. The relatively small sample size (at a team level N=12) makes it difficult to produce highly reliable estimates. I will conflate both group effects and individual effects to produce a regression model. As mentioned earlier in this chapter, the number of planners proved to be statistically significant in predicting the outcome (success versus failure). I have, therefore held the number of planners to be four, thereby controlling for the three-three person planning subteams.

The basic logistic model I have developed is:

$$Solve = C + Aveed + Tenure + OthExp\ .$$

Note this is shown in word form and not exponential form for discussion purposes. The variable Aveed is average education of the team and is a group effect that I apply to all 88 subjects as an indicator of the group effect of each team. Tenure and OthExp are individual measures and, along with Aveed should be a strong indicator of successful outcomes. (Recall from the early work in cognitive gap analysis Tenure and OthExp are primary components of the cognitive level variable). The three items shown in the regression model were three of the four *a priori* variables I expected to have an impact on group problem solving. The fourth, KAI scores, had no material effect in any combination that I explored and, consequently, I omitted it from the final model.

The logistic regression model discussed above is shown in Table VI-4 below. I have reproduced the full logistic regression report including all the significance testing routines in Appendix I. The model output begins with Appendix Table I-24 and shows a classification table for the model without the variables; i.e., only a constant. In SPSS terms this is shown as "Block 0," and I have retained that nomenclature for presentation purposes.

Average education (Aveed) is shown to be statistically significant at the $p<.001$ level in Table VI-4. The finding shows that the odds of solving the puzzle decreases by .144 for each additional year of average education on the team. Note that both Tenure and Othexp are

Table VI-4. Binary Logistic Regression Model [a]

	B	S.E.	Wald	df	Sig.	Exp(B)	95.0% C.I. for EXP(B)	
							Lower	Upper
Aveed	-1.936	.528	13.472	1	.000	.144	.051	.406
Tenure	.004	.065	.004	1	.947	1.004	.884	1.141
Othexp	-.074	.041	3.283	1	.070	.929	.857	1.006
Constant	33.614	8.963	14.064	1	.000			

[a] Dependent Variable, Succeed=1, Fail=0

shown to be not statistically significant. And, both have 95% confidence intervals that contain one. That means these factors may either increase the odds of solving the puzzle or decrease the odds—an unacceptable range of conclusions for making substantive interpretation. However, when these variables are removed from the regression model its predictive capability as shown by the Hosmer and Lemeshow Test reduces to an insignificant level, thereby suggesting a poor goodness of fit. I have, therefore, kept these variables in the full model since they were part of my *a priori* theory of problem solving for intact groups.

Appendix Table I-24 is a classification table of observations showing the number of individuals who solved or failed to solve the puzzle. This is Block 0 in SSPS terminology and means the model sets all the variable coefficients to zero. Appendix Table I-24A indicates Wald statistic is significant at the $p<.001$ level. This means that the null hypothesis should be rejected and the proposed variables are statistically significant. Appendix Table I-24B shows statistical significance of the variables not in the equation for Block 0. I added all three independent variables at one time. Appendix Table I-24C shows significance tests for the model with all three independent variables added at once. The model is statistically significant at the $p<.001$ level. Appendix Table I-24D can be thought of as pseudo R-squared terms analogous to R^2 in ordinary least squares linear regression models. Nagelkerke R Square shows that the model accounts for about 51% of the variance. The Hosmer and Lemeshow Test procedure is shown in Appendix Table I-24E and Appendix Table I-24F. In Appendix Table I-24E the significance level indicates that the model adequately fits the observed data. In this test the desirable significance value is $p>.05$. The classification table shown in Appendix Table I-24G indicates that the model predicts 94% of the successful individuals and 60% of the unsuccessful individuals in solving the puzzle.

3.8 Post Exercise Attitudinal Survey

After each experiment was complete I asked participants to fill out a Post Exercise Impressions survey. The survey is shown in Appendix D. It contains seven questions and was designed to see if participants on successful teams felt differently than participants on unsuccessful teams concerning several points of interest. Because question seven was misunderstood by many participants and because of omissions in this topical area I have elected to not present that information. With each of the six questions remaining I will present findings from a joint frequency distribution in order to discuss the goodness of fit of expected frequencies and observed frequencies. The expected frequencies in each column should follow the same trend as the marginal totals. This is the null hypothesis and rejection of the null hypothesis requires a chi-squared to be significant at the $p<.05$ level. I will report on the χ^2-statistic and corroborating tests for each of the six questions.

Question one asked, “Rate how you felt about performing your task role for this problem.” I expected participants who solved the puzzle to be more favorable toward their task than participants who failed to solve the puzzle as a general rule. Appendix Table I-25 and companion Appendix Tables I-25A and B contain all the pertinent information on the joint frequency distribution for question one. The results showed participants who were successful in solving the puzzle were considerably more favorable toward their task role (97% favorable) than those who failed to solve the puzzle (65% unfavorable). I am classifying participants who scored either comfortable or very comfortable as favorable and those who scored either very frustrated or slightly frustrated as unfavorable. There are statistically significant differences between these two classes ($\chi^2 = 45.04$, df=3, $p<.001$, (2-sided)).

Question two asked, “Rate how well your subteam communicated about the problem.” Appendix Table I-26 and companion Appendix Tables I-26A and B show the joint frequency distribution for this question and the variable solve. I expected this question to be highly correlated with success versus failure; i.e., a higher portion of failures would rate their subteams unfavorably and a higher portion of successful teams would rate their subteams favorably. I underestimated the degree to which individuals who were on unsuccessful teams would rate their subteams favorably. In fact, approximately 85% of participants who were *unsuccessful* rated their subteam favorably (defined as good or excellent on the questionnaire). While the unsuccessful participants rated their subteams surprisingly high, *100% of the successful subteams rated their subteam favorably*. Regarding question two, there are statistically significant differences between the two classes, solve and fail (χ^2 = 36.55, df=3, p<.001, (2-sided)).

Question three asked, “Rate how well your sister subteam communicated with your subteam.” Appendix Table I-27 and companion Appendix Tables I-27A and B show the joint frequency distribution for question two and solve. I expected there to be a high correlation between unsuccessful subteams and unfavorable replies on this question. This was considerably more in line with my *a priori* expectations than was question two. The number of unfavorable responses was consistent with my expectations as approximately 79% of unsuccessful participants responded unfavorably (defined as bad or poor). Conversely, nearly 90% of the successful participants responded favorably (defined as good or excellent). Question three shows that there are statistically significant differences between the two classes, solve and fail (χ^2 = 47.65, df=3, p<.001, (2-sided)).

Question four asked, “Rate the amount of time provided for this problem.” Appendix Table I-28 and companion Appendix Tables I-28A and B show the joint frequency distribution. I expected the favorable and unfavorable responses to mimic successful and unsuccessful participants respectively. Surprisingly, nearly 68% of the unsuccessful participants responded to this question favorably (defined as about right or way too much). An even larger portion, 93%, of successful participants answered this positively. Even with the unexpectedly large portion of unsuccessful participants answering favorably, there are still statistically significant differences between the two classes, solve and fail (χ^2 = 15.01, df=3, p<.01, (2-sided)). Note that this statistical significance is somewhat less pronounced than the first three questions at p<.01 versus p<.001.

Question number five asked, “Rate your subteam’s performance in solving this problem.” Appendix Table I-29 and companion Appendix Tables I-29A and B show the joint frequency distribution for question five and solve. As with all the questions, I presumed that successful participants would reply favorably (defined as helped a little or great help) and unsuccessful participants would reply unfavorably (defined as no help at all or not very helpful). The unsuccessful participants surprisingly responded favorably in 88% of the cases. Successful participants not surprisingly responded favorably in 100% of the cases. Again, even with the unexpectedly large portion of unsuccessful participants answering favorably, there are still statistically significant differences between the two classes, solve and fail (χ^2 = 36.59, df=3, p<.001, (2-sided)).

Question number six asked, “Rate your sister subteam’s performance in solving this problem.” Appendix Table I-30 and companion Appendix Tables I-30A and B show the joint frequency distribution for question six and solve. My basic expectation for this was like all the others; i.e., unsuccessful participants would answer unfavorably (defined as no help at all or not very helpful) and successful participants would answer favorably (defined as helped a little or great help). Approximately 59% of the unsuccessful participants answered unfavorably to this question. And, about 95% of successful participants answered favorably. I was surprised that over 40% of the unsuccessful participants answered favorably to this question about sister subteam. Regarding question six, there are statistically significant differences between the two classes, solve and fail ($\chi^2 = 45.82$, df=3, p<.001, (2-sided)).

3.9 Cognitive Gap Analysis

I developed the Jablokow-Booth cognitive gap model in Chapter IV and reported findings concerning differences of means testing on four concepts of the gap model. And, I presented a table of cognitive gaps and various combinations which were subsequently presented along with the trial descriptions. In an interest to bring those data together into one location I have consolidated all the cognitive gap data into Appendix Table I-31. One additional piece of information I felt worthy of recording was the aggregated cognitive level information. Recalling the discussion from Chapter IV there were no statistically significant differences between successful and unsuccessful trials based on the cognitive gap model with its several combinations of gaps.

I conducted difference of means tests for successful trials based on aggregated cognitive level using the factor scores shown in Appendix Table I-31. While the differences were not statistically significant at the p<.05 level they were, however worth reporting as a basis for future exploration and further theorizing about the Jablokow-Booth cognitive gap model. Appendix Table I-32 shows the results of that difference of means test F=3.25 and p=0.101, just beyond the level of statistical significance.

I was also interested in combinations of cognitive level and cognitive style that might be meaningful in helping predict successful problem solving outcomes. Thus, I analyzed the difference of means for cognitive level interacting with cognitive style. For this analysis I used factor scores discussed at length in Chapter IV. Again, this analysis indicated that the successful trials were not statistically different from unsuccessful trials. But again, the scores were encouraging in terms of suggestive of a possible line of reasoning supporting future research, F=2.003 and p=.187.

There are no known empirical research data in which the Jablokow-Booth cognitive gap model was previously tested. I believe the formulation I have introduce in Chapter IV constitutes the initial effort to operationalize cognitive gaps in pursuit of understanding how both cognitive style and cognitive level gaps work to foster better problem solving outcomes. Due to paucity of prior work I am unable to argue *a priori* assumptions. However, as I said earlier, the concept of cognitive gaps involving humans collaborating to solve problems is intuitively appealing and should ultimately lead to helpful insights for future researchers and practitioners.

3.10 Summary of Quantitative Findings

I have presented the quantitative findings from the hollow square experiments in this chapter. Also, I have presented some theoretical work developed in Chapter IV for the purpose of collecting all important quantitative data in this chapter. In the next chapter I will combine the qualitative and quantitative findings for the purpose of illuminating significant implications of this research and will conclude by discussing my original research interests and how these findings may lead to better small group problem solving in any context.

CHAPTER VII IMPLICATIONS

1. Overview

In the previous two chapters I have reported qualitative findings and quantitative findings respectively with only modest elaboration as to the meaning of findings. This chapter will firstly bring those two parallel analyses together for the purpose of explication of the findings and, in particular, discussion of results which differ from *a priori* expectations. I will spend considerable time discussing the issue of intact groups since that proved to be critical in my assumptions during hypothesis building. Secondly I will discuss the planning profession and the extent to which cognitive style theory specifically and cognitive gap theory generally might beneficially add theoretical framework and definitional structure that could be useful. Lastly, I will conclude with a discussion of unplanned findings and recommendations for future research on this topic.

2. Combining Quantitative and Qualitative Findings

The quantitative findings pertaining to hypothesis testing presented in Chapter VI can be fairly simply summarized. In essence, this research project provided insufficient evidence to reject the null hypothesis that problem-solving ability of ad hoc groups and intact groups is not statistically different. Note that the hypotheses were limited to only cognitive style as there has been no comparative work in cognitive level to enable such an analysis. I hypothesized that not only would intact groups outperform ad hoc groups, non role preferred intact groups would outperform role preferred ad hoc groups, for short periods of time, again based solely on cognitive style. And, I drew from the earliest recorded empirical work on work-group functioning inside organizational frameworks to assert some measurement concept for informal versus formal organization (Roethlisberger and Dixon 1939). However, in the famous Hawthorne Works experiments reported by Roethlisberger and Dixon the units of analysis were actual standing work units; i.e., they worked every day in close proximity with each other performing sometimes interrelated tasks. That has an important distinction in the realm of small group research. There is a considerable difference between small groups that work together on a daily basis and small groups that are assembled to solve a problem on a one-off basis, such as that explored in this research.

The definition I proposed for intact groups was inadequate by absence of a specification for the degree of integration necessary for intact groups to perform like teams vis-à-vis problem solving. Tuckman (1965) and Fisher (1970) discussed this issue in their work on team development resulting in their formulation of four distinct stages of team development: 1) form, 2) storm, 3) norm, and 4) perform. Carlile's (2002) concept of how knowledge boundaries are transcended also is informative in this discussion. And, I employed his terminology to describe how processes *integrate* knowledge across boundaries from *words* (syntax), to *meaning* (semantic), to *synergy* (pragmatic). Carlile was less concerned in the temporal aspect of integration than he was the knowledge transfer across boundaries. His view of knowledge as being *local, embedded, and invested* in practice is useful for illuminating the obstacles which must be overcome when cross functional groups assemble to solve problems. Or, in the context of my research, this helps explain the difference between ad hoc groups and intact groups and why my definition of intact groups is problematic.

McGrath (1991) offered a theory of groups which illuminates the issue of task group integration further. He suggested that four modes of activity could be identified in executing a group task. More recently Hare (2003) compared McGrath's suggested modes with similar arguments by Parsons (1961) and his own. For the purpose of identifying specific problems within my specification for intact groups I will reproduce the Hare comparisons in Table VII-1. Also, I will add Carlile's (2002) work as it has application.

My interest in McGrath's theory of groups is on the *temporal development* of the component parts of a task execution. This is the area about which my hypotheses were inadequately informed. In his model of group task execution McGrath offered four modes. I will comment briefly on each of these vis-à-vis my research program and execution of the hollow square puzzle by my experimental subjects.

Table VII-1 Components of Group Task Execution

McGrath	Parsons	Hare
Mode I: Inception and acceptance of a project	goal choice	meaning
Mode II: Solution of technical issues	means choice	resources
Mode III: Resolution of conflict, that is, of political issues	policy choice	integration
Mode IV: Execution of the performance requirements of the project	goal attainment	goal attainment

McGrath's Mode I is the manner in which a group takes ownership of a task. A group member might suggest a particular problem to tackle; a higher authority may assign the group an assignment; or the group's normal daily activity may enable it to engage on a project or task. Mode I includes some basic understanding of the goals and preliminary thinking about possible performance strategies. Parsons called this stage *goals choice*. And, Hare termed this *meaning*, by which he meant the cognitive understanding group members share about the task. McGrath's development of group theory assumes such groups are, "…intact social systems that engage in multiple, interdependent functions on multiple, concurrent projects while partially nested within and loosely coupled to surrounding systems" (Hare 2003:130). Carlile's (2002) propositions about integrating artifacts which enable knowledge to be productively used across internal organizational boundaries or silos do not fit McGrath's assumption of intact groups shown in the quote above. The key difference, "…is multiple, interdependent functions on multiple concurrent projects…" Carlile's notion of knowledge-in-action which is acquired in practice and which is local, embedded, and invested is considerably less intact than McGrath's notion.

The subjects who participated in my research worked for the same company but seldom worked within the same small group on a daily basis. McGrath's assertion about the interdependent nature of such group members would almost certainly be violated by the make-up of the subteams which comprised the planners and operators in this research. This is particularly true given the fact that I randomly selected and assembled the subteams for the experiment. My research participants would, however, fit the definition of cross functional groups which have many different knowledge domains and local, embedded, and invested knowledge repositories.

Mode II of McGrath's production task for groups is concerned with technical problem solving and the most appropriate means with which to approach and solve the project. Mode

II is concerned with the means of execution. He noted that this area has received the most attention with studies of problem solving or decision making in groups. But, importantly, the other modes have usually been relatively ignored during research on problem solving when studying this topic. McGrath posits that the inception of projects (Mode I) is considered a given; i.e., a superior assigns something and the group responds. Thus there is little research interest in that area of small group project execution. The resolution of conflict (Mode III) and execution (Mode IV) are considered relatively minor issues because the means of solution are so very important-in the realm of technical problem-solving. Parsons called this mode or stage means choice and Hare called it resources. The question here is how will the project or problem be executed?

Table VII-2 Successful Trials Solution Techniques

Trial	Solution Technique	Description
CW-T1 CHL-T2	Pattern Sheet Key Sketch	Planners sketched puzzle shapes onto the pattern sheet
WIL-T1 RAL-T4	Center Square Keystone	Planners assembled individual pieces around a center square keystone and instructed operators to combine into one puzzle
RAL-T2	Window Pane Framing Key	Planners framed the entire puzzle in front of each place and located each set of puzzle pieces inside at correct locations
CW-T2	Puzzle Pieces on Pattern Sheet	Planners placed each group of puzzle pieces onto the pattern sheet thereby showing how pieces fit together
RAL-T3	Exploded Puzzle Pieces	Planners placed puzzle pieces in a slightly exploded arrangement which could be easily visualized

Mode II in my research consisted of several different approaches to solving the puzzle. For purposes of identifying the Mode II “means of execution” see Table VII-2 for the solution techniques used in this research. The discussion which ensued within each successful trial was about how the suggested technique might work. The solutions identified in Table VII-2 are the *consequences* of synergistic combinations of meaningful(+) words(+) shared among the subteam solving the puzzle. These are Carlile's (2002) boundary spanning objects which contribute to *transformative* knowledge. These are the means which enabled the ends (solution) of the Hollow Square puzzle exercise.

McGrath called Mode III of the production function the political conflict resolution mode. It is the time during which conflicting values and interests arise in the group. Parsons called this mode the *policy choice* and Hare called it *integration*. Study in this area of group research has mostly been in jury deliberations and negotiations according to McGrath. I have adopted Hare's term, *integration* to describe the desirable outcome of this mode of group behavior. This term is similar in this context to the way the same term was used by Follett (1924) nearly 90 years ago. Recall that Simon (1947) argued about a values-facts dichotomy; i.e., a given set of facts may be established based on a given set of values but not the other way around. It was coincidental that Carlile (2002) also used the term *integrating* to describe the process that the three facets of knowledge transfer subsume. I will use the term as the melding of different ideas into a common understanding sufficient to adopt a solution to the problem at hand.

In my research the values question arose in different interpretations of the instructions. Two experimental groups found great moral difficulty in approach based on individual perceptions of right and wrong regarding interpretation of the instructions. One experimental group (RAL-T5) failed to overcome this moral dilemma and was unsuccessful in solving the puzzle; i.e., failed to integrate into a common understanding sufficient to adopt a solution. Another experimental group (CHL-T2) had three of the four planning subteam members agree to one set of values interpretation while one member rejected that concept as improper. This case did not achieve integration in total but in sufficient amount to overcome the lone dissenter and be successful.

McGrath's Mode IV includes the execution activity. This includes the attainment of the goal in question, the same terms used by both Parsons and Hare. McGrath argued that it should be quantifiable in terms of quantity, quality, and, perhaps, speed of execution. In my research case Mode IV was successful solution of the puzzle. However, I could also judge each experimental trial on the speed of execution, the quality of execution with respect to how rigidly the group followed the rules versus bended the rules, and other more elemental artifacts; e.g., Bales (1950) used the interaction process analysis to evaluate each utterance, oral or non-verbal, to classify communicative acts and to infer a cognitive style orientation.

In defining components of group task execution I want to highlight the fact that there is a temporal aspect of group formation which was ignored in my hypothesis development. Each of the stages or modes of group task performance requires some amount of real time in order for the group to integrate sufficiently to successfully solve any but the simplest of problems. My erroneous assumption that in terms of problem-solving groups, people who worked within the same organization are effectively *intact groups* is clearly inaccurate. In fact, even Carlile's (2002) propositions are based on the differences in knowledge (local, embedded, and invested) within the same organization but within different organizational units. This means that individual differences (e.g., *cognitive gaps—both style and level*) of members in small groups are real variables that only time and group developmental processes can overcome. Carlile (2002) specifically acknowledged that the pragmatic process involves an acceptance by the group that in order for transformative knowledge to occur some of the old knowledge must be changed. Clearly, this is a time based problem.

I want to recall the Jablokow-Booth problem-solving model shown in Figure IV-4. The cognitive gaps depicted in that model reflect some of Kirton's thinking on the Problem A-Problem B analogy discussed above. Consider the person-person cognitive gap (both level and style) and the person-problem cognitive gap (both level and style) shown in the model. Then consider that most problem-solving groups are much larger than two people and the magnitude of the integration challenge becomes apparent. This should be considered in light of McGrath's four modes of production. At each of the four modes of production each group member (PS1, PS2, etc.) perceives, interprets, and reacts uniquely to the challenges (stimuli) of that stage. Problem A occurs during Mode I—and is interpreted somewhat differently by each person (i.e., exactly what is the problem to be solved?). Without a standing group decision-making process at the disposal of the group the Problem A can take some time to resolve. Of course, it takes time because of Problem B—the diversity within the group. That diversity in newly formed problem-solving groups (in spite of the fact that they may already know one another) requires some process of integration which is in both Mode II and Mode III. Mode III, in fact, should precede Mode II if there are potential value system conflicts which must be resolved as exemplified in my research findings. Suffice it to say my use of the term intact groups was not accurately specified and resulted in my inability to reject the null hypothesis that ad hoc groups are not statistically different from intact groups.

I will follow my *mea culpa* with the observation that my research methods produced important qualitative findings that should illuminate group problem-solving behavior when considering the impact of cognitive style differences among group members, which was my principal focus in this research. Additionally, owing to some theoretical work by Jablokow and Booth (2006) and some empirical work by Carlile (2002) I was able to expand the discussion beyond simple differences in cognitive style to include the consideration of cognitive gaps in both style and level. In addition, I have proposed an operationalization of the Jablokow-Booth cognitive gap model for consideration and have included those considerations with my empirical findings.

Table VII-3 shows the consequences of cognitive level gaps and cognitive style gaps as viewed through both qualitative and quantitative information. This table contains information from the prior three chapters put in a format to simplify the review. The notation concerning role-preferred teams implies the planner role is performed by relatively more adaptive subteams. This is shown by an asterisk by the trial code number. Those trials that are not indicated mean they were non-role preferred subteam activities. The aggregate level scores, total level gap scores, and total style gap scores come from earlier tabulations but were aggregated into Appendix Table I-31. For clarity I will reiterate the components of Total Level Gap and Total Style Gap. They are the cognitive gap parts A + B + D for level and style as noted. Cognitive gap A is the person-person gap discussed at length in Chapter IV. Gap B is the person-person to team mean score gap. And gap D is the person-problem gap. All these gaps have both a level and a style component as shown in Appendix Table I-31. But for simplicity purposes in this presentation I have condensed some of the scores for clarity.

The Style KAI scores are mean KAI Z-scores for each subteam. While the planning subteams were most responsible for unsuccessful trials the operators also exhibited behaviors that were important to this research. I have classified causes and effects of specific behaviors (critical incidents) in Chapter V for all 12 trials based on cognitive level and cognitive style. In Table VII-3 I have condensed those opinions into two major categories: Cognitive

Integrating Influence and Cognitive Disintegrating Influence. The terms, integrating and disintegrating,

Table VII-3. Consequences of Cognitive Level and Style

Trial	Role[a]	Aggr. Level [b]	Mean Style [c]	Total Level Gap [d]	Total Style Gap [d]	Cognitive Integrating Influence [e]		Cognitive Disintegrating Influence [e]	
						Level	Style	Level	Style
FM-T1	Op	-1.99	-0.73	0.41	7.38			2	3
	Pl	-1.51	0.44	1.3	6.63			1	4
CW-T1*	Op	2.69	0.34	4.32	6.54	4	4		
	Pl	-0.94	-0.45	10.61	10.45	5	2		
CW-T2	Op	1.21	0.06	10.23	5.75	3	2		
	Pl	-0.52	1.04	6.57	16.38	4	5		
WIL-T1*	Op	0.32	0.51	11.45	10.5	3	4		
	Pl	4.15	-0.70	17.66	3.69	5	1		
WIL-T2*	Op	-2.98	0.79	2.07	13.3			3	5
	Pl	2.62	-0.87	5.02	5.14			2	1
CHL-T1*	Op	-1.93	0.65	-0.04	9.15			2	4
	Pl	-1.95	-0.64	0.76	5.28			2	1
CHL-T2*	Op	-2.54	0.58	0.79	11.55	2	4		
	Pl	-3.95	-0.94	-1.96	7.86	3	2		
RAL-T1	Op	2.91	-1.08	8.64	0.94			3	2
	Pl	1.76	0.60	11.71	17.8			1	5
RAL-T2*	Op	-0.55	0.69	10.31	15.01	4	4		
	Pl	-2.03	-1.31	4.55	4.9	3	1		
RAL-T3	Op	0.22	-1.01	15.63	7.51	3	2		
	Pl	4.14	0.60	14.03	15.14	3	5		
RAL-T4	Op	0.75	-0.66	10.67	10.52	4	1		
	Pl	0.35	1.79	14.42	22.34	5	4		
RAL-T5	Op	1.14	-1.01	12.22	3.73			3	2
	Pl	-1.35	0.84	12.29	15.1			2	5

[a] Subteams are noted as Operators (Op) and Planners (Pl). Role preferred teams have an asterisk by the trial name.
[b] Aggregate (Aggr) level is summation of subteam level factor scores.
[c] Mean Style is KAI Z-scores averaged for each subteam
[d] Total gaps are summations of subteam person-person gap (A+B) and person-problem gaps (D) for level and style as indicated
[e] Cognitive integrating influences are separated into two classes, Level and Style.
The categories for Level include: Five point Likert scale: 1=zero constructive knowledge transferred to 5=transformative knowledge transferred (relating to Carlile's boundary spanning knowledge)
The categories for Style include: Five point Likert scale: 1=extreme adaptor behavior, 2=distinctive adaptor behavior; 3=middling style; 4=distinctive innovator behavior; 5=extreme innovator behavior

derive from the discussion above on modes of group task execution, by the suggested terms used by Hare (2003) and Follett (1924), and by Carlile's (2002) work on knowledge boundaries and *integrating devices*. As indicated there are cognitive level factors and cognitive style factors which work in combination to affect team outcomes. I have devised a five-point Likert scale to grade the relative contribution of each of these. The footnotes to Table VII-3 explain the scoring concept.

I examined a number of different combinations of cognitive gaps in an effort to determine which scores appeared to correlate with empirical observations. Some of the combinations examined include the following equations and corresponding difference of means tests results factored for successful trial:

(7.1) Level ABD x Style ABD x Aggregate Level; $F=1.107$, $p=.318$

(7.2) Level AB x Style AB + Level D x Style D; $F=4.066$, $p=.056$

(7.3) Level AB x Style AB x Level D x Style D; $F=0.412$, $p=.535$

(7.4) (Level ABD x Style ABD)^2 $F=0.936$, $p=.344$

(7.5) Ln (Abs(Level ABD x Style ABD)); $F=6.688$, $p=.017$

(7.6) Ln (Abs(Level ABD)) x Ln (Style ABD); $F=5.871$, $p=.024$

(7.7) Total Gap ABCD; $F=2.261$, $p=.164$

In combinations shown in equations 7.1 through 7.6 all 24 subteams were included in the analysis. In combination shown in equation 7.7 the between-subteam gap is already factored into the quantity under analysis. Based on this *sensitivity analysis* of the data in consideration of the actual empirical evidence it appears that the combinations shown in equations 7.2, 7.5, and 7.6 are most reflective of the actual observations. However, in spite of the considerable degree of statistical significance that the natural log transformations yield ($p=.017$ and $p=.024$), I would suggest that equation 7.2 would be better used since the combinations can be conceptually understood and not obfuscated by the natural log transformation. I recognize that the combination shown in equation 7.2 has marginal statistical significance (p=.056) however, for the small sample size it is close enough to provide a degree of confidence in the process. Note that the cognitive gap C, discussed above, appeared to diminish the statistical significance of the gap combinations. It appeared above in equation 7.7 (p=.164). Based on these data I have focused the cognitive gaps shown in Table VII-3 on gaps A+B+D.

If the binary logistic model I proposed in Chapter VI can predict about 50% of the successful trials then adding the information concerning cognitive influences on both level and style contained in Table VII-3 should increase the ability to predict positive outcomes to a much higher level. In the following sections I will comment on the information shown in Table VII-3 in order to illuminate the findings. I will begin with the unsuccessful trials.

2.1 Unsuccessful Trials

There were five unsuccessful trials during this research program. For emphasis I have highlighted them in Table VII-3. Three of the five unsuccessful trials consisted of three-person planning teams; i.e., FM-T1, WIL-T2, and CHL-T1. I have evaluated each subteam from the perspective of cognitive *disintegrating* influence on both level and style dimensions. There are two cases of role preferred teams and three cases of non role preferred teams. The case where I identify affect conflict as a disintegrating influence was also non role preferred. I will comment on each of the unsuccessful trials in an effort to find causative combinations of cognitive functioning that contributed to the outcomes.

Before specific discussion of the unsuccessful trials I want to reprise discussion of three-person planning subteams. Hare (2003) surveyed the literature on small group research and discussed the question of group versus individual performance (p.132):

> The productivity of a group tends to be less than that of the same number of individuals if no division of labor is required, if there are problems of control, of if the group develops a norm against high productivity. When groups do appear to be better than individuals, part of the group effect (especially for tasks requiring low levels of creativity) is simply that of having a larger number of persons to remember facts, identify objects, or produce ideas. Many tasks are of an "eureka" type, whereby as soon as one person solves the problem, the other members adopt the solution. For these tasks, having a group increases the probability of having one skilled problem solver. This is especially true for puzzles for which the correct answer is obvious once one person discovers it.

The collective cognitive capacity, what I called aggregated level, of the three three-person planner subteams as shown in Table VII-3 contain two of the lowest scores of the 12 trials (these trials include FM-T1, WIL-T2, and CHL-T1). It could be argued that the low aggregated level of these experimental groups was responsible for their performance. Observe, however that WIL-T2 had an aggregated level of 2.62, considerably larger than the other three person teams. This certainly calls to question the adequacy of the cognitive level measure. However, I think Hare's comments above provide a simple and reasonable explanation; e.g., the probability that a good puzzle solver is on a four-person planner subteam versus a three-person planner subteam is 4/3=1.33; thus, a 33% increase in probability of having someone skilled in solving puzzles. I will present the other findings and comments related to the three-person planning subteams but the Hare observations are significant.

Two of the three-person planning groups were role preferred, WIL-T2 and CHL-T1. As it turned out they were both assembled with little variation in relative job status. And, they were both relatively adaptive groups, with mean style[12] scores of -0.87 and -0.64. Both planner subteams had college educated members and their aggregated cognitive levels[13] were 2.62 and -1.93, a considerable gap. Note also that the second lowest aggregated level score for planner subteams were for the three-person planner subteam of FM-T1, -1.51. Since the

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[12] Style scores shown are standardized KAI Z-scores

[13] Level scores shown are aggregates of subteams based on standardized level factor scores

WIL-T2 trial had aggregated cognitive level scores near the highest of the planner subteams it is difficult to attribute the failure simply to aggregated level scores. Clearly there is some other factor which exacerbated the WIL-T2 trial which I will explore below.

In review of the critical incidents and causal attribution shown in tables in Chapter V above I have developed a scoring system to for the aggregated behaviors as shown in Table VII-3. Based on the extreme fixation on a single narrow solution concept of planner subteams WIL-T2 and CHL-T1 I scored them with the following level and style (level, style): WIL-T2 (2,1) and CHL-T1 (2,1). In both cases the planner subteams demonstrated marked adaptor cognitive styles in seizing upon only one solution and missing the myriad of options that they could have employed. I considered the manifest cognitive levels for both groups near the low end of my scale, in spite of the fact that trial WIL-T2 was one of the higher aggregated level scores for planner subteams. Missed opportunities for something different and relative non-constructive dialogue contributed to the low score of manifest level. As indicated above in my argument about how level and style combine to affect problem-solving performance, I attribute the unsuccessful performance primarily to cognitive style and secondarily with cognitive level, but interactively. A contributing factor in both WIL-T2 and CHL-T1 included the relatively small variance in relative job status in the planner subteams. The total level gaps and total style gaps shown in Table VII-3 do not particularly illuminate the relative job status influence observed in trials WIL-T2 (5.02, 5.14) and CHL-T1 (0.76, 5.28). It was surprising that the relatively adaptive planners would miss some of the details about the time limits. Also, since the range of relative job status of the planners was small and since they were adaptive and therefore careful to not offend others in the group, little challenge and exploration occurred. Recalling Hare's (2003) observations, both these trials could have benefited by the addition of another "thinker."

The other unsuccessful three-person planner subteam trial was FM-T1. This planner subteam, as mentioned above, had the second lowest aggregated level score of all the planner subteams (-1.51). Again, having only three members contributes to this low score. There were some factors which combined to make this trial different, however, from the first two three-person planner subteams I discussed above. This planner subteam was mildly innovative (0.44) and the total level gap was only 1.3. The total style gap was 6.63. Based on the quality of the dialogue I scored the cognitive disintegrating influence (1, 4). The level score of (1) reflects the lack of any constructive or additive meaning and understanding that occurred between the planners during the exercise. The style score of 4 indicated some degree of observable innovative behavior but insufficient alone to be called the causative factor. The lack of variance in relative job status was also a contributing factor, like the first two unsuccessful trials mentioned above. In the end I attribute the unsuccessful performance for trial FM-T1 to low cognitive level primarily with significant interaction with cognitive innovative style.

Two other unsuccessful trials were identified under the disintegrating influence category. They were both non role preferred teams, meaning the planner subteams were relatively more innovative than the operator subteams. These teams both displayed some of the same group decision-making problems that the role preferred subteams displayed *but in marked innovative ways*, as A-I theory asserts. There were some differences as to the relative make-up of these two subteams that are worth reporting.

The planner subteam for RAL-T1 had significant aggregated level (1.76) and somewhat innovative style (0.60). The planners included three very high ranking executives within the organization, but in different divisions. The three high ranking executives demonstrated dominating personalities with no one giving way for others to lead (which I earlier termed "alpha-types"). They clearly had not previously functioned together in problem solving activities. Consequently this fact combined with the relative innovative nature of the subteam contributed to their failure to produce a plan for their operating team. This planner subteam's cognitive gap score was indicative of the observed difficulty in building a coherent solution strategy, level and style gaps (11.71, 17.8). They had too many ideas which were undeveloped and they ran out of time. It is worth noting that due to a last minute absence and some changing of personnel on the subteam assignments, there was a 30 point range of KAI scores on this planner subteam. Mel (KAI 88) and Ray (KAI 118) were two of the three alpha-types who dominated the conversation. They did not converge toward a solution but seemed to silently reject the other's suggestion by offering a new idea following the other's idea. I scored the disintegrating influence as (1, 5) to indicate that, in spite of the relatively high aggregated level, this group demonstrated the lowest degree of constructive problem-solving level. However, I attribute that demonstrated poor level performance on the cognitive style gaps as indicated. Again, it is clear that cognitive level and cognitive style are interactive. Or, perhaps it would be more accurate to say unfettered extreme cognitive styles exacerbate decision making processes in spite of cognitive levels. Since each of the three alpha-types refused to integrate his ideas with the other three they collectively performed quite poorly, certainly well below their individual capabilities. This trial was a vivid demonstration of failure based on the group's collective cognitive style.

The last unsuccessful trial for discussion was RAL-T5. It was similar to trial RAL-T1 in that the cognitive gaps were large (12.29, 15.1). This trial had a planner subteam aggregated level score of -1.35, considerably lower than RAL-T1. It was somewhat more innovative as its mean style was 0.84. This trial contained an interesting conflict that I attributed to cognitive affect (see Figure IV-3). A moral dilemma arose concerning the propriety of sketching the puzzle pieces on the back of the pattern sheet. I used the term affect conflict to capture this interaction after Devine (1999), which I discussed earlier. Cognitive affect conflict is directed toward others and causes emotional upheaval which clouds rational thought. In the sense it is used here I would deem it unintentional. Yet, it was sufficient to shut down thinking and exploration of the boundaries of the problems. The senior member of this four person planning subteam characterized a suggested solution concept as "cheating" when asked. He continued by saying, "That seems to be stretching it but I think that is a generational thing." He made another comment about pushing the limits of rules and attributed that to a generational difference. It was clear that this had a negative effect on creativity of the group since he implied the junior members were morally loose with the rules. Certainly this group's combined style contributed to its failure but the largest single communicative act was the insinuation that pushing the boundaries was cheating. While there was only a medium range of relative job status there was no one superior to the senior member in a position to keep the creative thought process open. [Subsequent to this trial I asked the participant code-named Ray as to why he viewed the sketch suggestion so negatively. He was a contrast; i.e., he was the oldest of his group and was the most innovative (KAI score of 118) yet he seemed most riveted to the rules—as he interpreted them. He was a former college professor, now retired professor emeritus. He answered my comment by saying that his profession was about following rules of conduct. If you want to get published you had to strictly adhere to tight prescription of rules.]

I placed the dialogue concerning the moral dilemma into the cognitive style category for evaluation. In this case I scored the planner subteam on disintegrating influence (2, 5). Clearly the demonstrated cognitive styles at work in this trial were examples of innovative behavior. Ray's insensitive remarks are directly related to his innovative, albeit conflicted, personality. I scored the cognitive level for this trial as 2 for the fact that the three other planners on this subteam actually conceived the notion of sketching a solution and argued its merit. But in the end this, like RAL-T1, unsuccessful trial was caused by high innovative style coupled loosely with lower cognitive level.

2.2 Successful Trials

There were seven successful trials during this research project as shown in Table VII-2 and Table VII-3. There were five different solution techniques as shown in Figure VII-2. As mentioned, for the successful trials I have defined a category of effects called cognitive *integrating* influence. Like with the unsuccessful trials I have included a cognitive level and cognitive style influence score for consideration. In the case of successful trials I will briefly present information about the trials based on the five unique solution techniques shown in Table VII-2. And following those presentations I will add some closing remarks about categories of solution techniques.

The solution technique called pattern sheet key sketch was employed by trial CW-T1 and CHL-T2. These two teams were considerably different as their planner subteams aggregated level scores were -0.94 and -3.95 respectively. Their cognitive styles were considerably closer at -0.45 and -0.94 respectively. The two trials diverged from there. Trial CW-T1 had total level and total style gaps of (10.61, 10.45) while CHL-T2 had gaps of (-1.96, 7.86). As discussed above, the trial CW-T1 demonstrated excellent integrating devices and I consequently scored their manifest level and style (5, 2). This planner subteam built an understanding systematically and ultimately provided an excellent set of instructions for the operating subteam. Their modestly low level score did not appear to impede their decision processes. Their mean style (-0.45) appeared to be near the optimum in terms of solving this problem. An important factor that these scores fail to highlight was the range of relative job status which this team enjoyed. From a high ranking long tenured executive to a relatively low ranking newer staff person this planner subteam exemplified job status diversity. That diversity contributed to the relatively low aggregated level score (based on the proxy used for level). However, the relative job status of the planners appeared to blend optimally for this trial including the emergence of a *natural leader*[14].

The approach to solution for CHL-T2 was much less rational than CW-T1 and ultimately required some degree of luck for the solution to be successful. Like the unsuccessful trial RAL-T5 this planner subteam encountered a moral dilemma with one of the planners concerning the propriety of sketching the puzzle pieces on the pattern sheet. Unlike RAL-T5 this subteam's other three planners were sufficiently integrated that they employed the sketch solution in spite of vigorous resistance by planner Abe. I scored the level and style for CHL-T2 (3, 2). A middling degree of integration occurred in cognitive level as the three planners combined to offer a sketch solution. But, the dissenting planner

[14] I have used this term without intending to imbue it with undue connotation; i.e., I do not mean to imply that the person referenced somehow was born with some innate abilities which mark them as leaders through life. Rather, these persons had higher domain knowledge, higher executive ranking, and greater seniority than their teammates. Those characteristics contributed to a visible acquiescence by the other teammates to the *natural leader*. These people were the best equipped problem solvers given the problem and the context.

wrote a lengthy set of instructions which were confusing and, potentially, could have resulted in the operators not solving the puzzle. The operators were important in this trial to a greater degree than in some based on the fact that had they not discarded the written instructions and used the sketch they likely would not have been successful. The fact that the operators in this instance were somewhat innovative was helpful in this successful trial.

In summary, the *pattern sheet key sketch* solution trials consisted of one planner subteam which functioned about as well as could be expected and one that was very lucky in the outcome. I would attribute the differences in these two executions to the combination of cognitive aggregated level and cognitive level and style gaps. The excellent execution of CW-T1 had cognitive level gap of 10.61 and an aggregated level of -0.94 while the lucky outcome CHL-T2 had a small cognitive level gap of -1.96 and an aggregated level of -3.95. These were significant differences and when combined with the range of relative job status discussed above for CW-T1 provides explanation for the observed differences in behavior during the exercise.

The second solution technique recorded in Table VII-2 was the center square keystone. Two teams employed this technique and, interestingly, one was role preferred and one was not. The aggregated levels of WIL-T1 and RAL-T4 are 4.15 and 0.35 respectively. Their mean style scores were quite different, however, -0.70 versus 1.79—nearly two standard deviations apart! There were such significant differences in the total cognitive gaps that I will report them separately.

The planner subteam for WIL-T1 had cognitive level and style gaps of 17.66 and 3.69. The level gap was considerable while the style gap was minor. The relatively small style gap meant all the planners were near the same KAI score. In spite of the relatively small style gap there was some spirited discussion during this solution. Based on the thorough integration of all the planners in WIL-T1 into the solution concept I scored the integrating factors as (5, 1). This means they demonstrated the highest cognitive level score available based on their collective knowledge forming and decision processes. I also scored them as extreme adaptor based on their approach and the absolute integrity of the solution; i.e., there can be no question as to the propriety of this solution technique. As mentioned earlier, this was largely a result of one planner who conceived the solution, persuaded the other planners of its merit, and instructed the operators how to solve the puzzle. This individual emerged as a *natural leader*, in a similar fashion as the CW-T1 trial.

The planner subteam for RAL-T4 had cognitive level and style gaps of 14.42 and 22.34 respectively. They, like WIL-T1 and CW-T1, had a *natural leader* which proved very valuable in its performance. Unlike WIL-T1 this planner subteam was high on the innovative scale at 1.79. The *natural leader* in this case conceived the exact solution technique as did WIL-T1, a surprising fact given the considerable difference between cognitive style of the two groups and the two individuals that came up with the solutions. There were considerably large cognitive level and style gaps for this trial (14.42, 22.34). Such large style gaps were instrumental in unsuccessful trials for RAL-T1 and RAL-T5, as reported above. However, in this case the *natural leader* gently guided the planners to his solution technique without the kind of unfettered conflict exhibited in the other two trials mentioned. I scored this planner cognitive level and style as (5, 4). They demonstrated the highest degree of cognitive integrating devices in their deliberations and also behaved in a marked innovative style although not the extreme degree. In this case the operating subteam was also very effective in completing its work. I scored the operating subteam's cognitive level and style as (4, 1).

The third unique solution technique was the window pane framing key employed by the planner subteam for RAL-T2. This solution was very similar to the center square keystone discussed above but, obviously, with an outside key rather than an inside one. This role preferred planner subteam actually completed two solutions but I am basing this comment on the window pane framing solution since it was unique. There was little relative difference in job status among the planners. The planners aggregated level was -2.03 and mean style -1.31. The cognitive gaps in level and style were modest (4.55, 4.9). And, this relatively small cognitive gap could be observed during their deliberations as there was little conflict. I scored the planners integrating level and style as (3, 1). The middling cognitive level score was based on the fact that in spite of the planners' creative work they failed to understand the time constraints of the problem. They worked well to understand all other aspects but missed one critical element—the requirement of instructing the operators within the 25 minute time limit.

In the case of RAL-T2 the operators played an important role as well. Since the planners had no time left to provide oral instructions the operators could have been unsuccessful had they been careless in their approach. But, the operators appeared to be quite cautious in their approach and, fortunately, found the written instructions which were left prior to moving any of the puzzle pieces around. The operators mean style was 0.69 and I scored their cognitive integrating level and style as (4, 4). They did a good job of talking through the exercise to enable the trial to be successful.

The next solution technique to be reported is the *puzzle pieces on the pattern sheet*. This trial was CW-T2 and was a good example of cognitive style dominating the exercise. The planner subteam's aggregated level score was -0.52. Its mean style score was 1.04.

However, the cognitive gaps were considerably more extreme in level and style (6.57, 16.38). The cognitive style gap was evident during the execution of the puzzle in that the solution technique was obviously an eureka moment; i.e., a bright idea. And following that good idea the planners sat with no apparent intention of retrieving the operators for the instruction period. This was classic innovator behavior.

This trial benefited by its operator subteam being punctual in coming back into the room where the planners were working. The operators came in about three minutes before the 25 minute period had expired and, fortunately, the planners had the opportunity to provide oral instructions as to how to bring all four sets of puzzle pieces together in one location.

I scored the planners' subteam integrating cognitive level and style as (4, 5) in this case. The effective and constructive dialogue demonstrated a relatively high level while the group's cognitive style was clearly extremely innovative. It was also important that the operators subteam had a relatively high aggregated level 1.21 and I scored their integrating cognitive level and style (3, 2). While this trial was successful, the planners' problem-solving process was decidedly innovative and, consequently, hard to replicate. Yes, they were successful, but it required a good deal of luck.

The last solution technique was the exploded puzzle pieces, which was done by RAL-T3. The planners in this trial pushed the limits of the rules to the boundary and beyond. Interestingly, this planner subteam had the one of the highest aggregated level scores of all the planner subteams (4.14). They were only mildly innovative as their mean style score was (0.60). Their total cognitive gaps for level and style were (14.03, 15.14). The style gap was in evidence during the planners' deliberations. They had numerous ideas and quickly abandoned one idea and moved to another just as quick. Their final solution required some degree of stretching of the rules concerning keeping the puzzle pieces in front of each member. But they found creative ways to rationalize around the apparent restrictions. In terms of cognitive integrating level and style I scored the planners' subteam (3, 5). The middling score for manifest cognitive level was based on the random approach to solving the problem and the haphazard discussion that ensued. In spite of the relatively high aggregated cognitive level score they had considerable cognitive gap conflict (including both level and style) and were fortunate to converge on a solution just before the time expired. By virtue of their simple solution the operators were not challenged much. But, had the planners let the time totally expire the operators may have not been as successful as they were.

In the preceding discussion I have employed the cognitive integrating influences as cognitive level and cognitive style in a relatively generic sense. I want to aggregate those into broader categories of integrating influences based on this research. There were three distinctive categories of integrating influence which I deemed critical to the successful solution of this problem. I will briefly discuss each of the three types and other factors which bear on their successful execution. This will be repetitive of some of the information listed above, but from a different perspective and, therefore, worthwhile.

The first planners integrating influence I identified I will call *natural leader*. As it turned out there were three cases where the range of relative job status was classified as *large*. And in all three cases one member of the planner subteam played a dominant role in guiding the subteam to a successful solution concept. Two of these cases were role preferred and one was non role preferred.

The planner subteam for CW-T1 was relatively more adaptive hence role preferred (KAI mean score 88) and consisted of four planners one of whom was a senior executive with the company. He was joined by another senior project manager, a computer programmer, and a graphic designer. In terms of decision-making process this was probably the ideal example. The senior executive's KAI score was 96. Several ideas were verbalized some of which pushed the boundary lines of the instructions. This was surprising at first since this planning subteam was relatively more adaptive. However, the mean score of 88 points is just slightly adaptive and the defacto team leader had a score of 96 making this team capable of a wide range of behavior, as evidenced by their boundary-pushing dialogue. The *natural leader* happened also to have closely read the instructions and provided answers which were unchallenged. This *natural leader* engaged the other members of the planners subteam and listened intently to everyone's ideas. This team recognized its responsibility to instruct the operators subteam within the 25 minute time limit and did so quite effectively. I would characterize this subteam as relatively well "formed" using Tuckman's term and integrated using Carlile's term. The solution concept consisted of both written and oral instructions and allowed time for the operators to ask questions. This could easily be identified as an adaptive planner solution based on the planner's attention to detail. While these people do not work together daily, they were clearly significantly more integrated than some other trials. This was an ideal example of the degree of integration I assumed with my hypotheses concerning intact groups versus ad hoc groups. I should comment on the group dynamics which occurred in the brief moments that this planning subteam spent together and why I attributed the integrating influence to *natural leader*. There was, in fact, a clear and implicitly understood role hierarchy as the group came together. Chris (KAI 96) is a 23 year company veteran and regional manager superior to the other three members. Bo (KAI 87) is a five-year senior project manager used to taking direction from Chris and known for his critical thinking skills. Dale (KAI 96) is a graphic designer whose degree was in fine arts and who works in marketing and proposal development. She works with Chris and Bo routinely supporting their needs regarding proposal creation. Abe (KAI 73) is the junior of the group and is a computer programmer. He was the least communicative of the group but picked up on the specific time limitations shown in the instructions. Chris' role as defacto leader and his ability to probe the boundaries of the problem were critical to this team's success. However, the other participants made valuable contributions consistent with the role and relative hierarchical positions they hold in the organization.

The other role preferred relatively adaptive planner subteam was WIL-T1. The *natural leader* in this trial (Bo, KAI 85) was very dominant in assuming control after considerable time studying the instructions. He happened to be joined on this subteam by three relatively junior members as regards range of relative job status. His personal mastery of the problem and ability to influence the other planners was necessary and sufficient to conceive a successful solution concept and instruct the operators. Examples of adaptive cognitive style were present in the formulation of the concept and the instructions to the operators. This planner subteam did not provide any written instructions for the operators. The thoroughness of their instructions negated the need for written instructions. In this case the *natural leader* single handedly solved the problem and his subteam members made little contribution to the outcome. I would characterize this as an example of Hare's comment above about "an eureka type" solution by one member and the other members quickly adopting the solution. While this was a successful trial, it did not represent a team formation as effectively as the CW-T1 trial. Bo is a high ranking executive in the organization and, consequently, the other planners quickly ceded authority to him. It was fortuitous that Bo also had sufficient domain knowledge to find a solution for the puzzle. His integrating influence was based on his perceived knowledge *by his teammates* and relative rank in the organization to which the other planners gave heed.

The third and final successful trial in which a *natural leader* was the dominant integrating influence was RAL-T4. This trial was a relatively innovative non role preferred planner subteam. Its KAI mean score was 120, somewhat innovative. Interestingly the *natural leader* on this planner subteam conceived the exact solution concept as the *natural leader* in the WIL-T1 trial—in spite of the fact that the *natural leader* in WIL-T1 had a KAI score of 85 versus the *natural leader* on RAL-T4 who had a KAI score of 132. Also interesting was the fact that there was large range of relative job status on this planner subteam. While the *natural leader* conceived the solution to the problem, he engaged the other planners in the process and, consequently, this subteam more closely approximated the CW-T1 exemplar of an intact problem solving unit. Like CW-T1, RAL-T4 had a senior executive with considerable tenure; Ray (KAI 132) was a 19 year veteran with the organization. He was assisted by Mel (KAI 108, 2 year tenure) and Nat (KAI 114, 2 year tenure), both of whom were professional engineers and proven problem solvers. Pat (KAI 126, 3 year tenure) is a marketing researcher who collaborated freely with the others during the deliberations and who has regular interaction with Bo and Nat in her regular job. None of the participants works for each other directly. But, there was an implicit role hierarchy in this planning subteam which needed little time to develop. As indicated, I have used the term *natural leader* to describe the integrating effect observed during the experiment. That term probably does not fully explicate the complicated preconceived ideas of self and others that had an impact on the planners' subteam in this trial.

I have identified three cases of integrating influence being defined as *combined resource*. Two of the cases were role preferred (CHL-T2 and RAL-T2) and one case was non role preferred (CW-T2). I want to elaborate on the term *combined resource*. In the sense of Carlile's (2002) knowledge being local, embedded, and invested, I have considered *combined resource* as the sum of all knowledge and skills accumulated throughout life. This term comes from Kirton's schema as shown in Figure IV-3. Cognitive resource is a term that is related to the proxy I developed for cognitive level. Recall that my definition of cognitive level includes components of age, tenure, total experience, and job status. Certainly this is a proxy for some unknown total cognitive level. This is the reservoir which feeds both cognitive effect and cognitive affect (recall my conceptualized depiction of cognitive schema shown in Figure IV-3). The expanded term *combined resource* is used to mean the planners worked well to help collectively solve the problem. As it turned out, two of the trials were role preferred (relatively adaptive planning subteams) while one was non role preferred (relatively innovative planning subteams). I viewed the dominant integrating influence as the *combined resource* for these trials. For sake of summarizing some key observations I will mention each of these three cases.

Trial CHL-T2 was a role preferred case (relatively more adaptive KAI mean 81). Owing to last minute personnel changes code name Dale was assigned to someone with the lowest KAI score (71) even though my protocol called for him to be code-named differently. Dale (KAI 71, 4 year tenure) and Chris (KAI 93, 2 year tenure) were of relatively equal hierarchical level in the organization and both were male. Abe (KAI 75, 2 year tenure) and

Bo (KAI 85, 3 year tenure) were the primary antagonists during the discourse as indicated above. Both are women and are at relatively equal positions in the company. In this case Abe had difficulty accepting the suggestions about sketching the puzzle key on the pattern sheet, a problem she did not overcome throughout the 25 minute problem period. The other three participants, however, were able to successfully prepare a sketch suitable for the operating subteam to solve the problem. Had those three planners yielded to Abe's objections this would not have been a successful trial. These planners work in rather close proximity to each other and while they have little direct responsibility over one another they brought implicit role hierarchies for themselves and the other participants. This was borne out in the free and easy way they communicated and explored boundaries of possible solutions. Ultimately, the consensus that was reached by three of the four was sufficient to reach a successful conclusion. I considered this an example of combined resource.

The second example of combined resource was trial CW-T2. This trial consisted of four women in a non role preferred planning subteam. All the KAI scores were innovative ranging from 100 to 121 points. The planners explored several ideas and one (KAI 109) had an eureka moment when she suggested the notion of placing the puzzle pieces on the puzzle pattern sheet for orientation purposes. All members offered ideas and contributed. This is an example of *combined resource*. However, it was not considered an exemplar of good problem solving in that it was not process oriented; i.e., it would be difficult to replicate this in another setting.

The trial RAL-T2 was one of the best examples of collaborative problem solving by a group. This was a relatively adaptive planning subteam (KAI mean 76). It consisted of middle level staff members representing the IT group, engineering, and marketing staff. Abe

(KAI 67, 11 year tenure) and Bo (KAI 70, 17 year tenure) were the senior participants. Chris (KAI 82, 4 year tenure) is an engineer and Dale (KAI 84, 1 year tenure) is a marketing coordinator. Abe, in his company role as an IT manager, is well known to all and well respected. Abe is a high adaptor with only about 5% of the general population more adaptive. Abe's contribution, as mentioned earlier, was to conceive the notion of a window pane framing for each participant to place his puzzle pieces inside. He also wrote detailed instructions for completing the puzzle. While Abe was guiding the others with his solution Chris and Dale began a dialogue about sketching their individual puzzle shapes on their individual pattern sheets to supplement the other instructions. While they fretted over the appropriateness of this solution concept, in the end, they concluded that it was not "showing the puzzle key sheet" by sketching the individual puzzle pieces on each person's pattern sheet. In spite of the acute attention to solving the problem with two completely sufficient solutions, this group failed to understand the 25 minute time during which they must devise an instruction and tell the operators. Even without having an opportunity to orally communicate with the operators' subteam this planners' subteam left sufficient instructions for a successful solution.

The final trial, RAL-T3, was a non role preferred relatively innovative planner subteam (KAI mean 107) which I have characterized the solution concept as *combined style*. Ray (KAI 116, 5 year tenure) was the most vocal and assertive of this planner subgroup. The other very vocal and assertive member was Mel (KAI 95, 13 year tenure). Nat (KAI 96, 2 year tenure) and Pat (KAI 105, 4 year tenure) passively contributed but were clearly subservient to the other two. This planner subteam was perhaps the most egregious in terms of pushing the limits to the problem instructions. They demonstrated marked innovator tendencies regarding ideation, offering numerous solutions but following through with few. They had little comprehension of the time constraints and but for the fact that the operator subteam barged in on the planners there would have been no instructions given. However, this planner subteam had conceived a creative solution of placing the pieces in an exploded arrangement so that with only limited explanation the operators could easily assemble the puzzle. This team, more than any other, displayed little regard for the rules and easily moved pieces of the puzzle around anywhere on the table that they felt they needed to. This more so than any other trial was an example of *combined style* contributing to the outcome. While it was successful in that the operator subteam did assemble the puzzle it would not be considered an exemplar of a good problem solving team, as mentioned above.

2.3 Intact Groups versus Teams

Intact groups are not necessarily teams, vis-à-vis problem-solving capability, as discussed in some detail above. It is clear by the quantitative results presented here that successful problem solving groups need some degree of integration or else they would perform at no better rate than ad hoc groups. And, it is clear that just belonging to the same organization (institution, committee, or association) provides insufficient integrating influence to produce a fully functional problem-solving team. This is a significant finding when considering how organizations are frequently operated today. It is not uncommon for companies to be organized around projects and project teams. People in these firms may serve on several different project teams at the same time. And, members of project teams are not integrated into the teams to the same degree depending on team tenure, relative job status, subject-matter knowledge, seniority, style, level, resource, and motivation. There is not one single factor which supersedes all others when building teams for any problem-solving purpose. However, it is quite significant that all five unsuccessful cases shown in Table VII-3 show disintegrating influences in cognitive level and cognitive style with extreme scores in one or both of those dimensions. Additionally, cognitive gaps, both level and style, proved to be indicative of challenges unless mitigated by *natural leaders*. I would argue that all of the five failures featured cognitive style based failures with interacting effects from cognitive level.

This research placed relatively higher adapters in subteams and relatively higher innovators in subteams. The planner subteams were, by design, relatively homogeneous in problem solving style. The homogeneity of unsuccessful planner subteams appeared to exacerbate the style based decisions of participants while successful planner subteams were able to overcome "groupthink" (Janis 1972).

Cognitive style is a significant contributor to interpersonal communications and behavior during group decision processes. Similarly cognitive level[15] is an important consideration with group problem-solving exercises. Awareness of others' preferred cognitive style and consciousness of our own preferred cognitive style can be helpful in group processes. Similarly put, awareness of cognitive gaps as argued by Jablokow and Booth (2006) enable thinking at a higher plateau within groups. However, with respect to cognitive style, as Scott (2007) observed during her research, a one hour lecture on A-I theory and KAI scores alone were insufficient to help ad hoc groups improve problem solving using the hollow square experiment. I would recommend that, in addition to typical team-building exercises to integrate groups, an experiential training activity based on KAI

[15] I used this term in the sense of Carlile's (2002) definition of knowledge as being local, embedded, and invested in practice.

style would be very useful and bring to consciousness the natural tendencies of our individual problem-solving style preferences. Similarly, cognitive level gaps (as I have used the term) could be illuminated by rational processes that create shared knowledge of a local, embedded, and invested nature for all participants.

2.4 Concluding Observations on Quantitative and Qualitative Results

I would assert that for reasonably integrated *intact groups* as exemplified by the two categories of integrating influence 1) *natural leader* and 2) *combined resource* my hypotheses H1 and H2 would meet my original *a priori* expectations. Few would argue that well integrated teams of people are more successful than ad hoc groups. The fact that this research process showed no statistically significant difference was due to improper definition of intact groups, not flawed hypotheses. What this work has highlighted is the potentially powerful impact of cognitive styles among people assembled to solve problems. Likewise, it highlights the manner in which cognitive level interacts with cognitive style to either exacerbate or mitigate the problem-solving ability of the group. Like others have suggested, cognitive style theory can be put to good use in the area of team composition, conflict management, counseling, and team building if skillfully employed (see e.g., Hayes and Allinson 1994; Kirton 1980 and 1994; and Lindsay 1985). Additionally, cognitive gap theory might also inform team building and as more empirical work is done it too may enhance the use and understanding of cognitive style theory.

I would not, however, reassert hypothesis number three concerning degree of congruence between formal and informal organization. That subject is beyond the scope of what this research method was able to explore. However, this research program was able to isolate and amplify individual cognitive styles and individual cognitive levels manifested during group problem-solving exercises. And, by video recording the group deliberations with the benefit of previously recorded information about each participant (including the KAI scores) this research process has provided theory based explanations for individual and group behaviors, a needed contribution to small group problem-solving research. Also, this research has elaborated and extended some recent work which combines cognitive style theory and cognitive level theory into a concept called cognitive gap theory which is promising in the study of group development or integration. This was recently highlighted by an article appearing in *Small Group Research* by Arrow et al. (2004) on the temporal development on groups. They reviewed the extant literature with emphasis on the extent to which theory has guided empirical research on small groups and provide compelling summary thoughts (p.99):

> Some areas, such as group development, are rich in models but need more theoretical integration. We need a metaframework that incorporates multiple paths of development and seeks to identify the factors that predispose groups toward one part or another—or that can shift a group from one part to another. Models that apply to different time scales or types of activity—group development, decision development, group learning, performance spirals, and structuration and microlevel action cycles in conversation—could also benefit from better integration, so that we have a better sense of the ways in which temporal patterns evident at different time scales mesh with or disrupt one another.

Arrow et al. (2004) called for more theory-based empirical research on the development of small groups and said existing empirical research was, "…mixed and often confusing results across many domains of small group research" (p.100). My research regarding small group problem solving was grounded in the theory of cognitive psychology with special emphasis on cognitive style theory and some speculative work on cognitive level theory. Although the temporal issue of group development was outside the scope of this work I submit that this theory based analysis of group problem solving can provide useful educational and developmental benefits to community based groups, organizations, institutions, and other associations which operate with small groups comprising the primary decision units.

3. Applications in a Planning Context

In the introductory section of Chapter I in this research report I posited planning as a group learning process. I will conclude this exposition reaffirming that contention and expanding it based on these findings. Public boards, commissions, or committees are routinely assembled for making democratic decisions. The range of solutions for those decisions is limited by the members; e.g., in this research some participants read severe prohibitions into the rules while others pushed right to the limits of the rules. There were wide variations in those interpretations. Cognitive gaps were evident in both level and style as suggested by Jablokow and Booth (2006). Kirton's *paradox of structure* resurfaced as an important fact that is better understood by experience than by oratory or composition. Recall that the paradox of structure is premised on the fact that all people are different and see/internalize/interpret the world in ways unique to them. Carlile (2002) called these different kinds of knowledge local, embedded, and invested in practice. This was expanded significantly in Chapter IV with a review of the literature on cognitive style theory and an introduction of cognitive gap theory which added a variable for cognitive level. I introduced a model of problem solving which illuminates cognitive gap theory and makes the paradox of structure clear. Recall that the paradox of structure also bears on the Problem A-Problem B phenomena; i.e., Problem A is the initial problem the group is assembled to solve and Problem B is the problem arising because everyone has differing views as to the nature of the problem and the breadth of possible solutions, hence the paradox of structure.

The KAI scores which range from high adapter to high innovator with the average centering around 96 provide a vocabulary which can add value to public discourse. Society cries out for great innovation when, often, what is needed is greater effort at adaptive solutions. Of course, all these solutions are judged by different people as too much or too little depending on their natural cognitive styles. Similarly, when groups are assembled for problem-solving exercises there are wide variations in knowledge, as evidenced in the Carlile work in cross functional product development companies. The *localness, embeddedness*, and *investedness* of individual knowledge must be considered when groups are problem solving.

Cognitive style theory does not make anyone more or less amenable to accepting change. It does, however, bring to the surface the real fact that change is also perceived by different people in very different degrees. Cognitive gap theory also helps illuminate that fact. These conscious realizations can be useful when dealing with complex value-laden problems in public agencies (certainly this realization also has utility in private sector organizations).

My primary research objective was to determine how and if group problem-solving outcomes may be improved by judicious selection of group members based on cognitive style preference. Based on some theoretical work in cognitive gap theory I extended this into cognitive level considerations as well. I am satisfied that this empirical work showed the potential impact, both negative and positive, of cognitive styles and cognitive levels manifested during collaborative problem-solving exercises. It, unfortunately, did not offer a panacea for grouping people based on KAI scores to solve problems. That is outside the scope of what is possible in this research. What is clear is that cognitive style has an identifiable influence on collaborative functioning of small groups and when combined with cognitive level can provide helpful insight to foster better problem solving. The highly homogeneous make-up of the cases in this research should provide useful guidance for those who regularly work with groups of people, either within the organization or within the community.

Cognitive psychology may seem only distantly connected to the planning profession. However, Lynch's (1960) *The Image of the City* was fundamentally grounded in cognitive psychology and has been considered one of the most influential books on planning in the last 100 years (Hodder 2009). Lynch realized that the images people perceive of city buildings, streets, monuments, and other elements are subjective interpretations, "The environment suggests distinctions and relations, and the observer—with great adaptability and in the light of his own purposes—selects, organizes, and endows with meaning what he sees" (p.6). This was an acknowledgement of how man interacts with external stimuli via a process scholars call cognitive psychology. Lynch, of course was interested in the physical environment or what he termed the "…external agent in the interaction which produces the environmental image" (p.7). His work did not concern itself with individual differences, the focus of psychology, as he acknowledged that his independent variable was the physical environment. Rather, he built a vocabulary (paths, edges, districts, nodes, and landmarks) for communication which has helped city planning professionals shape more useful and positive physical environments for two generations.

Lynch's work, however impactful it was at the time, was focused on the *simple* part of city and regional planning—physical plans. The profession was soon to be challenged to concern itself more with *wicked problems* than with problems of city form (Davidoff 1965). I referred to this in the opening paragraph of this exposition by suggesting the planning profession changed from an emphasis on product (*plan*) to an emphasis on process (*democratically determined decisions*). It is interesting that Lynch used cognitive psychology as a means to help planners better understand the impact of physical environments while I propose the use of cognitive psychology as a means to help planners better facilitate *democratically determined decisions*. In either case, cognitive psychology is a means, not an end.

My research interest is about how cognitive processes work to help people successfully function in a world of subjective reality. This work also suggests some vocabulary not for artifacts in the physical environment but, rather, language for qualifying observations in that environment. Relatively more adaptive solutions versus relatively more innovative solutions are rarely *objectively defined* since there is no omniscient narrator who is absolutely objective. Planners, however, can and should aspire to understand the nature of solutions in a variety of contexts so as to understand where those solutions fall on the adaptive-innovative scale, and the local, embedded, and invested nature of knowledge in that context. The paradox of structure also provides a useful concept with which to view problems which arise in planning domains. The Jablokow-Booth problem solving model can be useful when conceptualizing problem-solving exercises as a rich extension of the paradox of structure. The presumed norms and standards within which all problems are housed are at once limiting to future possibilities and enabling for solutions within them. And, anyone who has dealt with groups of people during any kind of decision seeking process knows, intuitively, the power and truth of the Problem A-Problem B analogy. Recall from Figure IV-3 that the human actor-decision maker exists within some kind of organizational or institutional climate which influences him in some way. Climate and the human exist within a larger culture which influences both. Opportunities exist which the human must scan, select for further processing, and/or dismiss. And based on motive and opportunity the human may take action to interact with the external world in either preferred or coping styles of behavior. While simple in concept, this offers a useful framework with which to view and approach problems in any context.

4. Adaption and Innovation in 100 Years of Planning

Since its inception in 1909 the planning profession has been engaged in a struggle between forces pushing for substantial and profound *innovative* change versus forces which argue for incremental and prudent *adaptive* change. Frederick Law Olmstead, Jr., and Benjamin C. Marsh led the two opposing views at the inaugural National Conference on City Planning (NCCP) which was held May 21-22, 1909 in Washington, D.C. Marsh was a social reformer who advocated for a strong governmental activism in dealing with injustices he felt were the result of a ruling power elite. Olmstead, on the other hand, pushed the emerging profession to be concerned with technical aspects of planning cities and felt the social injustice agenda was outside the bounds of the professional planners' domain (Birch and Silver 2009). With respect to cognitive style theory these represent an innovative position (Marsh's) and an adaptive position (Olmstead) based on the then prevailing norms. It is interesting to consider a few significant events over the last 100 years which had an interesting effect on the planning profession and the way that profession has been perceived.

Olmstead, who is considered the father of city and regional planning, led the profession in promoting technically sound comprehensive plans as an objective. Like Lindblom's (1959) disjointed incrementalism, adaptive change builds off the known and is unlikely to create major societal change. Unfortunately, innovative change risks the other extreme.

Following the 1949 and 1954 Federal Housing Acts and the 1956 Federal Aid Highway Act planners were at the epicenter of societal change that they were helping create but which they likely did not fully understand. By any measure this was innovative change to the extreme. Some consider planners' work at that time destructive to communities, facilitating sprawl, and contributing to racial animosity after which an anti-planning view emerged across many regions of the country. Jacobs and Paulsen (2009) commented on the changing views of planners following their mid-century experience with massive *innovative* change, "…planners today seem far more comfortable interpreting the role of planning through the anti-authoritarian, anti-expert, anti-modern and pro-community, pro-poor, pro-environment criticism of planning that emerged from responses to urban renewal and interstate highways" (p.138). These are but some of the things that led Davidoff (1965) to introduce an expanded role for planners which included, "…the need to rectify racial and social injustices." The planner as advocate for the underclass has emerged as an enduring theme since the 1960s. In the language of cognitive psychology, adaptive change leads to furthering the interests of the power elite at the expense of the powerless. These and other issues provided sufficient motivation for planning scholar Forester (1989) to assert a role for the "progressive planner" which included, "…information control, misinformation, and distorted communications…" in his polemic *Planning in the Face of Power* (p.27). Clearly the paradigm of city planning has changed rather significantly since 1909 and, surprisingly, in some quarters it is closer to Marsh's social activism position than Olmstead's technical expert. Consider Marsh's opening remarks at the inaugural NCCP meeting, "Much of the planning that has heretofore been suggested in the United States has been a bonus to real estate and corporation interests, without regard to the welfare of the citizens" (Peterson

2009:127). I think Marsh would applaud Forester's (1989) assertion 80 years later about the duty of the professional *progressive* planner to balance the power pendulum,

> In a world of severe inequalities, planning strategies that treat all parties 'equally' end up ironically reproducing the very inequalities with which they began. Nowhere is this paradox of 'equal opportunity' more obvious and poignant than in apparently democratic, participatory planning processes—in which initial inequalities of time resources, expertise and information threaten to render the actual democratic character of these processes problematic, if not altogether illusory" (p.9).

It is interesting to consider that Forester's suggestion today seems relatively benign while Marsh's similar thoughts in 1909 were considered rather radical. This is an example of the way paradigms may evolve over time.

There have been other paradigm shifts of significant magnitude over the past 100 years which have influenced planners and planning. Consider, for example, the substantially racially segregated society that existed in 1909 versus the condition today where the United States has its first African American president. Consider the fact that in 1909 women in the US were not allowed to vote. Both these changes required conflict and major shifts in public opinion. These were innovative changes in the strictest sense. Both required federal action to achieve the change; i.e., one change required the Nineteenth Amendment to the United States Constitution and one required the Civil Rights Act of 1964.

What lessons might planners take from the profound changes which have occurred in American society over the past 100 years in light of the findings presented in this research project? Due to the highly focused nature of this research, albeit theoretically based, I must limit my suggested lessons to the individual actor within the context of her job. The common denominator to all contemporary planning activity is the interaction planners have with their constituents. Thus, I will limit my comments to the elemental level of planner's activity. The following items are general observations and recommendations for planners based on this research:

- People have distinctive problem-solving styles which may be viewed as falling on a bipolar continuum from highly adaptive to highly innovative as defined above. The extreme cases of either can be a major source of conflict during consensus seeking activities. Modest variation of cognitive styles can contribute to more thoughtful and wide ranging ideation. A keen awareness of one's own preferred problem solving style will enable the planner to understand some sources of conflict and to develop techniques to reduce them.
- All people are problem solvers and therefore creative but with different styles and with different levels. Adaptive creative solutions are just as effective as innovative solutions, depending on the dimensions and demands of the problems to be solved. Other individual differences may be more or less manifest during problem solving; e.g., extroversion-introversion.
- Knowledge is local, embedded, and invested in practice. This interacts with cognitive style to exacerbate the variety of views and perceptions of problems and opportunities.
- Considerable variation in interpretation of information during any type of group processes can be expected based on cognitive style, cognitive level, and cognitive resource, not to mention individual motivation of participants.
- Be cognizant of the powerful role of facilitator or leader in group processes (natural leader). People interpret words and non-verbal behaviors subjectively in ways that can be vastly different from the intent. Repeat important messages or instructions in multiple ways using different terms.

- Standing organizations or committees have climates which influence group behaviors and may conduce to integrate or segregate participants due to knowledge being local, embedded, and invested in practice of those organizations.
- There are no unbiased participants in any organization or committee activity. Bias is part of the life experience of every person and can be a subconsciously powerful inertia during decision seeking processes.
- Community planning processes are substantially composed of ad hoc members who have widely varying motives for participation, not to mention all the differences discussed above.

In addition to the general recommendations for planners in the eight bullet items shown above, what insights might this research provide to planning directors; i.e., to the people who must manage city planners and city planning processes? There are three major observations which surfaced during this research program that can be educational for planning directors: 1) variety versus isomorphism, 2) ambiguity versus certainty and 3) the cognitive gap challenge.

The fundamental premise upon which cognitive style theory is based is the law of requisite variety as elaborated earlier. Recall that the law asserts that an organization or system must be at least as diverse as the external environment against which the organization must regulate itself. Planning directors must run an organization; albeit a planning organization, it is, in fact, an organization exhibiting all the attributes of any type of formal organization *but for the profit motive* (Downs 1967). Planning directors, by definition, run *bureaucratic* organizations which are not driven by profit but by serving the public weal.

And, planning directors are keenly interested in surrounding themselves with competent planners who understand zoning issues, development codes, building codes, transportation issues, public involvement processes, and a host of other critical knowledge bases (knowledge being local, embedded, and invested in practice following Carlile (2002)). Usually employers (and planning directors are no exception) advertise for and recruit staff members who have the greatest depth of knowledge as sketched above. And, usually employers select and employ people much like themselves as Schneider et al. (1995) asserted in their work on the attraction-selection-attrition (ASA) framework. This process can lead to what DiMaggio and Powell (1983) called *isomorphism*, which is simply a condition where the entire organization is composed of very similar people. Kirton and de Ciantis (1994) studied this tendency with a focus on cognitive style as measured by the KAI instrument. They concluded that such isomorphism tendencies based on cognitive style will ultimately make an organization relative homogeneous and will make it relatively inhospitable to people who are significantly outside the cognitive style climate mean based on KAI scores. This runs counter to the law of requisite variety upon which much of my work was based, which suggests that such situations may lead to skewed (either toward the adaptive or the innovative end of the scale) or suboptimal decision-making processes.

There were some clear examples of highly homogeneous planning subteams which failed to provide a coherent solution concept to their operations' subteams. The trials for FM-T1, WIL-T2, and CHL-T1 demonstrated the effect of relatively narrow variation in both cognitive style and cognitive level. Absent a team leader on the planning subteam the relatively isomorphic planning subteams failed to achieve even a semblance of solution for their operations' subteams. What does this have to do with planning directors and their planning departments? First I would suggest that planning directors should understand their own problem-solving style preferences as indicated by A-I theory and, specifically, by the KAI psychometric instrument, because that probably heavily influenced the cognitive style climate of the staff they have assembled. Secondly, I would suggest that planning directors should have the KAI inventory administered for all their staff members. While the cognitive styles amongst the staff members might vary considerably, the cognitive levels (knowledge is local, embedded, and invested in practice) are not likely to vary largely. These things combine to make the problem-solving capacity challenging for such isomorphic planning departments. Like the examples of planning subteams which were homogeneous and non-differentiated hierarchically, such small groups inside planning departments may struggle to find optimal solutions. Such challenges may be ameliorated by adding a designated team leader with some cognitive style or cognitive level differences or by specifying a problem-solving process which ensures some exploration of the boundaries of possible solutions. The problem-solving process mentioned here gives rise to the second educational benefit of this work for planning directors.

Planning directors are charged with a host of managerial tasks in order to meet the demands of local municipal governments. For example, zoning variance requests are typically discussed internally prior to being submitted to the zoning board for resolution. Environmental regulations are usually buried inside massive volumes of development codes and planners are expected to be accurate interpreters of those rules. Planning staff members have regular interaction with code enforcement officers for interpretation of a variety of issues during construction as well. Most of these items may be pegged as relatively adaptive—using *cognitive style* terminology. In fact much of this kind of work is considerably adaptive. Enter into this labyrinth of rules and regulations the citizen who desires to build a house, develop an apartment complex, or remove trees near a stream. Such citizens demand consistent and fair interpretations of the rules—the *raison d'être* of bureaucracy or a bureaucratic system of governance. What this citizen may encounter is a system of equivocality as evidenced by the experiments in this research.

This research clearly showed considerably different interpretations of the instructions by different planner subteams. There were planning subteams which interpreted the instructions to strictly limit the solution concepts to non-written information. There were planning subteams which interpreted the instructions to remain in the solution room without retrieving the operation subteams. And there were planning subteams which provided clever solution concepts with both written and graphical information. These observations provide a stark realization that the written word alone is, at best, an equivocal guide and therefore should be augmented by other forms of communication. This observation also explains why, in spite of an attempt at consistent interpretations (the essence of bureaucracy) there are often different interpretations on questions from the same planning department. The lesson for planning directors in this instance is to not expect all interpretations to be the same across different planners and to design systems to minimize the variation.

This research revealed cognitive gaps (both level and style) that appeared to influence the understanding of the task by the planner subteam. Also, different preferences for directions (map versus written) between women and men were revealed. An informed response to these realizations would be to design a multi-media communicative system for both planners inside the department and for citizens in the community. Such multi-media systems may include graphs, charts, photographs, mini-movies such as would be found on

Youtube©, Facebook©, or other social networking sites, in addition to the voluminous written development codes. Extensive application of the various forms of information exchange will narrow the gap between what the citizens understand and the actual intent of the development code. Any narrowing of this gap would be considered beneficial to the planning director who is usually the person that receives negative feedback from his superior based on complaints from citizens.

The cognitive gap challenge is the third and final example of possible helpful recommendations this research is able to offer to planning directors. In this case I am most concerned with the cognitive gaps between the staff planners and the citizens with whom the staff must work. In the case of the observed experiments there were several examples of large cognitive gaps, both level and style, that seemed to exacerbate the problem-solving process. For example, RAL-T1 contained three alpha males and one female planner. The alpha males were quite similar in cognitive level (that used for this experiment). The female was considerably more junior in both cognitive level and job status level. The range of cognitive styles varied by a full 30 KAI points between two of the male planners. It was startling to see the degree of communicative disconnect between the high and low cognitive style planners. I consider this failed trial to be largely based on the cognitive style gap for the planners' subteam. In another example RAL-T5 planners were relatively innovative. Unlike RAL-T1 this planner subteam had considerable cognitive level gap between the most innovative of the planners and the other three planners. This trial also proved to be unsuccessful based on the communicative distrust that emerged in dialogue. I considered this failure to be cognitive gap induced similar to RAL-T1 but this one was substantially more a result of cognitive level gap than style. The cognitive level measure employed for this problem was largely age based (age + tenure + total experience + job status). The most innovative planner in this trial twice voiced pejorative opinions about how the younger people were relatively lax with rules, a notion he asserted was "a generational thing." This obvious bias, while not intended to offend the other planners, did exactly that and, consequently this trial was unsuccessful. I want to consider these examples in the case where a citizen (land developer) is trying to get land rezoned to build a non-conforming project and must deal with the planning department.

As indicated above, the nature of development codes and enforcement, from a cognitive style perspective is relatively adaptive. And, also for reasons articulated above, the planner who is administering such development codes is likely to be somewhat adaptive if he is happily employed in the requisite bureaucratic agency which is responsible for these kinds of things. Consider the land developer who is seeking a code variance for his non-conforming project proposal. The land development business is decidedly risky, not for the faint of heart, and anything but bureaucratic. The land development business is, in a word, innovative. For reasons similar to the argument I made about the average planning staff member, there is a high likelihood that the land developer in my example is a relatively high innovator. Thus, the two individuals who sit on opposite sides of the table to initially discuss the non-confirming request are very likely to be considerably different from a cognitive style perspective; that is, the cognitive style gap is likely to be considerable. And, similarly, the cognitive level gap between the two is likely to be large. The planner has sat and defended the city or county's development ordinance against many developers who frequently want to push the envelope of acceptable practice (like the innovators I suggest they are). And the planner has developed considerable reservations about motives and integrity of some land developers. All the many prior encounters the planner has experienced contribute to the planners' general deep seeded distrust of land developers. Now consider the land developer.

The land developer in this example may have scores of projects under his belt. He has dealt with countless planning bureaucrats whose only job, or so it seems to the land developer, is to delay or deny anything the land developer is suggesting. This bias accumulates in the cognitive level storage bin for the land developer. Add to this the fact that this land developer is considerably innovative—decidedly more so than the planner bureaucrat. In some respects they actually have different goals; i.e., the planner's objective is to keep the development ordinance sacrosanct—no modifications from the exact written word while the land developer's objective is to receive a variance—by definition change the development ordinance.

The land developer and the staff planner begin with three considerable gaps; i.e., a considerable cognitive style gap, a considerable cognitive level gap, and really conflicting goals as indicated. As mentioned above, cognitive style gaps (KAI) of 10 points or more have been known to produce some difficulty in communicating. Cognitive style gaps of 15 points (approximately one standard deviation) have been shown to be very challenging. And cognitive style gaps of 20 or more KAI points have been shown to cause considerable distrust and in some cases cause a total breakdown in communication. To those challenges for honest and effective communication must be added the cognitive level gaps mentioned above and the conflicting goals of the staff planner and the land developer. This example bears out the opportunity for mistrust, misunderstanding, and total communication breakdown to occur during the deliberations between a staff planner and a land developer. Although there are no overt destructive acts either way in this example, the combination of cognitive gaps and conflicting goals can quickly escalate into defective interaction and consequently rise up to the community appeals board of adjustment for adjudication. This final escalation to the appeals board is deemed by both the staff planner and the land developer to reinforce their deep prejudice of the other.

I suggest that these cognitive gaps could and should be anticipated by the planning director and acted on in a positive way to minimize the pain and emotional discomfort appeals often entail. In the cases cited above the employees all knew each other, liked each other on some level, and did not have conflicting goals . Yet, large cognitive gaps alone were sufficient to render their efforts ineffective. Knowledge of cognitive styles and cognitive levels of the planning staff can help anticipate potential conflicts with citizens. Acting on that knowledge can be very helpful in minimizing such conflict.

5. Limitations to this Research

Honest reflection following this extensive research program requires the identification of threats to internal and external validity, or limitations of this research. The five areas identified which I will comment on include: 1) interobserver reliability, 2) facilitator instructions, 3) boss as principal investigator, 4) sample size, and 5) spatial intelligence control.

It is common in research such as this to have multiple reviewers of the dialogue and to measure interobserver reliability; i.e., the degree to which multiple observers make the same interpretation of the observed behaviors or recorded dialogue. In this research there were no additional reviewers against which such comparison could be made. This, obviously, could be considered a weakness or limitation in the findings. Such interobserver reliability was noted above in the method used by Bales. However, the Bales method, called the interaction process analysis, consisted of recording the smallest element of dialogue, not interpreting that dialogue. My method required observing larger groupings of dialogue and/or behavior and inferring meaning deductively into the cognitive style and cognitive level frameworks employed for this task. Not having independent corroboration as indicated by interobserver reliability tests certainly weakens this work. However, it would have been extremely difficult to either train or find suitably trained observers to assist in this effort within the time constraints for this research.

The facilitator instructions and the instructions shown on the Hollow Square Puzzle sheet could be considered ambiguous for this exercise, a problem that was reported during post-exercise debriefings. In point of fact, the instructions were purposely prepared so as to leave room for interpretation during the planning portion of the exercise—an outcome that was observed in this research. While the proportion of unsuccessful trials made the hypothesis testing appear to provide unsatisfactory conclusions, the same unsuccessful trials proved very valuable in demonstrating extreme examples of cognitive style and cognitive level gaps and how, uncontrolled, they can have very negative consequences during problem-solving exercises. In addition, the unsuccessful trials provided the researcher more teachable moments during debriefing than did the successful trials.

I noted during the explication of the research protocol that I had to make my involvement as the principal investigator known to all the participants—all of whom were employees of a company I co-founded and in which I currently serve as chairman and chief executive officer. This was a condition of the Institutional Review Board's approval of my research plan. My presence in the work could threaten the internal validity to the extent that people modified their behavior in some amount as a result of my observation. The fact that my experimental outcomes proved to be not statistically different from those of two other major studies gives me some degree of comfort that my personal involvement had minimal effect on behaviors and outcomes.

There were only 12 trials conducted during this research. That made the statistical comparison with the other studies challenging. Based on the limited number, the statistical technique I employed for hypothesis testing was suspect when the number of cases was five or less. The number of trials surely limited the external validity of this work. However, the exploratory analysis that my methods employed provided me considerable evidence of marked cognitive style extremes consistent with predicted behaviors. Those observations should have reasonable generalizability for broader application, in spite of the relatively small number of trials.

Some of the planners appeared to possess greater spatial intelligence (or cognitive level) for solving such a puzzle than others. There was an effort to account for this in the supplemental information which asked the preference for maps versus written directions. Individuals who preferred maps were not statistically more successful than individuals who preferred written directions. A couple of final comments might be worth sharing. First, women prefer written directions while men prefer maps to a statistically significant difference, $\chi^2 = 13.65$, $p < .001$ (2-tailed test). In spite of this finding, men and women were not statistically different in terms of individually solving the puzzle. This indicates a gender predisposition toward prescriptive instructions versus conceptual instructions. Kirton (1994) has shown that after thousands of subjects women are a few points more adaptive than men (approximately 4 points). If this preference for directions is based in cognitive style it points up the extreme sensitivity of the KAI instrument. Otherwise, this may suggest a possible new individual difference which may provide future research opportunities for cognitive psychologists. Secondly, there were three cases where individual planners appeared to have greater spatial intelligence (cognitive level toward this specific puzzle). These cases included the two center square keystone solutions and the window pane framing key as indicated in Table VII-2. The three pivotal planners in these three cases were all men. Interestingly only two of the three pivotal planners preferred maps over written directions. This suggests that the control for spatial intelligence was not particularly effective. However, the one male planner who preferred written directions was the most adaptive of all the planners in his team (KAI 67) which could partially explain the relationship between written directions preference and relatively higher adaptive problem-solving style preferences.

6. Postscript and Recommendations for Future Research

The standard protocol when conducting analyses using the KAI Inventory and A-I theory is to provide personal feedback to the participants either in one-on-one sessions or in groups. Following the experimental sessions and after evaluating the video taken during the exercises I scheduled debriefing sessions in each of the five offices which participated in this work. I prepared a written handout which outlined the basic research and I included a copy of the formal *KAI Feedback Booklet*. While planning a one hour debriefing session I concluded that the nearly 12 hours of video was too voluminous to be useful. Consequently I began a process of making a movie which captured the essence of the planners' decision processes. Each trial was condensed to roughly four minutes of critical comments or actions. My debrief lecture included roughly 10 minutes of A-I theory overview, an introduction to Problem A-

Problem B challenge, the paradox of structure, and KAI scores. I answered a few questions about how each of the subteams was composed. And, lastly I showed the movie.

While this was not part of my original research plan it proved to be highly educational for the participants *and for me as well*. Since many of the participants were somewhat familiar with the people in the video and since there were many *laugh lines* the interest level remained quite high throughout. One unintended consequence of this post-research feedback was to observe the visceral impact of being part of the educational video. The same video if shown to complete strangers would quickly grow boring. However, when the video features many of the viewers there is a considerable affective attention that was pleasantly surprising.

I would suggest that the experimental procedure in my research program constitutes an effective *problem-solving training* for any kind of groups, public sector or private sector. Further, I would argue that a video-based feedback process which provides a video record of critical incidents is much more effective than either oral or written instruction. But, combining oral, written, and video educational programs can synergistically improve all three.

Further research should be done in the degree of improvement that such exercises can cause. Because this was not a planned part of my original research protocol, I did not have *a priori* expectations. Following my video-based feedback to participants I have received considerable feedback about how enlightening the entire process was. I am interested in measuring the degree of improvement such a process may foster. That is a topic for future research and development.

For managers, agency chiefs, or others who facilitate group decision seeking processes, I strongly recommend a three-step process as followed in this research with the third step including a video-based feedback lecture using the agency members as featured stars.

APPENDIX A

THE HOLLOW SQUARE: A COMMUNICATIONS EXPERIMENT[16]

Reproduced from
A Handbook of Structured Experiences for
Human Relations Training, Volume II
J. William Pfeiffer and John E. Jones, Editors
La Jolla: UNIVERSITY ASSOCIATES Publishers, Inc., 1974

[16] The Hollow Square exercise is used with permission from the editors for educational/training events based on display of the credit box above

HOLLOW SQUARE: A COMMUNICATIONS EXPERIMENT

Goals

I. To study dynamics involved in planning a task to be carried out by others.

II. To study dynamics involved in accomplishing a task planned by others.

III. To explore both helpful and hindering communication behaviors in assigning and carrying out a task.

Group Size

A minimum of twelve participants (four on the planning team, another four on the operating team, and at least four to be observers). The experiment can be directed with multiple groups of at least twelve participants each.

Time Required

Approximately one hour.

Materials

I. For the four members of the planning team:

1. A Hollow-Square Planning-Team Briefing Sheet for each member.

2. Four envelopees (one for each member), each containing puzzle pieces. (Instructions on how to prepare the puzzle follow.)

3. A Hollow-Square Pattern Sheet for each member.

4. A Hollow-Square Key Sheet for each member.

II. Copies of the Hollow-Square Operating-Team Briefing Sheet for the four members of the operating team.

III. Copies of the Hollow-Square Observer Briefing Sheet for all process observers (the rest of the group).

IV. Pencils for all participants.

Physical Setting

A room large enough to accommodate the experimental groups comfortably. Two other rooms where the planning and operating teams can be isolated. A table around which participants can move freely.

Process

I. The facilitator selects four people to be the planning team and sends them to an isolation room.

II. The facilitator selects four people to be the operating team, gives them copies of the Operating-Team Briefing Sheet, and sends them to another room. This room should be comfortable, because this team will have a waiting period.

III. The facilitator designates the rest of the members as the observing team. He gives each individual a copy of the Observer Briefing Sheet and allows time to read it. Each observer chooses one member from each of two teams he will observe. The facilitator explains to the observers that they will gather around the table where the planning and operating teams will be working. Their job will be to observe, take notes, and be ready to discuss the results of the experiment.

IV. The facilitator then brings in the members of the planning team and has them gather around the table. He distributes a Planning-Team Briefing Sheet and an envelopee to each individual on the team.

V. The facilitator explains to the planning team that all the necessary instructions are on the Briefing Sheet. If questions are raised, the facilitator answers, "All you need to know is on the Briefing Sheet."

VI. The facilitator then cautions the observing team to remain silent and not to offer clues.

VII. The experiment begins without further instructions from the facilitator.

VIII. After the planning and operating teams have performed the task as directed on their instruction sheets, observers meet with the two persons whom they observed to give feedback.

IX. The facilitator organizes a discussion around the points illustrated by the experiment. He calls on the observers for comments, raises questions himself, and gradually includes the planning and operating teams.

An evaluation of the Planning-Team Briefing Sheet may be one topic for discussion. Any action not forbidden to the planning team by the rules is acceptable, such as drawing a detailed design on the Pattern Sheet or drawing a template on the table or on another sheet of paper. Did the planning team restrict its efficiency by setting up artificial constraints not prescribed by the formal rules? Did it call in the operating team early in the planning phase, an option it was free to choose?

Variations

I. While the operating-team members are waiting to be called, they can be involved in a team-building activity such as "Twenty-Five Questions" (Vol. IV: Structured Experience 118).

II. An intergroup competition can be set up if there are enough participants to form two sets of teams. The winner is the team that achieves the correct solution in the least amount of time.

III. With smaller groups, the number of envelopees can be reduced. (It would be possible to have individuals work alone.)

IV. The members of the operating team can be instructed to carry out their task non-verbally.

Preparing the Puzzle

Prepare the hollow-square puzzle from cardboard with dimensions and shapes as in the following drawing. Lightly pencil the appropriate letter on each piece. Put all letter-A pieces in one envelopee, all letter B's in another envelopee and so on. Then erase the penciled letters.

HOLLOW-SQUARE PLANNING-TEAM BRIEFING SHEET

Each of you has an envelopee containing four cardboard pieces which, when properly assembled with the other twelve pieces held by members of your team, will make a hollow-square design. You also have a sheet showing the design pattern and a key sheet showing how the puzzle pieces fit to form the hollow square.

Your Task

During a period of twenty-five minutes, you are to do the following:

1. Plan to tell the operating team how the sixteen pieces distributed among you can be assembled to make the design.
2. Instruct the operating team how to implement your plan.

   (The operating team will begin actual assembly after the twenty-five minutes is up.)

Ground Rules for Planning and Instructing

1. You must keep all your puzzle pieces in front of you at all times (while you both plan and instruct), until the operating team is ready to assemble the hollow square.

2. You may not touch other member's pieces or trade pieces during the planning or instructing phases.

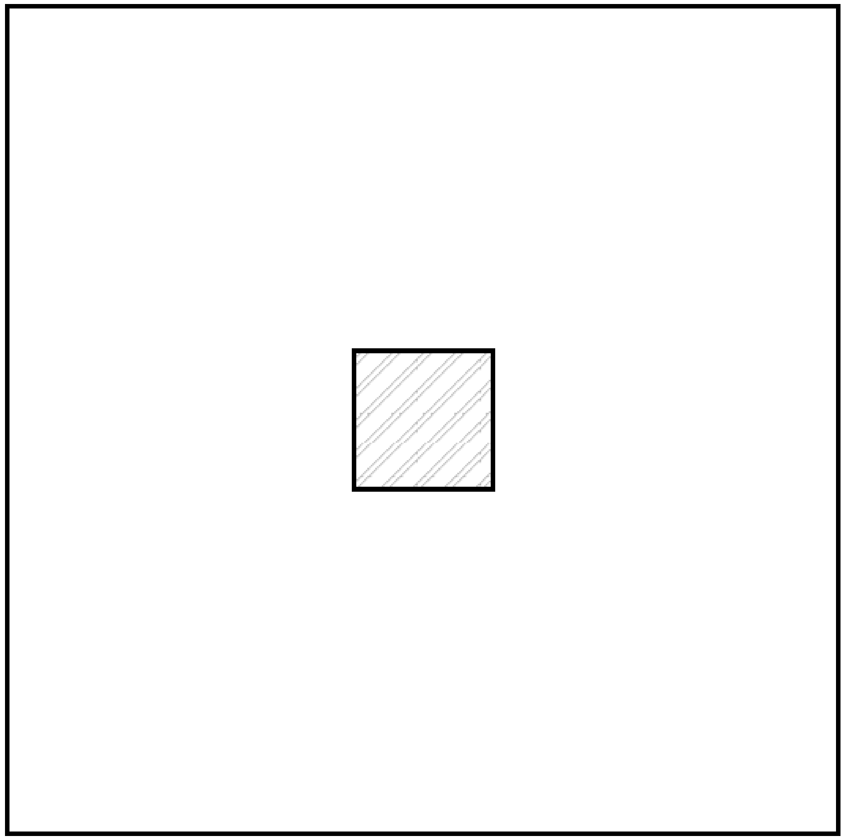
3. You may not show the key sheet to the operating team at any time.

4. You may not assemble the entire square at any time. (This is to be done only by the operating team.)

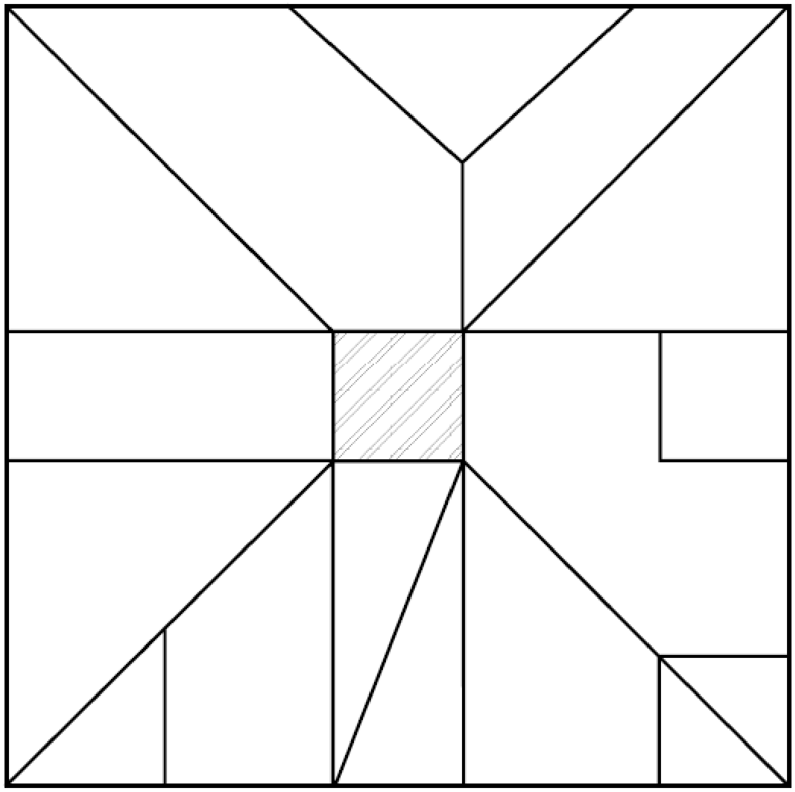
5. You may not mark on any of the pieces.

6. When it is time for your operating team to begin assembling the pieces, you may give no further instructions; however, you are to observe the team's behavior.

HOLLOW-SQUARE PATTERN SHEET



HOLLOW-SQUARE KEY SHEET



HOLLOW-SQUARE OPERATING-TEAM BRIEFING SHEET

1. You have the responsibility of carrying out a task according to instructions given by your planning team. Your task is scheduled to begin no later than twenty-five minutes from now. The planning team may call you in for instructions at any time. If you are not summoned, you are to report anyway at the end of this period. No further instructions will be permitted after the twenty-five minutes have elapsed.
2. You are to finish the assigned task as rapidly as possible.
3. While you are waiting for a call from your planning team, it is suggested that you discuss and make notes on the following questions:

    i. What feelings and concerns are you experiencing while waiting for instructions for the unknown task?
    ii. How can the four of you organize as a team?

4. Your notes recorded on the above questions will be helpful during the discussion following the completion of the task.

HOLLOW-SQUARE OBSERVER BRIEFING SHEET

You will be observing a situation in which a planning team decides how to solve a problem and gives instructions on how to implement its solution to an operating team. The problem is to assemble sixteen pieces of cardboard into the form of a hollow square. The planning team is supplied with the key to the solution. This team will not assemble the parts itself but will instruct the operating team how to do so as quickly as possible. You will be silent throughout the process.

1. You should watch the general pattern of communication, but you are to give special attention to one member of the planning team (during the planning phase) and one member of the operating team (during the assembling period).

2. During the planning period, watch for the following behaviors:

    i. Is there balanced participation among planning-team members?
    ii. What kinds of behavior impede or facilitate the process?
    iii. How does the planning team divide its time between planning and instructing? (How soon does it invite the operating team to come in?)
    iv. What additional rules does the planning team impose upon itself?

3. During the instructing period, watch for the following behaviors:

    i. Which member of the planning team gives the instructions? How was this decided?
    ii. What strategy is used to instruct the operating team about the task?
    iii. What assumptions made by the planning team are not communicated to the operating team?
    iv. How effective are the instructions?

4. During the assembly period, watch for the following behaviors:

    i. What evidence is there that the operating-team members understand or misunderstand the instructions?
    ii. What nonverbal reactions do planning-team members exhibit as they watch their plans being implemented?

APPENDIX B

KIRTON'S ADAPTION-INNOVATION INVENTORY

Table B1. KAI Inventory[17]					
How easy or difficult do you find it to present yourself consistently, over a long period of time, as a person who:	Very Hard	Hard		Easy	Very Easy
	1	**2**	**3**	**4**	**5**
1. Has original ideas					
2. Proliferates ideas					
3. Is stimulating					
4. Copes with several new ideas at the same time					
5. Will always think of something when stuck					
6. Would sooner create than improve					
7. Has fresh perspectives on old problems					
8. Often risks doing things differently					
9. Likes to vary set routines at a moment's notice					
10. Prefers to work on one problem at a time					
11. Can stand out in disagreement against group					
12. Needs the stimulation of frequent change					
13. Prefers changes to occur gradually					
14. Is thorough					
15. Masters all details painstakingly					
16. Is methodical and systematic					
17. Enjoys detailed work					
18. Is (not) a steady plodder					
19. Is consistent					
20. Imposes strict order on matters within own control					
21. Fits readily into "the system"					
22. Conforms					
23. Readily agrees with the team at work					
24. Never seeks to bend or break the rules					
25. Never acts without proper authority					
26. Is prudent when dealing with authority					
27. Likes the protection of precise instructions					
28. Is predictable					
29. Prefers colleagues who never "rock the boat"					
30. Likes bosses and work patterns which are consistent					
31. Works without deviation in a prescribed way					
32. Holds back ideas until obviously needed					

[17] Source: Kirton (1976). Items 1-13 comprise the sufficiency of originality (SO) subscale. Items 14-20 comprise the reliability and efficiency (E) subscale. And, items 21-32 comprise the rules/group conformity (R) subscale. Items are randomly arranged on measurement instrument.

APPENDIX C

SUPPLEMENTAL INFORMATION

SUPPLEMENTAL INFORMATION

Please provide the following information in addition to the KAI Inventory form:

1. How long have you worked in this organization? ____________
2. How long have you worked in other, similar, organizations? ____________
3. What is your work group's name in this organization? ____________
4. What is your title in this organization? ____________
5. Please select the answer that best describes your preference: When I am driving to a location that I am unfamiliar with I prefer: _____Written directions

   _____A map

APPENDIX D

POST EXERCISE IMPRESSIONS

Post Exercise Impressions			
1) Rate how you felt about performing your task role for this problem:			
a) very frustrated	b) slightly frustrated	c) comfortable	d) very comfortable
2) Rate how well your subteam communicated with each other about the problem			
a) Bad	b) poor	c) good	d) excellent
3) Rate how well your sister subteam communicated with your subteam			
a) Bad	b) poor	c) good	d) excellent
4) Rate the amount of time provided for the problem			
a) Way too little	b) Slightly too little	c) about right	d) way too much
5) Rate your subteam members performance in solving this problem			
a) No help at all	b) Not very helpful	c) Helped a little	d) Great help
6) Rate your sister subteam members performance in solving this problem			
a) No help at all	b) Not very helpful	c) Helped a little	d) Great help
7) Rate your subteam member's communication style on this problem (omit your own)			

Member A	a) abrasive	b) talk not listen	c) listen & talk	d) synergistic
Member B	a) abrasive	b) talk not listen	c) listen & talk	d) synergistic
Member C	a) abrasive	b) talk not listen	c) listen & talk	d) synergistic
Member D	a) abrasive	b) talk not listen	c) listen & talk	d) synergistic

APPENDIX E

EMAIL INVITATION TO PARTICIPANTS

To: Michael W. Creed
Subject: Example 080609 Modification
To: EXAMPLE--080609 Modification
Subject: Research Opportunity

Hello all,

As many of you know, I've been involved with the Department of City & Regional Planning at UNC CH for a number of years. I have finally reached the point of having an approved research project which will fulfill part of my doctoral requirements. To that end, I have attached an invitation for you to participate in my research.

The topic is one which many of us are concerned about and, perhaps, you will be as well. This invitation is entirely voluntary and I certainly understand if you have no interest in participating or are too busy. I will not contact you again about this, and it is my sincere wish that you do not in any way feel coerced to participate.

Thanks
Mike Creed

Michael W. Creed
Chief Executive Officer

McKIM&CREED
ENGINEERS SURVEYORS PLANNERS

1730 Varsity Drive, Suite 500
Raleigh, NC 27606

919.233.8091
919.657.8895 fax
919.219.7402 mobile

http://www.mckimcreed.com/

APPENDIX F

INVITATION LETTER

UNC
COLLEGE OF
ARTS & SCIENCES

THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

DEPARTMENT of CITY and REGIONAL PLANNING

CAMPUS BOX 3140
NEW EAST BUILDING
CHAPEL HILL, NC 27599-3140

T 919-962-3983
F 919-962-5206
www.planning.unc.edu

August 26, 2009

McKim & Creed, PA
Employees

Dear McKim & Creed Employees,

I have been involved in a doctoral program in the Department of City & Regional Planning at UNC Chapel Hill since 2001. My research interests have evolved into how small groups of people interact during decision-making processes. This interest grew out of watching city councils, county commissions, and our own executive and project teams collaborate to make decisions. I am excited and honored to invite you to become a volunteer in this research project. Please understand that your participation is voluntary, and even if you volunteer, you can withdraw from participation at any time—there is no penalty whatsoever for not volunteering or from withdrawing from participation.

The research will involve breaking into small groups of people and solving a puzzle within a prescribed timeframe and within prescribed rules and procedures. The exercise just described will be done during one lunch period. Following the completion of all the trials across the company there will be a debriefing period which will also occur during a lunch period. Lunch will be provided for all participants at the exercise hour and the debrief hour.

There will be a brief introductory meeting (15 to 20 minutes) in your office within the next few weeks. This meeting will be scheduled to occur during a lunch period but lunch will not be provided. Two of your colleagues will be assisting me in administering this exercise and providing follow-up feedback. Phyllis Elikai and Linda Vaughn have previously received special training in the specific activities anticipated for this exercise. The exercise is non-trivial but requires no special training or education. The exercise should be entertaining and, hopefully, educational for all participants.

All lunches and materials supplied for this research will be paid for by me personally and no costs will be borne by either the company or the participants.

On behalf of the Department of City & Regional Planning at UNC Chapel Hill I cordially invite you to assist me in this research project. It can provide insight for improved decision processes across a wide variety of applications.

Sincerely,
Department of City & Regional Planning

Michael W. Creed

Michael W. Creed, Principal Investigator

APPENDIX G

INTRODUCTORY SCRIPT AND IRB CONSENT FORM

Creed Research on Problem Solving

Introduction and personal invitation

Good morning (*afternoon*) everyone! I am (*NAME*) and have volunteered to assist Mike Creed in this research project. First, I want to thank you for responding to Mike's invitation for you to participate. I'm sure you have questions like, "what exactly will we be doing and when will we be doing it?" You may also be thinking, "Why is (*NAME*) reading their lines?" I'll begin with the last question and then provide some general explanation of Mike's dissertation research.

<u>Why am I reading this information?</u>

This process is a major part of Mike Creed's PhD dissertation research. And, because there will be sessions like this one given across all our offices facilitated by different people; we need to insure that the instructions and information given to all participants is exactly the same. This will provide some assurance that the facilitators did not bias any participant in any way.

<u>What exactly will we be doing?</u>

Today <u>volunteers</u> will be given three documents to fill out:

1. A Consent Form
2. A Supplemental Information Form
3. A KAI Response Sheet

The <u>Consent</u> form is required by Institutional Review Boards (IRB) at every major research university for any research involving human subjects. It is for the protection of participants and its purpose is to prevent psychological or physical abuses. The research exercise proposed by Mike Creed has been performed at two other major universities in the US and there have been no reports of problems. In addition, the IRB at UNC has deemed this to be very un-invasive research. <u>I want to emphasize that participation in this research is totally voluntary and you may withdraw at any time.</u>

The Supplemental Information simply asks some basic questions about your relationship with this organization such as length of time here and in other similar organizations among other things.

The KAI Response Sheet asks you to respond to some questions about "how easy or difficult would you find it to present yourself, consistently, over a long period of time" in different circumstances. There are no right answers or wrong answers and we would recommend that you not over-analyze the question but simply read the question and respond to it. Also, responses bunched to one side or the other side or down the middle of the response form may be difficult to interpret. Please answer all 33 questions! The KAI Response Sheet and feedback are used across the globe similarly to the MBTI process that many of you have gone through.

What is the schedule for this research?

Today's meeting (which we call Step One) will be very brief, just long enough for me to read this information and ask for volunteers to fill out the three forms mentioned above. As soon as you have filled out the information sheets you are free to go.

Each volunteer will be placed in different eight person groups. Each eight-person group will be scheduled for a one-hour problem-solving exercise session (which we call Step Two). The exercise you will be asked to do is to solve a simple puzzle within a limited amount of time. We will video tape the teams during their deliberations, so don't become anxious if you see a camcorder being used by the facilitator.

After all the exercises have been completed across the company we will schedule larger group meetings (which we call Step Three) to debrief everyone on the process and provide feedback about Mike Creed's research objectives. In addition, we will give all participants feedback on the forms you fill out as part of this research. You will be given a KAI Feedback Booklet which contains valuable information on group problem-solving and your personal preferences during problem-solving processes. This information, like MBTI feedback, can help you understand yourself and how you relate to others during group problem-solving or decision-making processes.

Due to the economy and struggles that our firm is experiencing, I want to assure you that no McKim & Creed resources are being used for the research. That is why you are being asked to volunteer and why all meetings are scheduled and held outside of normal working hours or during lunch. Further, all materials for this research including the KAI Response Sheets, Feedback Booklets, and lunches provided for all volunteers will be paid for by Mike Creed personally.

Now for everyone willing to continue as a volunteer, I will now pass out envelopees which contain the three forms mentioned above. Please fill them out, put them back into the envelopees, and give them to me. Thank you for your participation.

Are there any questions? [BEWARE OF GETTING BOGGED DOWN HERE]

University of North Carolina-Chapel Hill
Consent to Participate in a Research Study
Adult Participants
Social Behavioral Form

IRB Study #: 09-1352
Consent Form Version Date: Aug 10, 2009

Title of Study: Planning, Problem Solving, and Kirton's A-I Theory Within an Organizational Framework

Principal Investigator: Michael W. Creed
UNC-Chapel Hill Department: City & Regional Planning
UNC-Chapel Hill Phone number: 919-219-7402
Email Address: mcreed@mckimcreed.com

What are some general things you should know about research studies?
You are being asked to take part in a research study. To join the study is voluntary. You may refuse to join, or you may withdraw your consent to be in the study, for any reason, without penalty.

Research studies are designed to obtain new knowledge. This new information may help people in the future. You may not receive any direct benefit from being in the research study. There also may be risks to being in research studies.

Details about this study are discussed below. It is important that you understand this information so that you can make an informed choice about being in this research study.

You will be given a copy of this consent form. You should ask the researchers named above, or staff members who may assist them, any questions you have about this study at any time.

What is the purpose of this study?
The purpose of this research study is to learn about how different people interact in small group problem-solving activities. The objective is to determine ways to improve small group problem solving quality.

How many people will take part in this study?
If you decide to be in this study, you will be one of approximately 200 people in this research study.

How long will your part in this study last?
Your involvement will require about two and one half hours. Two one-hour sessions will occur during your lunch period and lunch will be provided. The initial half-hour session will also be at lunch time but lunch will not be provided for that session.

What will happen if you take part in the study?
Volunteers will complete a problem-solving style inventory and a brief questionnaire. Researchers will evaluate that information and place participants into small groups for the experimental part of the exercise. During the one-hour experiment small groups of people will be asked to solve a geometric puzzle in a prescribed way and in a predetermined time. Some of the small groups may be videotaped during the experiment.

After all experimental trials have been completed the researchers will do a debriefing of the results during a second lunch period. Participants will receive booklets of information of some of the theory upon which this research was based.

Participants will be given code names for the experiment in an effort to provide privacy for your information.

What are the possible benefits from being in this study?
Research is designed to benefit society by gaining new knowledge. You may also expect to benefit by participating in this study by learning about your most preferred approach to problem solving and how your problem solving style agrees with and conflicts with others. This may be thought of as similar to the MBTI preferences.

What are the possible risks or discomforts involved from being in this study?
There may be uncommon or previously unknown risks. You should report any problems to the researcher. This study has been carried out in a similar fashion for approximately 1400 participants in university settings with no reported problems or discomforts.

How will your privacy be protected?

Participants *will not* be identified in any report or publication about this study. Information collected in this study will be no more invasive than the Myers-Briggs Type Indicator questionnaires that are routinely done and discussed throughout the company. And, there is no state or federal disclosure law requiring publication or sharing of this information beyond the principal investigator. Some of the small groups will be videotaped during their deliberations for the purpose of recording interactions between different people. Only code names will be used during this phase of the research so that no real names will be used in the recordings. Tapes will be maintained by the researcher for future reference. No tapes will be kept in the host company files or personnel records. If the participants so choose, the videotaping may be turned off.

Check the line that best matches your choice:
_____ OK to record me during the study
_____ Not OK to record me during the study

<u>What if you want to stop before your part in the study is complete?</u>
You can withdraw from this study at any time, without penalty.

<u>Will you receive anything for being in this study?</u>
You will be receiving lunch on two occasions for taking part in this study.

<u>Will it cost you anything to be in this study?</u>
There will be no costs for being in the study

<u>What if you have questions about this study?</u>
You have the right to ask, and have answered, any questions you may have about this research. If you have questions, complaints, concerns, or if a research-related injury occurs, you should contact the researchers listed on the first page of this form.

<u>What if you have questions about your rights as a research participant?</u>
All research on human volunteers is reviewed by a committee that works to protect your rights and welfare. If you have questions or concerns about your rights as a research subject, or if you would like to obtain information or offer input, you may contact the Institutional Review Board at 919-966-3113 or by email to IRB_subjects@unc.edu.

- -

Title of Study: Planning, Problem Solving, and Kirton's A-I Theory Within an Organizational Framework

Principal Investigator: Michael W. Creed

<u>Participant's Agreement:</u>

I have read the information provided above. I have asked all the questions I have at this time. I voluntarily agree to participate in this research study.

____ __________________
Signature of Research Participant Date

____
Printed Name of Research Participant

APPENDIX H

COGNITIVE GAP DEVELOPMENT AND ASSESSMENT

		Age	Tenure	TotExp	KAI	JobStat
Table H-1 Correlation Matrix						
Correlation	Age	1.000				
	Tenure	.485	1.000			
	TotExp	.794	.570	1.000		
	KAI	-.132	-.137	-.036	1.000	
	JobStat	.334	.396	.442	.013	1.000
Sig. (1-tailed)	Age					
	Tenure	.000				
	TotExp	.000	.000			
	KAI	.111	.101	.368		
	JobStat	.001	.000	.000	.452	

Table H-2 Communalities

	Raw		Rescaled	
	Initial	Extraction	Initial	Extraction
Age	128.861	113.947	1.000	.884
Tenure	41.109	16.477	1.000	.401
TotExp	125.022	112.787	1.000	.902
KAI	204.179	204.067	1.000	.999
JobStat	2.836	.533	1.000	.188

Extraction Method: Principal Component Analysis.

Table H-3 Total Variance Explained

Component		Initial Eigenvalues(a)			Rotation Sums of Squared Loadings		
		Total	% of Variance	Cum %	Total	% of Variance	Cum %
Raw	1	252.664	50.331	50.331	242.337	48.274	48.274
	2	195.147	38.873	89.204	205.474	40.931	89.204
	3	30.833	6.142	95.346			
	4	21.194	4.222	99.568			
	5	2.168	.432	100.000			
Rescaled	1	252.664	50.331	50.331	2.353	47.051	47.051
	2	195.147	38.873	89.204	1.022	20.441	67.492
	3	30.833	6.142	95.346			
	4	21.194	4.222	99.568			
	5	2.168	.432	100.000			

Extraction Method: Principal Component Analysis.
a When analyzing a covariance matrix, the initial eigenvalues are the same across the raw and rescaled solution.

Figure H-1 Scree Plot

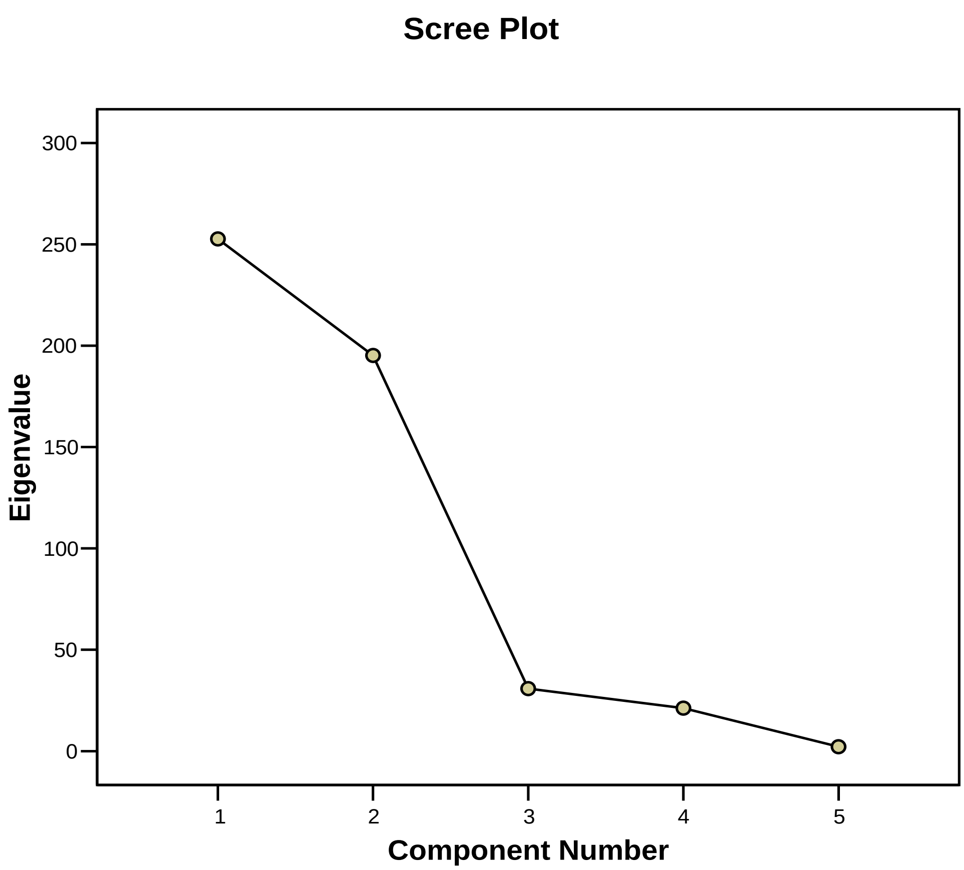


Table H-4 Component Matrix[a]

	Raw		Rescaled	
	Component		Component	
	1	2	1	2
Age	10.082	3.508	.888	.309
TotExp	9.564	4.617	.855	.413
Tenure	3.933	1.004	.613	.157
JobStat	.635	.359	.377	.213
KAI	-6.609	12.664	-.463	.886

Extraction Method: Principal Component Analysis.
a 2 components extracted

Table H-5 Rotated Component Matrix [a]

	Raw		Rescaled	
	Component		Component	
	1	2	1	2
TotExp	10.619		.950	
Age	10.618		.935	
Tenure	3.988	-.757	.622	-.118
JobStat	.728		.432	
KAI		14.272		.999

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 3 iterations.

Table H-6 Component Transformation Matrix

Component	1	2
1	.906	-.424
2	.424	.906

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Figure H-2 Component Plot in Rotated Space

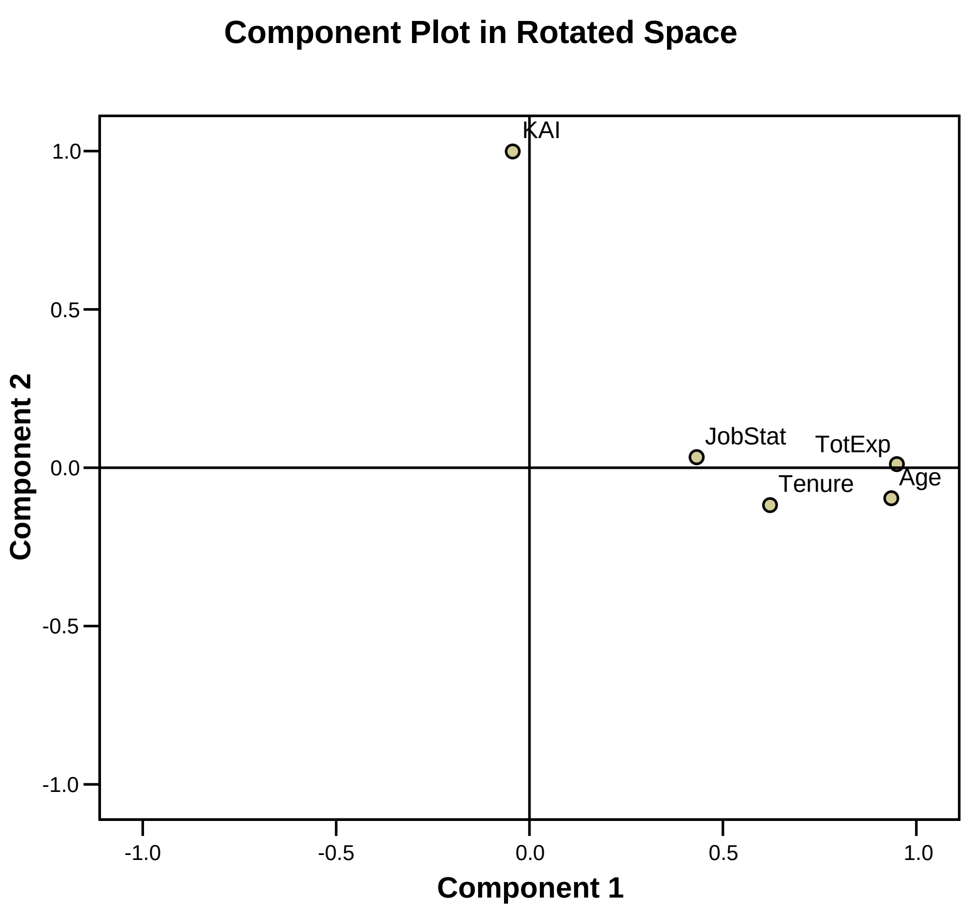


Table H-7 Difference of Means Tests [a]

Additive Model with Factor Scores (Planner Subteam)

		Sum of Squares	df	Mean Square	F	Sig.
Level Gap A	Between Groups	13.105	1	13.105	1.380	.267
	Within Groups	94.987	10	9.499		
	Total	108.092	11			
Level Gap B	Between Groups	1.576	1	1.576	.830	.384
	Within Groups	18.982	10	1.898		
	Total	20.558	11			
Level Gap C	Between Groups	.017	1	.017	.038	.855
	Within Groups	1.780	4	.445		
	Total	1.797	5			
Level Gap D	Between Groups	.331	1	.331	.028	.870
	Within Groups	116.851	10	11.685		
	Total	117.182	11			
Style Gap A	Between Groups	3.898	1	3.898	1.104	.318
	Within Groups	35.291	10	3.529		
	Total	39.189	11			
Style Gap B	Between Groups	.366	1	.366	.674	.431
	Within Groups	5.429	10	.543		
	Total	5.795	11			
Style Gap C	Between Groups	.011	1	.011	.054	.827
	Within Groups	.841	4	.210		
	Total	.852	5			
Style Gap D	Between Groups	.004	1	.004	.000	.991
	Within Groups	258.112	10	25.811		
	Total	258.116	11			

[a] Tests conducted for Successful trials

Table H-8 Difference of Means Tests [a]

Additive Model with Factor Scores (Operator Subteam)

		Sum of Squares	df	Mean Square	F	Sig.
Level Gap A	Between Groups	15.422	1	15.422	1.648	.228
	Within Groups	93.586	10	9.359		
	Total	109.007	11			
Level Gap B	Between Groups	2.620	1	2.620	1.643	.229
	Within Groups	15.947	10	1.595		
	Total	18.566	11			
Level Gap C	Between Groups	.015	1	.015	.119	.748
	Within Groups	.506	4	.127		
	Total	.521	5			
Level Gap D	Between Groups	3.871	1	3.871	.570	.468
	Within Groups	67.922	10	6.792		
	Total	71.793	11			
Style Gap A	Between Groups	1.720	1	1.720	.507	.493
	Within Groups	33.932	10	3.393		
	Total	35.652	11			
Style Gap B	Between Groups	.097	1	.097	.141	.715
	Within Groups	6.839	10	.684		
	Total	6.936	11			
Style Gap C	Between Groups	.018	1	.018	.054	.828
	Within Groups	1.352	4	.338		
	Total	1.370	5			
Style Gap D	Between Groups	9.176	1	9.176	.674	.431
	Within Groups	136.046	10	13.605		
	Total	145.222	11			

[a] Tests conducted for Successful trials

Table H-9 Difference of Means Tests [a]

Additive Model with Factor Scores (Planner Subteam)

		Sum of Squares	df	Mean Square	F	Sig.
Level Gap A+B	Between Groups	23.843	1	23.843	1.211	.297
	Within Groups	196.822	10	19.682		
	Total	220.665	11			
Style Gap A+B	Between Groups	6.653	1	6.653	.983	.345
	Within Groups	67.650	10	6.765		
	Total	74.303	11			

[a] Tests conducted for Successful trials

Table H-10 Difference of Means Tests [a]

Additive Model with Factor Scores (Operator Subteam)

		Sum of Squares	df	Mean Square	F	Sig.
Level Gap A+B	Between Groups	30.699	1	30.699	1.656	.227
	Within Groups	185.384	10	18.538		
	Total	216.083	11			
Style Gap A+B	Between Groups	2.632	1	2.632	.376	.553
	Within Groups	69.999	10	7.000		
	Total	72.631	11			

[a] Tests conducted for Successful trials

Table H-11 Difference of Means Tests [a]

Additive Model with Factor Scores (Planner Subteam)

		Sum of Squares	df	Mean Square	F	Sig.
Level Gap A+B+D	Between Groups	29.781	1	29.781	.746	.408
	Within Groups	399.352	10	39.935		
	Total	429.133	11			
Style Gap A+B+D	Between Groups	6.981	1	6.981	.167	.691
	Within Groups	417.573	10	41.757		
	Total	424.554	11			

[a] Tests conducted for Successful trials

Table H-12 Difference of Means Tests [a]

Additive Model with Factor Scores (Operator Subteam)

		Sum of Squares	df	Mean Square	F	Sig.
Level Gap A+B+D	Between Groups	56.393	1	56.393	2.127	.175
	Within Groups	265.116	10	26.512		
	Total	321.509	11			
Style Gap A+B+D	Between Groups	21.669	1	21.669	1.397	.265
	Within Groups	155.100	10	15.510		
	Total	176.769	11			

[a] Tests conducted for Successful trials

Table H-13 Difference of Means Tests [a]

Additive Model with Factor Scores

		Sum of Squares	df	Mean Square	F	Sig.
Total Team Gap A+B+C+D	Between Groups	412.137	1	412.137	2.261	.164
	Within Groups	1822.919	10	182.292		
	Total	2235.056	11			

[a] Tests conducted for Successful trials

Table H-14 Difference of Means Tests [a]

Additive Model with Raw Scores (Planner Subteam)

		Sum of Squares	df	Mean Square	F	Sig.
Level Gap A	Between Groups	14309.172	1	14309.172	1.982	.190
	Within Groups	72203.017	10	7220.302		
	Total	86512.189	11			
Level Gap B	Between Groups	1748.892	1	1748.892	1.257	.288
	Within Groups	13908.358	10	1390.836		
	Total	15657.250	11			
Level Gap C	Between Groups	119.122	1	119.122	.339	.592
	Within Groups	1404.479	4	351.120		
	Total	1523.602	5			
Level Gap D	Between Groups	138.305	1	138.305	.018	.896
	Within Groups	77277.873	10	7727.787		
	Total	77416.178	11			
Style Gap A	Between Groups	795.438	1	795.438	1.104	.318
	Within Groups	7202.229	10	720.223		
	Total	7997.667	11			
Style Gap B	Between Groups	75.579	1	75.579	.681	.428
	Within Groups	1109.224	10	110.922		
	Total	1184.803	11			
Style Gap C	Between Groups	2.370	1	2.370	.055	.826
	Within Groups	172.316	4	43.079		
	Total	174.686	5			
Style Gap D	Between Groups	.777	1	.777	.000	.991
	Within Groups	52660.202	10	5266.020		
	Total	52660.978	11			

[a] Tests conducted for Successful trials

Table H-15 Difference of Means Tests [a]

Additive Model with Raw Scores (Operator Subteam)

		Sum of Squares	df	Mean Square	F	Sig.
Level Gap A	Between Groups	11924.277	1	11924.277	1.988	.189
	Within Groups	59968.132	10	5996.813		
	Total	71892.409	11			
Level Gap B	Between Groups	2044.992	1	2044.992	2.065	.181
	Within Groups	9901.303	10	990.130		
	Total	11946.295	11			
Level Gap C	Between Groups	3.239	1	3.239	.078	.794
	Within Groups	165.683	4	41.421		
	Total	168.922	5			
Level Gap D	Between Groups	3303.720	1	3303.720	.703	.421
	Within Groups	46975.425	10	4697.543		
	Total	50279.145	11			
Style Gap A	Between Groups	351.086	1	351.086	.507	.493
	Within Groups	6924.914	10	692.491		
	Total	7276.000	11			
Style Gap B	Between Groups	19.861	1	19.861	.142	.714
	Within Groups	1396.102	10	139.610		
	Total	1415.963	11			
Style Gap C	Between Groups	3.760	1	3.760	.055	.827
	Within Groups	275.912	4	68.978		
	Total	279.672	5			
Style Gap D	Between Groups	4562.543	1	4562.543	.578	.465
	Within Groups	78915.975	10	7891.597		
	Total	83478.518	11			

[a] Tests conducted for Successful trials

Table H-16 Difference of Means Tests [a]

Additive Model with Raw Scores (Planner Subteam)

		Sum of Squares	df	Mean Square	F	Sig.
Level Gap A+B	Between Groups	26062.000	1	26062.000	1.763	.214
	Within Groups	147834.859	10	14783.486		
	Total	173896.859	11			
Style Gap A+B	Between Groups	1361.232	1	1361.232	.986	.344
	Within Groups	13812.177	10	1381.218		
	Total	15173.409	11			

[a] Tests conducted for Successful trials

Table H-17 Difference of Means Tests [a]

Additive Model with Raw Scores (Operator Subteam)

		Sum of Squares	df	Mean Square	F	Sig.
Level Gap A+B	Between Groups	23845.864	1	23845.864	2.032	.185
	Within Groups	117379.032	10	11737.903		
	Total	141224.895	11			
Style Gap A+B	Between Groups	537.904	1	537.904	.376	.553
	Within Groups	14287.205	10	1428.721		
	Total	14825.109	11			

[a] Tests conducted for Successful trials

Table H-18 Difference of Means Tests [a]

Additive Model with Raw Scores (Planner Subteam)

		Sum of Squares	df	Mean Square	F	Sig.
Level Gap A+B+D	Between Groups	29997.839	1	29997.839	1.015	.337
	Within Groups	295460.122	10	29546.012		
	Total	325457.960	11			
Style Gap A+B+D	Between Groups	1427.293	1	1427.293	.167	.691
	Within Groups	85252.387	10	8525.239		
	Total	86679.680	11			

[a] Tests conducted for Successful trials

Table H-19 Difference of Means Tests [a]

Additive Model with Raw Scores (Operator Subteam)

		Sum of Squares	df	Mean Square	F	Sig.
Level Gap A+B+D	Between Groups	44901.036	1	44901.036	2.409	.152
	Within Groups	186371.552	10	18637.155		
	Total	231272.589	11			
Style Gap A+B+D	Between Groups	1966.989	1	1966.989	.324	.582
	Within Groups	60679.819	10	6067.982		
	Total	62646.808	11			

[a] Tests conducted for Successful trials

Table H-20 Difference of Means Tests [a]

Additive Model with Raw Scores

		Sum of Squares	df	Mean Square	F	Sig.
Total Team Gap A+B+C+D	Between Groups	139314.880	1	139314.880	1.071	.325
	Within Groups	1300363.306	10	130036.331		
	Total	1439678.185	11			

[a] Tests conducted for Successful trials

Appendix I

Quantitative Reports

Table I-1 Person Success Dependence on Number of Planners

			Number of Planners		Total
			3.00	4.00	
Solve	Fail	Count	19	15	34
		Expected Count	7.3	26.7	34.0
		% within Solve	55.9%	44.1%	100.0%
	Solve	Count	0	54	54
		Expected Count	11.7	42.3	54.0
		% within Solve	.0%	100.0%	100.0%
Total		Count	19	69	88
		Expected Count	19.0	69.0	88.0
		% within Solve	21.6%	78.4%	100.0%

Table I-1A. Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	38.486(b)	1	.000		
Continuity Correction(a)	35.256	1	.000		
Likelihood Ratio	45.154	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	38.049	1	.000		
N of Valid Cases	88				

a) Computed only for a 2x2 table
b) 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.34.

Table I-1B. Directional Measures for Success versus Number of Planners

			Value	Asymp. Std. Error(a)	Approx. T(b)	Approx. Sig.
Nominal by Nominal	Lambda	Symmetric	.434	.140	2.495	.013
		Succeed Dependent	.559	.085	4.923	.000
		NumbPl Dependent	.211	.273	.688	.492
	Goodman and Kruskal tau	Succeed Dependent	.437	.072		.000(c)
		NumbPl Dependent	.437	.085		.000(c)
	Uncertainty Coefficient	Symmetric	.432	.072	5.107	.000(d)
		Succeed Dependent	.385	.076	5.107	.000(d)
		NumbPl Dependent	.492	.065	5.107	.000(d)

a) Not assuming the null hypothesis.
b) Using the asymptotic standard error assuming the null hypothesis.
c) Based on chi-square approximation
d) Likelihood ratio chi-square probability.

Table I-1C. Symmetric Measures Number of Planners

		Value	Approx. Sig.
Nominal by Nominal	Phi	.661	.000
	Cramer's V	.661	.000
	Contingency Coefficient	.552	.000
N of Valid Cases		88	

a) Not assuming the null hypothesis.
b) Using the asymptotic standard error assuming the null hypothesis.

Table I-2. Team Success Dependence on Number of Planners

			Number of Planners		Total
			3.00	4.00	
Solve	Fail	Count	3	2	5
		Expected Count	1.3	3.8	5.0
		% within Solve	60.0%	40.0%	100.0%
	Solve	Count	0	7	7
		Expected Count	1.8	5.3	7.0
		% within Solve	.0%	100.0%	100.0%
Total		Count	3	9	12
		Expected Count	3.0	9.0	12.0
		% within Succeed	25.0%	75.0%	100.0%

Table I-2A. Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5.600(b)	1	.018		
Continuity Correction(a)	2.857	1	.091		
Likelihood Ratio	6.766	1	.009		
Fisher's Exact Test				.045	.045
Linear-by-Linear Association	5.133	1	.023		
N of Valid Cases	12				

a) Computed only for a 2x2 table
b) 3 cells (75.0%) have expected count less than 5. The minimum expected count is 1.25.

Table I-2B. Directional Measures for Success versus Number of Planners

			Value	Asymp. Std. Error(a)	Approx. T(b)	Approx. Sig.
Nominal by Nominal	Lambda	Symmetric	.500	.342	1.124	.261
		Succeed Dependent	.600	.219	2.000	.046
		NumbPl Dependent	.333	.609	.451	.652
	Goodman and Kruskal tau	Succeed Dependent	.467	.200		.023(c)
		NumbPl Dependent	.467	.227		.023(c)
	Uncertainty Coefficient	Symmetric	.454	.193	2.053	.009(d)
		Succeed Dependent	.415	.205	2.053	.009(d)
		NumbPl Dependent	.501	.178	2.053	.009(d)

a) Not assuming the null hypothesis.
b) Using the asymptotic standard error assuming the null hypothesis.
c) Based on chi-square approximation
d) Likelihood ratio chi-square probability.

Table I-2C. Symmetric Measures Number of Planners

		Value	Approx. Sig.
Nominal by Nominal	Phi	.683	.018
	Cramer's V	.683	.018
	Contingency Coefficient	.564	.018
N of Valid Cases		12	

a) Not assuming the null hypothesis.
b) Using the asymptotic standard error assuming the null hypothesis.

Table I-3. Hammerschmidt Findings

Team Category	Subteam Description	KAI Range Mean	KAI Lower Range Mean	KAI Upper Range Mean	Success
1. Subteam KAI Means Range < 15.7 N=17	Relatively Adaptive Planners	90.02 (σ = 7.66)	83.24 (σ = 9.69)	95.59 (σ = 7.49)	82.35% 14/17
	Relatively Innovative Implementer	99.73 (σ = 5.56)	96.77 (σ = 6.28)	102.59 (σ = 6.20)	
2. Subteam KAI Means Range > 15.7 N=16	Relatively Adaptive Planners	84.41 (σ = 5.65)	75.93 (σ = 8.81)	91.44 (σ = 5.70)	87.5% 14/16
	Relatively Innovative Implementer	112.95 (σ = 11.62)	108.38 (σ = 11.40)	118.06 (σ = 12.62)	
3. Subteam KAI Means Range < 15.7 N=22	Relatively Innovative Planners	119.31 (σ = 7.22)	115.00 (σ = 7.25)	124.18 (σ = 8.23)	77.27% 17/22
	Relatively Adaptive Implementers	109.69 (σ = 8.07)	107.36 (σ = 8.08)	111.64 (σ = 7.66)	
4. Subteam KAI Means Range > 15.7 N=14	Relatively Innovative Planners	121.15 (σ = 6.53)	115.36 (σ = 6.83)	127.29 (σ = 9.28)	42.85% 6/14
	Relatively Adaptive Implementers	83.89 (σ = 12.02)	78.43 (σ = 12.48)	88.21 (σ = 11.47)	
5. Random N=50	Unknown	104	N/A	N/A	52% 26/50
6. Total	Mixed	N/A	N/A	N/A	64.7% 77/119

Table I-4. Scott Findings

Team Category	Description	KAI mean	s.d.	Success Proportion Successes/Trials
Experimental KAI Means Range < 15 N=10	Similar Approach	97	7.22	90% 9/10
Experimental KAI Means Range > 15 N=10	Dissimilar Approach	97	20.56	60% 6/10
Control KAI Means Range < 15 N=10	Similar Approach	96	6.57	70% 7/10
Control KAI Means Range > 15 N=10	Dissimilar Approach	96	17.55	40% 4/10
Total N=40	Mixed	104	N/A	65% 26/40

Table I-5. S.E. of Difference Between Two Independent Proportions

Comparison Categories	N_1 N_2	$Solve_1$ $Solve_2$	Not $Solve_1$ Not $Solve_2$	p_w	q_w	$s_{p_1-p_2}=\sqrt{p_w q_w\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}$
H4 v. C3	12 119	7 77	5 42	0.6412	0.3588	0.1453
H1 v. C2	6 33	3 28	3 5	0.7949	0.2051	0.1792
H1 v. C5	5 33	3 28	2 5	0.8158	0.1842	0.1860
H4 v. C6	9 119	7 77	2 42	0.6562	0.3437	0.1641
S1 v. C3	12 40	7 26	5 14	0.6346	0.3654	0.1585

Table I-6. Supplemental Information Descriptive Statistics

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
Age	Fail	34	39.5000	11.56864	1.98400	35.4635	43.5365
	Solve	54	41.3148	11.26495	1.53297	38.2401	44.3896
	Total	88	40.6136	11.35167	1.21009	38.2084	43.0188
Education	Fail	34	15.3235	2.54321	.43616	14.4362	16.2109
	Solve	54	15.5741	1.46148	.19888	15.1752	15.9730
	Total	88	15.4773	1.94154	.20697	15.0659	15.8886
Tenure	Fail	34	5.6588	5.29901	.90877	3.8099	7.5077
	Solve	54	7.1250	7.01074	.95404	5.2114	9.0386
	Total	88	6.5585	6.41160	.68348	5.2000	7.9170
Other Experience	Fail	34	9.3529	9.17633	1.57373	6.1512	12.5547
	Solve	54	8.9889	9.28144	1.26304	6.4555	11.5222
	Total	88	9.1295	9.18971	.97963	7.1824	11.0767

Table I-7. Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Age	.115	1	86	.736
Education	13.573	1	86	.000
Tenure	3.450	1	86	.067
Other Experience	.026	1	86	.872

Table I-7A. Robust Tests of Equality of Means

		Statistic [a]	df1	df2	Sig.
Education	Welch	.273	1	46.888	.604
	Brown-Forsythe	.273	1	46.888	.604
Tenure	Welch	1.238	1	83.029	.269
	Brown-Forsythe	1.238	1	83.029	.269

[a] Asymptotically F distributed

Table I-8. Successful Trials Difference of Means Tests [a]

		Sum of Squares	df	Mean Square	F	Sig.
Age	Between Groups	68.715	1	68.715	.530	.468
	Within Groups	11142.148	86	129.560		
	Total	11210.864	87			
Education	Between Groups	1.310	1	1.310	.345	.559
	Within Groups	326.645	86	3.798		
	Total	327.955	87			
Tenure	Between Groups	44.850	1	44.850	1.092	.299
	Within Groups	3531.601	86	41.065		
	Total	3576.451	87			
Other Experience	Between Groups	2.765	1	2.765	.032	.858
	Within Groups	7344.458	86	85.401		
	Total	7347.223	87			

[a] AVOVA with Solve=1, Fail=0

Table I-9. Constructed Variables Descriptive Statistics

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
Average Education Planners	Fail	5	16.2500	2.42670	1.08525	13.2368	19.2632
	Solve	7	15.0714	.79993	.30234	14.3316	15.8112
	Total	12	15.5625	1.69078	.48809	14.4882	16.6368
Cumulative Education Planners	Fail	5	55.6000	13.68576	6.12046	38.6069	72.5931
	Solve	7	60.2857	3.19970	1.20937	57.3265	63.2449
	Total	12	58.3333	8.91713	2.57415	52.6677	63.9990

Table I-10. Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Average Education Planners	3.083	1	10	.110
Cumulative Education Planners	8.672	1	10	.015

Table I-10A. Robust Tests of Equality of Means

		Statistic [a]	df1	df2	Sig.
Cumulative Education Planners	Welch	.564	1	4.314	.492
	Brown-Forsythe	.564	1	4.314	.492

[a] Asymptotically F distributed

Table I-11. Successful Trials' Difference of Means Tests [a]

		Sum of Squares	df	Mean Square	F	Sig.
Average Education Planners	Between Groups	4.051	1	4.051	1.479	.252
	Within Groups	27.395	10	2.739		
	Total	31.446	11			

[a] AVOVA with Solve=1, Fail=0

Table I-12. Constructed Variables Descriptive Statistics

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
Average Education Teams	Fail	34	15.3324	1.95180	.33473	14.6513	16.0134
	Solve	54	15.5852	.82403	.11214	15.3603	15.8101
	Total	88	15.4875	1.36893	.14593	15.1975	15.7775
Average Education Planners	Fail	17	15.6588	1.90593	.46226	14.6789	16.6388
	Solve	28	15.0857	.74322	.14046	14.7975	15.3739
	Total	45	15.3022	1.31866	.19657	14.9061	15.6984
Cumulative Education Planners	Fail	17	57.1176	12.63370	3.06412	50.6220	63.6133
	Solve	28	60.2857	3.01671	.57010	59.1160	61.4555
	Total	45	59.0889	8.12634	1.21140	56.6475	61.5303

Table I-13. Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Average Education Teams	33.120	1	86	.000
Average Education Planners	16.740	1	43	.000
Cumulative Education Planners	45.900	1	43	.000

Table I-13A. Robust Tests of Equality of Means

		Statistic [a]	df1	df2	Sig.
Average Education Teams	Welch	.513	1	40.505	.478
	Brown-Forsythe	.513	1	40.505	.478
Average Education Planners	Welch	1.407	1	18.995	.250
	Brown-Forsythe	1.407	1	18.995	.250
Cumulative Education Planners	Welch	1.033	1	17.115	.324
	Brown-Forsythe	1.033	1	17.115	.324

[a] Asymptotically F distributed

Table I-14. Successful Trials' Difference of Means Tests [a]

		Sum of Squares	df	Mean Square	F	Sig.
Average Education Teams	Between Groups	1.334	1	1.334	.709	.402
	Within Groups	161.703	86	1.880		
	Total	163.036	87			
Average Education Planners	Between Groups	3.474	1	3.474	2.046	.160
	Within Groups	73.035	43	1.698		
	Total	76.510	44			
Cumulative Education Planners	Between Groups	106.165	1	106.165	1.631	.208
	Within Groups	2799.479	43	65.104		
	Total	2905.644	44			

[a] AVOVA with Solve=1 and Fail=0

Table I-15. Interaction Variables Descriptive Statistics

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
Tenure X Education	Fail	34	85.8529	80.26650	13.76559	57.8466	113.8592
	Solve	54	112.4185	115.27198	15.68653	80.9553	143.8817
	Total	88	102.1545	103.47846	11.03084	80.2296	124.0795
Tenure X Average Education	Fail	34	86.5126	79.49951	13.63405	58.7740	114.2513
	Solve	54	111.1639	109.07785	14.84361	81.3914	140.9364
	Total	88	101.6395	98.95064	10.54817	80.6739	122.6052
Tenure X Cumulative Education	Fail	34	312.9794	301.32934	51.67756	207.8406	418.1182
	Solve	54	439.7037	434.48321	59.12568	321.1126	558.2948
	Total	88	390.7420	391.52721	41.73694	307.7854	473.6987
Total Experience	Fail	34	15.0118	10.65417	1.82718	11.2943	18.7292
	Solve	54	16.1139	11.57887	1.57568	12.9535	19.2743
	Total	88	15.6881	11.18134	1.19193	13.3190	18.0572
Education X Total Experience	Fail	34	684.5912	641.48594	110.01393	460.7662	908.4162
	Solve	54	769.6898	688.59751	93.70625	581.7389	957.6408
	Total	88	736.8108	668.34462	71.24578	595.2021	878.4195

Table I-16. Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Tenure X Education	3.859	1	86	.053
Tenure X Average Education	4.331	1	86	.040
Tenure X Cumulative Education	5.166	1	86	.026
Total Experience	.406	1	86	.526
Education X Total Experience	.437	1	86	.510

Table I-16A. Robust Tests of Equality of Means

		Statistic [a]	df1	df2	Sig.
Tenure X Education	Welch	1.620	1	85.052	.207
	Brown-Forsythe	1.620	1	85.052	.207
Tenure X Average Education	Welch	1.496	1	84.060	.225
	Brown-Forsythe	1.496	1	84.060	.225
Tenure X Cumulative Education	Welch	2.604	1	85.123	.110
	Brown-Forsythe	2.604	1	85.123	.110

[a] Asymptotically F distributed

Table I-17. Successful Trials Difference of Means Tests [a]

		Sum of Squares	df	Mean Square	F	Sig.
Tenure X Education	Between Groups	14724.092	1	14724.092	1.381	.243
	Within Groups	916853.786	86	10661.091		
	Total	931577.878	87			
Tenure X Average Education	Between Groups	12678.492	1	12678.492	1.299	.257
	Within Groups	839158.423	86	9757.656		
	Total	851836.916	87			
Tenure X Cumulative Education	Between Groups	335050.100	1	335050.100	2.216	.140
	Within Groups	13001489.235	86	151180.107		
	Total	13336539.334	87			
Total Experience	Between Groups	25.343	1	25.343	.201	.655
	Within Groups	10851.597	86	126.181		
	Total	10876.940	87			
Education X Total Experience	Between Groups	151089.828	1	151089.828	.336	.564
	Within Groups	38710464.674	86	450121.682		
	Total	38861554.502	87			

[a] AVOVA with Solve=1 and Fail=0

Table I-18. KAI Scores Descriptive Statistics

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound
KAI	Fail	34	93.6765	13.69300	2.34833	88.8988	98.4542
	Solve	54	94.9074	14.75878	2.00841	90.8790	98.9358
	Total	88	94.4318	14.28913	1.52323	91.4042	97.4594
SO	Fail	34	43.7059	7.91443	1.35731	40.9444	46.4674
	Solve	54	43.4444	6.91093	.94046	41.5581	45.3308
	Total	88	43.5455	7.27128	.77512	42.0048	45.0861
E	Fail	34	16.6471	4.70256	.80648	15.0063	18.2879
	Solve	54	16.8148	4.08437	.55581	15.7000	17.9296
	Total	88	16.7500	4.30784	.45922	15.8373	17.6627
R	Fail	34	33.3235	6.60909	1.13345	31.0175	35.6295
	Solve	54	34.6481	7.59632	1.03373	32.5748	36.7215
	Total	88	34.1364	7.22095	.76976	32.6064	35.6663

Table I-19. Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
KAI	.000	1	86	.993
SO	1.207	1	86	.275
E	.556	1	86	.458
R	.998	1	86	.320

Table I-20. Successful Trials' Difference of Means Tests [a]

		Sum of Squares	df	Mean Square	F	Sig.
KAI	Between Groups	31.613	1	31.613	.153	.696
	Within Groups	17731.978	86	206.186		
	Total	17763.591	87			
SO	Between Groups	1.426	1	1.426	.027	.871
	Within Groups	4598.392	86	53.470		
	Total	4599.818	87			
E	Between Groups	.587	1	.587	.031	.860
	Within Groups	1613.913	86	18.766		
	Total	1614.500	87			
R	Between Groups	36.608	1	36.608	.700	.405
	Within Groups	4499.756	86	52.323		
	Total	4536.364	87			

[a] AVOVA with Solve=1 and Fail=0

Table I-21. Individual Success Dependence on Map Preference

			Map		Total
			Write	Map	
Solve	Fail	Count	11	23	34
		Expected Count	10.0	24.0	34.0
		% within Solve	32.4%	67.6%	100.0%
	Solve	Count	15	39	54
		Expected Count	16.0	38.0	54.0
		% within Solve	27.8%	72.2%	100.0%
Total		Count	26	62	88
		Expected Count	26.0	62.0	88.0
		% within Succeed	29.5%	70.5%	100.0%

Table I-21A. Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.210(b)	1	.647		
Continuity Correction(a)	.048	1	.827		
Likelihood Ratio	.209	1	.648		
Fisher's Exact Test				.811	.411
Linear-by-Linear Association	.207	1	.649		
N of Valid Cases	88				

a Computed only for a 2x2 table
b 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.05.

Table I-21B. Directional Measures for Success Depending on Map Preference

			Value	Asymp. Std. Error(a)	Approx. T(b)	Approx. Sig.
Ordinal by Ordinal	Somers' d	Symmetric	.049	.107	.454	.650
		Solve Dependent	.052	.115	.454	.650
		Map Dependent	.046	.101	.454	.650

a Not assuming the null hypothesis.
b Using the asymptotic standard error assuming the null hypothesis.

Table I-22. Individual Success Dependence on Gender

			Gender		Total
			Female	Male	
Solve	Fail	Count	12	22	34
		Expected Count	11.2	22.8	34.0
		% within Solve	35.3%	64.7%	100.0%
	Solve	Count	17	37	54
		Expected Count	17.8	36.2	54.0
		% within Solve	31.5%	68.5%	100.0%
Total		Count	29	59	88
		Expected Count	29.0	59.0	88.0
		% within Succeed	33.0%	67.0%	100.0%

Table I-22A. Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.137(b)	1	.711		
Continuity Correction(a)	.019	1	.891		
Likelihood Ratio	.137	1	.712		
Fisher's Exact Test				.817	.443
Linear-by-Linear Association	.136	1	.713		
N of Valid Cases	88				

a Computed only for a 2x2 table
b 0 cells (.0%) have expected count less than 5. The minimum expected count is 11.20.

Table I-22B. Directional Measures for Success Depending on Gender

			Value	Asymp. Std. Error(a)	Approx. T(b)	Approx. Sig.
Ordinal by Ordinal	Somers' d	Symmetric	.039	.107	.368	.713
		Solve Dependent	.041	.111	.368	.713
		Gender Dependent	.038	.103	.368	.713

a Not assuming the null hypothesis.
b Using the asymptotic standard error assuming the null hypothesis.

Table I-23. Map Preference Dependence on Gender

			Map		Total
			Write	Map	
Gender	Female	Count	16	13	29
		Expected Count	8.6	20.4	29.0
		% within Solve	55.2%	44.8%	100.0%
	Male	Count	10	49	59
		Expected Count	17.4	41.6	59.0
		% within Solve	16.9%	83.1%	100.0%
Total		Count	26	62	88
		Expected Count	26.0	62.0	88.0
		% within Succeed	29.5%	70.5%	100.0%

Table I-23A. Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	13.647(b)	1	.000		
Continuity Correction(a)	11.872	1	.001		
Likelihood Ratio	13.235	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	13.491	1	.000		
N of Valid Cases	88				

a Computed only for a 2x2 table
b 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.57.

Table I-23B. Directional Measures for Map Preference Dependence on Gender

			Value	Asymp. Std. Error(a)	Approx. T(b)	Approx. Sig.
Ordinal by Ordinal	Somers' d	Symmetric	.394	.105	3.521	.000
		Map Dependent	.406	.109	3.521	.000
		Gender Dependent	.382	.104	3.521	.000

a Not assuming the null hypothesis.
b Using the asymptotic standard error assuming the null hypothesis.

Table I-24. Block 0-Classification Table (c,d)

Observed		Predicted					
		Selected Cases(a)			Unselected Cases(b)		
		Solve		Percentage Correct	Solve		Percentage Correct
		Fail	Solve		Fail	Solve	
Solve	Fail	0	15	.0	0	19	.0
	Solve	0	54	100.0	0	0	.
Overall Percentage				78.3			.0

a Selected cases NoPlan EQ 4
b Unselected cases NoPlan NE 4
c Constant is included in the model.
d The cut value is .500

Table I-24A. Block 0-Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	1.281	.292	19.261	1	.000	3.600

Table I-24B. Block 0-Variables not in the Equation

			Score	df	Sig.
Step 0	Variables	Aveed	20.850	1	.000
		Tenure	.671	1	.413
		Othexp	3.254	1	.071
	Overall Statistics		23.086	3	.000

Table I-24C. Block 1-Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	27.680	3	.000
	Block	27.680	3	.000
	Model	27.680	3	.000

Table I-24D. Block 1-Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	44.575(a)	.330	.509

a Estimation terminated at iteration number 6 because parameter estimates changed by less than .001.

Table I-24E. Block 1 Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	2.724	8	.950

Table I-24F. Block 1-Contingency Table for Hosmer and Lemeshow Test

		Solve = Fail		Solve = Solve		Total
		Observed	Expected	Observed	Expected	
Step 1	1	6	5.768	1	1.232	7
	2	4	3.948	3	3.052	7
	3	1	2.049	6	4.951	7
	4	1	1.281	6	5.719	7
	5	1	.734	6	6.266	7
	6	1	.531	6	6.469	7
	7	1	.396	6	6.604	7
	8	0	.174	7	6.826	7
	9	0	.105	7	6.895	7
	10	0	.014	6	5.986	6

Table I-24G. Block 1-Classification Table (c)

Observed		Predicted					
		Selected Cases(a)			Unselected Cases(b)		
		Solve		Percentage Correct	Solve		Percentage Correct
		Fail	Solve		Fail	Solve	
Solve	Fail	9	6	60.0	0	19	.0
	Solve	3	51	94.4	0	0	.
Overall Percentage				87.0			.0

a Selected cases NoPlan EQ 4
b Unselected cases NoPlan NE 4
c The cut value is .500

Table I-24H. Binary Logistic Regression Model [a]

	B	S.E.	Wald	df	Sig.	Exp(B)	95.0% C.I.for EXP(B)	
							Lower	Upper
Aveed	-1.936	.528	13.472	1	.000	.144	.051	.406
Tenure	.004	.065	.004	1	.947	1.004	.884	1.141
Othexp	-.074	.041	3.283	1	.070	.929	.857	1.006
Constant	33.614	8.963	14.064	1	.000			

[a] Dependent Variable, Succeed=1, Fail=0

Table I-25. Joint Frequency Distribution for Q1 X Solve

Rate how you felt about performing your task role for this problem

			Q1Role a	Q1Role b	Q1Role c	Q1Role d	Total
Solve	Fail	Count	6	16	11	1	34
		Expected Count	2.3	7.0	13.1	11.6	34.0
		% within Solve	17.6%	47.1%	32.4%	2.9%	100.0%
	Solve	Count	0	2	23	29	54
		Expected Count	3.7	11.0	20.9	18.4	54.0
		% within Solve	.0%	3.7%	42.6%	53.7%	100.0%
Total		Count	6	18	34	30	88
		Expected Count	6.0	18.0	34.0	30.0	88.0
		% within Solve	6.8%	20.5%	38.6%	34.1%	100.0%

a) Very frustrated; b) Slightly frustrated; c) Comfortable; d) Very comfortable

Table I-25A. Chi-Square Tests for Q1

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	45.038(a)	3	.000
Likelihood Ratio	53.276	3	.000
Linear-by-Linear Association	42.221	1	.000
N of Valid Cases	88		

(a) 2 cells (25.0%) have expected count less than 5. The minimum expected count is 2.32.

Table I-25B. Directional Measures for Q1

			Value	Asymp. Std. Error(a)	Approx. T(b)	Approx. Sig.
Ordinal by Ordinal	Somers' d	Symmetric	.635	.049	10.496	.000
		Q1Role Dependent	.778	.063	10.496	.000
		Solve Dependent	.536	.042	10.496	.000

a) Not assuming the null hypothesis.
b) Using the asymptotic standard error assuming the null hypothesis.

Table I-26. Joint Frequency Distribution for Q2 X Solve

Rate how well your subteam communicated about the problem

			Q2Comm a	Q2Comm b	Q2Comm c	Q2Comm d	Total
Solve	Fail	Count	1	4	25	4	34
		Expected Count	.4	1.5	14.7	17.4	34.0
		% within Solve	2.9%	11.8%	73.5%	11.8%	100.0%
	Solve	Count	0	0	13	41	54
		Expected Count	.6	2.5	23.3	27.6	54.0
		% within Solve	.0%	.0%	24.1%	75.9%	100.0%
Total		Count	1	4	38	45	88
		Expected Count	1.0	4.0	38.0	45.0	88.0
		% within Solve	1.1%	4.5%	43.2%	51.1%	100.0%

a) Bad; b) Poor; c) Good; d) Excellent

Table I-26A. Chi-Square Tests Q2

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	36.554(a)	3	.000
Likelihood Ratio	41.588	3	.000
Linear-by-Linear Association	34.013	1	.000
N of Valid Cases	88		

(a) 4 cells (50.0%) have expected count less than 5. The minimum expected count is .39.

Table I-26B. Directional Measures for Q2

			Value	Asymp. Std. Error(a)	Approx. T(b)	Approx. Sig.
Ordinal by Ordinal	Somers' d	Symmetric	.627	.071	8.029	.000
		Solve Dependent	.584	.068	8.029	.000
		Q2Comm Dependent	.677	.077	8.029	.000

a) Not assuming the null hypothesis.
b) Using the asymptotic standard error assuming the null hypothesis.

Table I-27. Joint Frequency Distribution for Q3 X Solve

Rate how well your sister subteam communicated with your subteam

			Q3SisCom				Total
			a	b	c	d	
Solve	Fail	Count	13	14	7	0	34
		Expected Count	5.0	7.7	11.6	9.7	34.0
		% within Solve	38.2%	41.2%	20.6%	.0%	100.0%
	Solve	Count	0	6	23	25	54
		Expected Count	8.0	12.3	18.4	15.3	54.0
		% within Solve	.0%	11.1%	42.6%	46.3%	100.0%
Total		Count	13	20	30	25	88
		Expected Count	13.0	20.0	30.0	25.0	88.0
		% within Solve	14.8%	22.7%	34.1%	28.4%	100.0%

a) Bad; b) Poor; c) Good; d) Excellent

Table I-27A. Chi-Square Tests Q3

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	47.649(a)	3	.000
Likelihood Ratio	60.378	3	.000
Linear-by-Linear Association	46.090	1	.000
N of Valid Cases	88		

(a) 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.02.

Table I-27B. Directional Measures for Q3

			Value	Asymp. Std. Error(a)	Approx. T(b)	Approx. Sig.
Ordinal by Ordinal	Somers' d	Symmetric	.647	.042	12.166	.000
		Solve Dependent	.533	.038	12.166	.000
		Q3SisCom Dependent	.821	.054	12.166	.000

a) Not assuming the null hypothesis.
b) Using the asymptotic standard error assuming the null hypothesis.

Table I-28. Joint Frequency Distribution for Q4 X Solve

Rate the amount of time provided for this problem

			Q4Time				Total
			a	b	c	d	
Solve	Fail	Count	4	7	21	2	34
		Expected Count	1.5	4.3	21.3	7.0	34.0
		% within Solve	11.8%	20.6%	61.8%	5.9%	100.0%
	Solve	Count	0	4	34	16	54
		Expected Count	2.5	6.8	33.8	11.0	54.0
		% within Solve	.0%	7.4%	63.0%	29.6%	100.0%
Total		Count	4	11	55	18	88
		Expected Count	4.0	11.0	55.0	18.0	88.0
		% within Solve	4.5%	12.5%	62.5%	20.5%	100.0%

a) Way too little; b) Slightly too little; c) About right; d) Way too much

Table I-28A. Chi-Square Tests Q4

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	15.010(a)	3	.002
Likelihood Ratio	17.286	3	.001
Linear-by-Linear Association	14.747	1	.000
N of Valid Cases	88		

(a) 3 cells (37.5%) have expected count less than 5. The minimum expected count is 1.55.

Table I-28B. Directional Measures for Q4

			Value	Asymp. Std. Error(a)	Approx. T(b)	Approx. Sig.
Ordinal by Ordinal	Somers' d	Symmetric	.374	.080	4.239	.000
		Solve Dependent	.349	.072	4.239	.000
		Q4Time Dependent	.404	.093	4.239	.000

a) Not assuming the null hypothesis.
b) Using the asymptotic standard error assuming the null hypothesis.

Table I-29. Joint Frequency Distribution for Q5 X Solve

Rate your subteams performance on solving this problem

			Q5Team a	Q5Team b	Q5Team c	Q5Team d	Total
Solve	Fail	Count	2	2	17	13	34
		Expected Count	.8	.8	7.3	25.1	34.0
		% within Solve	5.9%	5.9%	50.0%	38.2%	100.0%
	Solve	Count	0	0	2	52	54
		Expected Count	1.2	1.2	11.7	39.9	54.0
		% within Solve	.0%	.0%	3.7%	96.3%	100.0%
Total		Count	2	2	19	65	88
		Expected Count	2.0	2.0	19.0	65.0	88.0
		% within Solve	2.3%	2.3%	21.6%	73.9%	100.0%

a) No help at all; b) Not very helpful; c) Helped a little; d) Great help

Table I-29A. Chi-Square Tests Q5

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	36.586(a)	3	.000
Likelihood Ratio	39.569	3	.000
Linear-by-Linear Association	29.354	1	.000
N of Valid Cases	88		

(a) 4 cells (50.0%) have expected count less than 5. The minimum expected count is .77.

Table I-29B. Directional Measures for Q5

			Value	Asymp. Std. Error(a)	Approx. T(b)	Approx. Sig.
Ordinal by Ordinal	Somers' d	Symmetric	.630	.074	6.379	.000
		Solve Dependent	.682	.070	6.379	.000
		Q5Team Dependent	.585	.087	6.379	.000

a) Not assuming the null hypothesis.
b) Using the asymptotic standard error assuming the null hypothesis.

Table I-30. Joint Frequency Distribution for Q6 X Solve

Rate your sister subteams performance in solving this problem

			Q6SisHelp				Total
			a	b	c	d	
Solve	Fail	Count	12	8	13	1	34
		Expected Count	5.0	3.9	10.0	15.1	34.0
		% within Solve	35.3%	23.5%	38.2%	2.9%	100.0%
	Solve	Count	1	2	13	38	54
		Expected Count	8.0	6.1	16.0	23.9	54.0
		% within Solve	1.9%	3.7%	24.1%	70.4%	100.0%
Total		Count	13	10	26	39	88
		Expected Count	13.0	10.0	26.0	39.0	88.0
		% within Solve	14.8%	11.4%	29.5%	44.3%	100.0%

a) No help at all; b) Not very helpful; c) Helped a little; d) Great help

Table I-30A. Chi-Square Tests Q6

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	45.832(a)	3	.000
Likelihood Ratio	55.005	3	.000
Linear-by-Linear Association	42.742	1	.000
N of Valid Cases	88		

(a) 1 cell (12.5%) has expected count less than 5. The minimum expected count is 3.86

Table I-30B. Directional Measures for Q6

			Value	Asymp. Std. Error(a)	Approx. T(b)	Approx. Sig.
Ordinal by Ordinal	Somers' d	Symmetric	.659	.052	11.130	.000
		Solve Dependent	.559	.048	11.130	.000
		Q6SisHelp Dependent	.803	.060	11.130	.000

a) Not assuming the null hypothesis.
b) Using the asymptotic standard error assuming the null hypothesis.

Table I-31 Cognitive Gaps [a]

Trial	Solve	Level Aggregate Proxy	Level Gap A+B	Style Gap A+B	Level Gap A+B+D	Style Gap A+B+D	Total Gap A+B+C+D
FM-T1	Operator	-1.99	3.06	6.3	0.41	7.38	17.04
	Planner	-1.51	3.32	0.89	1.3	6.63	
CW-T1	Operator	2.69	0.73	1.17	4.32	6.54	33.84
	Planner	-0.94	11.79	7.7	10.61	10.45	
CW-T2	Operator	1.21	8.61	1.49	10.23	5.75	40.43
	Planner	-0.52	7.22	6.19	6.57	16.38	
WIL-T1	Operator	0.32	11.05	2.94	11.45	10.5	45.47
	Planner	4.15	12.47	2.17	17.66	3.69	
WIL-T2	Operator	-2.98	5.8	4.34	2.07	13.3	28.81
	Planner	2.62	1.53	4.62	5.02	5.14	
CHL-T1	Operator	-1.93	2.53	2.57	-0.04	9.15	16.44
	Planner	-1.95	3.36	3.83	0.76	5.28	
CHL-T2	Operator	-2.54	3.97	3.64	0.79	11.55	20.11
	Planner	-3.95	2.98	7.56	-1.96	7.86	
RAL-T1	Operator	2.91	4.76	1.26	8.64	0.94	41.29
	Planner	1.76	9.5	9.8	11.71	17.8	
RAL-T2	Operator	-0.55	10.99	6.58	10.31	15.01	37.13
	Planner	-2.03	7.09	6.44	4.55	4.9	
RAL-T3	Operator	0.22	15.35	7.56	15.63	7.51	54.89
	Planner	4.14	8.86	7.14	14.03	15.14	
RAL-T4	Operator	0.75	9.74	8.82	10.67	10.52	60.5
	Planner	0.35	13.97	8.4	14.42	22.34	
RAL-T5	Operator	1.14	10.8	3.78	12.22	3.73	45.82
	Planner	-1.35	13.98	5.88	12.29	15.1	
Mean Scores [b]	Operator	-0.09	8.64	4.60	9.07	9.62	41.77
	Planner	0.56	9.19	6.51	9.41	11.54	
Mean Scores [c]	Operator	0.55	5.39	3.65	4.66	6.90	29.88
	Planner	-1.20	6.34	5.00	6.22	9.99	

[a] Unsuccessful trials are highlighted gray
[b] Mean scores for successful trials
[c] Mean scores for unsuccessful trials

Table I-32 Difference of Means Tests [a]

Additive Model with Raw Scores

		Sum of Squares	df	Mean Square	F	Sig.
Aggregated Level Subteam Mean	Between Groups	10469.023	1	10469.023	3.253	.101
	Within Groups	32179.186	10	3217.919		
	Total	42648.209	11			

[a] Tests conducted for Successful trials

Table I-33 Difference of Means Tests [a]

Additive Model with Factor Scores

		Sum of Squares	df	Mean Square	F	Sig.
Aggregated Level X Style	Between Groups	46790340.49	1	46790340.49	2.003	.187
	Within Groups	233567327.43	10	23356732.74		
	Total	280357667.92	11			

[a] Tests conducted for Successful trials

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