5-1-1997

Computerized Brainstorming and Decision Making

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COMPUTERIZED BRAINSTORMING AND DECISION MAKING

A Thesis

Presented to the

Department of Psychology

and the

Faculty of the Graduate College

University of Nebraska

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

University of Nebraska at Omaha

by

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May 1997

THESIS ACCEPTANCE

Acceptance for the faculty of the Graduate College, University of Nebraska, in partial fulfillment of the requirements of the degree of Master's of Arts in Industrial/Organizational Psychology, University of Nebraska.

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Date June 30, 1997

ACKNOWLEDGMENTS

I would like to thank Dr. Roni Reiter-Palmon for your expertise, encouragement and guidance. This research is a reflection of your care and attention to detail and willingness to see me through the tough times. You shared your experience and demonstrated your patience as we wandered this pathway together.

Thank you also to Dr. Philip Craiger, Dr. Lisa Scherer, Dr. Ray Millimet and Dr. Bill Clute. Each of you made major contributions in shaping this piece of research. I appreciate the time and effort you gave so willingly. In addition to my committee, a major contribution was made by Tony Susa and Jody Illies. As quality raters, your job was arduous but was carried out with diligence and a smile. Thank you.

To Joan Bell, a special thanks for creating the computer environment used in this research. Joan, your computer networking expertise was a lifesaver. Thank you for your time and patience. I would also like to thank Ventana Corporation for donating the GroupSystem software used in this study. Your technical support saved the day more than once!

To Travis, Evan and Jim, though our lives have changed, you have never wavered in your support and encouragement as I've reached for my stars. I thank you with my love.

And to Libby who walked each step with me, encouraging me to trust myself, giving me courage and hope and laughing me through each day, I thank you with my love. You are a golden thread in the tapestry of my life.

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Abstract

Computers are widely used in business and industry today and are frequency considered essential to efficient job performance. A great deal of research has been generated over the past decade regarding computer use in the workplace. However, research has lagged regarding computer technology and group performance.

The purpose of this study is to determine empirically if there are enhancements in the performance of groups and individuals when they use a computer to facilitate the problem solving process. It is hypothesized that the quality of solutions generated to a complex problem will be a function of the interaction between use of computer and whether participants work independently or in groups. In addition, number of new factors generated and time taken for completion of the problem solving task will also be a function of this same interaction.

One hundred and sixty-one participants were randomly assigned to one of four treatment conditions: group computer, group non-computer, individual computer and individual non-computer. All participants were asked to generate factors which might contribute to a final solution of the complex problem and to generate an initial and final solution to the problem. The group computer condition utilized GroupSystems (GS) software to network computers for group interaction and to facilitate individual work on the computer. The other two treatment conditions (group non-computer and individual non-computer) employed paper and pencil. The problem solutions

were rated for appropriateness, originality and resolving power. In addition, number of new factors generated were counted and time taken for task completion was recorded.

Overall, this study had several major findings. A marginally significant difference was noted in the gain in quality of solution as measured by appropriateness from the pre-group to the post-group condition for those people working in groups. An “anticipation effect” appears to have been at work in the group conditions which contributed to a depression of the quality of the original solutions. Contrary to previous research on the group dynamics of production blocking, free riding and evaluation apprehension, the non-computer group generated significantly more new factors than did the other conditions. In addition, groups took significantly more time for task completion than did those individuals working alone. The computer group stayed engaged for a significantly greater time than did other conditions. This group also report greater satisfaction with the problem solving process.

This study indicates that problems can be addressed and solved effectively via computer interaction. Such access to the dialogue of problem solving allows for individual time management as well as group interaction.

Generation X is moving full steam ahead into the American workplace as the Baby Boom Generation eases into retirement. Although this generation of workers has grown up in the computer age, we are still at the beginning of our understanding of the dynamics that electronic technologies bring to our work environment. Computers are currently so widely used in business and industry that they are considered to be essential to efficient job performance at all levels of organizational life. As computer hardware and software advances continue at lightning speed with design updates occurring every six months, research into the impact of these technologies on individual and group performance has lagged behind (McGrath & Hollingshead, 1994). Although there has been a wealth of literature over the past decade about computers in the workplace, very little research has been conducted from the group perspective.

The purpose of this study is to determine empirically if there are enhancements in the performance of groups and individuals when they use a computer to facilitate the problem solving process. To gain a stronger understanding of this relationship, a review of past research that looks at group performance, group versus individual performance, and the empirical studies dealing with group performance and the use of computers will be reviewed.

This review will focus on the body of research that uses a decision making or problem solving task approach. The productivity or performance of a group frequently is dependent on a groups quick and efficient solution to problems of various complexity. By improving a group's ability to solve a problem, or to make the best decision, it should be possible to improve the group's productivity as well (Moreland & Levine, 1992). The review will begin with group performance theory as the foundation on which the current technology performance research is based.

Group versus Individual Performance

Compelling evidence that groups were better at problem solving and decision making than individuals working on their own resulted from numerous groups versus individuals experiments during the first half of the 20th century (Davis, 1992). This is exemplified by Shaw's (1932) experiment comparing group versus individual performance on a complex problem solving task. These results suggested a proportional group performance superiority over individual performance. The efficiency (or inefficiency) of the group process was not evaluated at that time, and for better than twenty years, the belief in the efficacy of the group process was supported.

Lorge and Solomon (1955) reanalyzed the Shaw (1932) data and found group inefficiencies based on probabilities of problem solvers being members of groups. This became known as the Lorge-Solomon pooling model. Lorge and Solomon (1955) hypothesized that the superiority of group performance found by Shaw (1932) was a function of the ability of one or more of its members to solve the problem presented without taking into account the interpersonal rejection and acceptance of suggestions among its members. This implies that group enhancement is due to the abilities of the individual members rather than the contribution of personal interaction. Davis (1992) argues that freely interacting groups usually fall below the Lorge-Solomon baseline, occasionally match it and seldom exceed it. It should be kept in mind that this inefficiency is an expression of low group return relative to individual investment and not a function of comparison of solutions generated or speed of solution generated. A direct comparison based on these factors typically shows groups producing more solutions in a shorter time period than individuals (Davis, 1992).

The "assembly bonus effect" (Tindale & Larson, 1992a, 1992b) makes the assumption that a group's combined knowledge decisions will be of higher quality than any decision made by an individual in the group (Collins & Guetzkow, 1964). The implication of this is that the shared knowledge in the group will combine synergistically to produce the higher quality product. Nemeroff and King (1975) observed this effect with trained participants under consensus decision conditions. Michaelson, Watson and Black (1989) also studied the assembly bonus effect. Using trained participants, they found support for group superiority over the group's most knowledgeable member on low complexity decision-making tasks. These tasks were predominantly taken from course tests requiring recall, application and some synthesis. These findings were replicated in a second study (Watson, Michaelson, & Sharp, 1991).

Michaelson et al.'s (1989, 1992) interpretation of their findings have been challenged by Tindale and Larson (1992). They endeavored to replicate the Michaelson et al. study using a computer simulation. Their findings were typical of past research results with ad hoc laboratory groups; there were no assembly bonus effects. This was contrary to the results Michaelson et al. produced with the same data. They argued that the difference in interpretation of the data stems from the inferences of Michaelson et al. which were drawn from total test scores whereas the processes operate at the single item level. Tindale and Larson believe that when the phenomenon of interest, in this case the assembly bonus effect, operates on the level of the single item or disaggregate elements, it is inappropriate to aggregate the items for analysis. This process produces results that are not consistent with the underlying theoretical construct of assembly bonus effect which requires that the group's performance is not attributable to a combination of the individual efforts (Collins & Guetzkow, 1964).

Numerous situational factors have also been found to influence subjects performance within a group. For example, Kameda and Davis (1990) found a move toward a more conservative decision choice for members performing within a group. Group decision choice was compared to individual decision choice. All participants were exposed to the influence of differing levels of gains and losses. They found that individuals tended to make riskier choices under recent loss conditions. However, this decision making tendency did not transfer to the three member group decision situation in which conservative decisions tended to overrule risky choice.

In a summary of the research on the communication aspects of decision making in groups, Hirokawa and Johnston (1989) found three ways that group decision making is influenced by communication processes: (a)individual variables, such as attitudes, beliefs and values; (b)critical task requirements and functions; and, (c)social reality boundaries within which the decision is shaped. This communication process, along with social variables pertaining to the interpersonal relationships within the group and normative variables constituted by explicit decision rules all act on a global level to influence group decision making.

The nature of the problem to be solved and the process people engage in to arrive at a solution appear to influence the quality of decisions for groups (Hinsz, 1991). Under conditions of explicitly delineated process with a well-defined problem, Davis and Toseland (1987) found no significant difference between individuals (nominal groups) and interactive groups on the quality of the consensus decision. This study employed the use of group process leaders who had been trained in the use of Social Judgment Analysis, but were naive as to the experts' solutions to the problems. This approach can be compared to studies employing ill-defined problems with moderate process structure definition, where creativity is required. Under such conditions, interactive group process has been shown to impede both decision making and creativity (Vroom, Grant & Cotton, 1969). Hill (1982) conducted a meta-analysis on 140 studies on group versus individual decision making. He concluded that under conditions of high problem complexity, the group performance was often inferior to the best individual performance.

These conditions of high problem complexity now prevail for groups working in the fast paced maelstrom of today's business and industry. As stated earlier, the use of computers to facilitate performance in groups has been widely applied and reported but little researched. Over the past ten years, some effort has been made to fill this gap. These efforts will be summarized next.

Group Process and Performance

Research into group productivity and performance has been a roller coaster ride since Marjorie Shaw's (1932) classic experiment that attempted to prove the superiority of group productivity over individual productivity. The latest resurgence began with the publication of Ivan Steiner's book, *Group Process and Productivity*, in 1972. This marked the point at which interest in developing systems to support effective performance for a variety of tasks, including decision making, began in earnest (McGrath & Hollingshead, 1994). Steiner's (1972) research focused on ways to improve group productivity through the elimination of group inefficiencies. Brainstorming, nominal group techniques, and many other processes have their roots in this fertile period.

Brainstorming is a well established technique used for the purpose of generating ideas in an uncensored, uncritical environment. Although it is widely used today, there is little empirical evidence to support the superiority of brainstorming over other idea generation techniques (Gallupe, Cooper, Grise, & Bastianutti, 1994). Frequently, comparisons are drawn between the quantity of ideas generated in brainstorming groups and the quantity of ideas generated in groups where individuals work through a process of individual idea generation, pool their ideas and eliminate redundant ideas. With this later procedure known as a nominal group technique, results typically show that nominal groups outperform brainstorming groups. Researchers attribute this lack of superiority in brainstorming groups over nominal groups to three major group dynamics: production blocking, evaluation apprehension and social loafing (Gallupe, et al., 1994). Production blocking occurs when an individual in a group cannot immediately express his or her idea because someone else is expressing an idea at that particular moment. Evaluation apprehension occurs when individuals are reluctant to express their ideas in a group for fear of being criticized by other members. Social loafing, also known as free riding, occurs when an individual in a group is content to sit back and let others do the work knowing all will get credit for the group contribution.

In spite of these problems, group brainstorming remains a mainstay in industry and organizations due to a perception of productivity (Paulus, Dzindolet, Poletes, & Camacho, 1993). An analysis by these researchers revealed a tendency for brainstorming participants to report a perception of productivity bias in favor of groups versus solitary brainstorming. This favorable evaluation of brainstorming groups is attributed to the group member's ability to compare his or her own performance with others during the brainstorming session. This led participants to conclude that their group had been very productive and that they had personally made a major contribution to the group generation of ideas. In this study when the performance was measured by counting the number of ideas generated, there was no significant difference between brainstorming groups and individuals working on their own. Typically, however, nominal groups out-produce brainstorming groups by a two to one ratio (Diehl & Strobe, 1987; Mullen, Johnson, & Salas, 1991).

A meta-analysis conducted by Mullen et al. (1991), also revealed a significant productivity loss in brainstorming groups for both quality and quantity of responses. This analysis separated out the relative contribution to productivity loss from three sources: social psychological mechanisms (e.g., self-attention and drive arousal), procedural mechanisms such as production blocking (Diehl & Strobe, 1987), and economic mechanisms. An example of an economic mechanism would be intentional withdrawal of effort as in social loafing (Williams, Harkins, & Latane, 1981). Their findings indicate that social psychological mechanisms provide the most accurate predictions of productivity loss, with procedural mechanisms providing only marginally accurate predictions. Their measure of economic mechanisms generally provided erroneous predictions.

The elimination of production blocking was pinpointed by Valacich, Dennis, and Connally (1994) as the primary factor in the supremacy of interactive groups over nominal groups in an electronic media. Using the University of Arizona GroupSystems Electronic Brainstorming (EBS) software, this research team also took into consideration the group size and found a consistent performance enhancement for EBS groups over nominal groups when group size exceeded eight to ten members. Performance was found to be equal for EBS groups and nominal groups for group sizes ranging from three to six members. Valacich et al. (1994) concluded that for groups above a moderate size (eight to ten members), groups using the EBS technology outperform nominal groups on production of unique ideas. Performance is accomplished without any loss in idea quality or participant satisfaction. This research demonstrates that stimulation by other's ideas at short intervals can lead to higher productivity in idea generation over working alone.

Dennis and Valacich (1994) also found a group size main effect for electronic media brainstorming with optimal group size effect occurring in groups with 12 to 18 members. They suggest that the pattern of electronic communication could hold the key to this difference that occurs as a function of group size. An analysis of the conversation patterns used by the subjects in these groups indicates that the smaller groups tended to follow typical social rules for conversation, responding to others comments. Statistically significant differences were found between groups in the number of entries that make reference to a previous entry. The smaller groups made more frequent reference to others comments. As the group size increased, this communication technique was not used as readily, perhaps due to the increased amount of information requiring processing. This social communication technique is replaced with a "multiple monologue" technique that appears to facilitate the increase in idea generation (Dennis & Valacich, 1994).

A concluding word about group size is appropriate. Ideally, optimal group size should be determined by the situation and the complexity of the task or problem to be solved. There are situations that would benefit from the aggregation of experts with diverse backgrounds (Valacich et al., 1994). Such a group would have very little overlap in knowledge and skills. Typically, however, these studies have targeted fluency as the dependent variable, having subjects generate multiple responses to well-defined problems (e.g. What are all the possible ways for the State Department of Tourism to attract tourists?). There appears to be general agreement that the number of good ideas generated is highly correlated with the total number of ideas (Valacich et al., 1994; Diehl & Strobe, 1987). The conclusion is then drawn that the high cost of solution quality evaluation is not justified. Following this research, Diehl and Strobe decided to only measure number of ideas generated and to stop measuring idea quality. For this reason quality is assumed when number of alternatives is high even though it is frequently not measured. The relationship between quality and quantity could be expected to be different when solving ill-defined tasks.

In addition to the group effect mentioned above, social choice has been shown to effect group function and performance. Grofman and Feld (1992) reviewed the literature concerning social choice theory and majority rule voting using a mathematical approach. Grofman and Feld point out the tendency toward selection of alternatives that are central representations of the group rather than original or creative problem solutions that could be of higher quality. They indicate that when a group makes a decision, there can be a strong force toward maintaining the status quo. Similar conclusions were reached by Janis (1982) in his research. He discovered that for well established groups there exists in-group pressures to seek consensus. These pressures result in a reduction of mental efficiency, moral judgment, and reality testing that Janis labeled groupthink. This process is characterized by a group holding the illusory belief of consensus on an issue, when in fact there are unexpressed doubts and reservations. The suppression of these doubts and reservations occurs out of loyalty to the group or to the group leader. There is also a tendency for the group to overestimate the quality and inherent morality of the group. This leads to group rationalization for defective plans and decisions.

It can be readily seen from the literature, that there are a number of factors that contribute to lower performance measures in group face-to-face interaction. These factors are further clarified through a review of research that reviews group process and technology.

Group Process and Technology

Contrary to popular conception, typical group meetings are still facilitated through the use of flip charts and large hand written notes which express the collaborative effort of group members (Johansen, 1989). The move toward electronic group facilitation, however, is currently underway with software moving out of the research laboratory and into actual use in the business community. There is an emerging trend toward electronically supported group decision making, supported by a fast growing software industry that has developed various "groupware" system software. The use of such electronic technologies are perceived to be a benefit to business from both a performance and a cost standpoint. This perception has not been well supported in the empirical research forum; however, the trend in industry toward business teams as problem solving units will probably continue to drive the trend toward electronic supported group processing. Companies with decentralized project teams, high concentrations of networked PCs, and flexible organizational structures will be in the best position to capitalize on the blossoming technology (Johansen, 1989). Dhar and Olson (1989) encounter collaborative efforts most often directed at communication and problem solving. They suggest that electronic group decision teams provide "added value" benefits to the collaborative process. This occurs in the same way that electronic mail gives "added value" over face to face communication in the form of quick, action-oriented written communication.

The business environment in the information age is faced with an ever increasing need for knowledge within a complex and turbulent infrastructure. Huber (1984) suggests this necessitates faster organizational decision making, continuous information acquisition, organizational innovation and quicker information distribution in order to avoid overload, all of which point the way to electronic systems utilization at all levels of an organization.

Group electronic systems provide expanded dimensions for conversation unfettered by normal rules of face-to-face communication (Stefik & Brown, 1989). Research on diversity and group decision making processes suggests that homogeneous groups perform better than diverse groups (i.e., in terms of gender, culture, race, age, etc.), but that diversity can also serve to increase a group's performance (Maznevski, 1994). Group diversity provides more perspectives for solving problems in that diverse groups have more viewpoints at their disposal and therefore have a higher potential for performance. This diversity in knowledge, skills, gender and cultural perspectives can be a source of synergy for a group (Dennis & Valacich, 1993). However, diversity may also introduce communication barriers that contribute to an inability to integrate the perspectives. When the communication variables, such as motivation, ability to understand another's perspective (decenter), and confidence in one's ability to communicate are all working in a positive direction, the potential for problem solving within the group is increased (Maznevski, 1994). This dilemma posed by the benefits of diversity versus the decrements due to communication barriers can possibly be circumvented through electronic communication media. Every participant brings equal status and diversity to an environment that doesn't recognize age, ethnicity or gender thereby increasing the potential for synergy within the group.

The use of a computer network to facilitate brainstorming has been shown to overcome many of the brainstorming barriers and to assist a group through the simultaneous generation of ideas via computer to achieve performance in excess of that achieved by nominal groups or verbal brainstorming groups (Nunamaker, Dennis, Valacich, Vogel & George, 1991). Although performance was measured by number of non-redundant ideas, this research sets the stage for the current thesis research and the investigation of quality of solution that comes out of computer network problem solving activities.

This thesis intends to examine the relationship between a number of variables connected to problem solving. The subjects will be required to make decisions using information presented in the form of a complex, ill-defined problem. Most previous studies have focused on well-defined problems. Well-defined problems are rare in the work environment where problems tend to be complex and ill-defined. The approach required with such ill-defined problems differs from the approach required for well-defined problems. Before ideas can be generated for ill-defined problems, problem construction or definition is required (Mumford, Reiter-Palmon & Redmond, 1994).

Problem Construction

Problem construction has been shown to effect the problem solving process. Research by Reiter-Palmon (1993) suggests that problem construction can provide a plan for problem solving activities that contributes to the quality of the problem solution. This research examined an individual's interpretation and definition of ambiguous situations as a function of previous problem solving efforts. Some individuals were able to restate problems in numerous patterns with a variety of definitions making them more likely to find a problem definition that was a fit for their particular experience and knowledge structure. In turn, the availability of knowledge and a wide array of information or availability of environmental resources, can act to enhance this problem finding (i.e., problem restating) ability. A basic level of problem finding (problem construction) skill, however, appears to be requisite before people can take advantage of the opportunities presented by the environment. Those who are lacking in this basic skill would not be able to benefit from the additional information provided by the environment, and in fact, this additional information could serve to reduce the quality of their problem solutions.

Mumford, Mobley, Uhlman, Reiter-Palmon and Doares (1991) suggest a model for creative problem solving and present a design displaying the hypothesized relationships among eight processes: (a) problem construction, (b) information encoding, (c) category search, (d) specification of best-fitting categories, (e) combination and reorganization of best-fitting categories, (f) idea evaluation, (g) implementation, and (h) monitoring.

Mumford et al. (1991) view these processes as a consecutive series that provides feedback at each level and that occasionally passes information back and forth until the next step is formulated. An example of this would be the information encoding process interacting dynamically with the category search process until the best-fitting categories can be specified. The importance of this process is most notable when subjects are working in an ill-defined domain, or as the degree of a priori structure decreases. Problem construction has greater influence when goals, parameters, solution strategies, and pertinent information are unknown or under represented.

This lack of information or knowledge appears to present people with a situation that is highly ambiguous. Hogarth and Kunreuther's (1992) research addressed the question of ambiguity and the decision-making task. Their theory of decision-making under uncertain situations assumes that the problem solvers evaluate the desirability of a given alternative by weighting the utility of the outcome by the probability of obtaining that alternative. Under this model, people tend to choose an anchor point based on the probability of obtaining an alternative and then adjust above and below this anchor, assigning weights based on the ambiguity of the situation. Let's look, for example, at the conditions under which people purchase flight insurance. The probability of an air accident is actually very low, but based on the ambiguity of the situation, and the availability of the flight insurance, people tend to assign a high weight to the possibility of an accident and purchase the insurance. This scenario is also a reflection of a person's ability to imagine an accident happening. The easier it is to imagine the outcomes, the more readily this will contribute to the weighting process. Hogarth and Kunreuther believe that the amount of perceived ambiguity and the person's attitude towards ambiguity in a specific situation will influence the anchoring and adjusting (weighting) process. According to Mintzberg, Duru, Raisinghani and Theoret (1976) organizational problems and the strategic decision process is characterized by ambiguity in the form of openendedness, complexity, and novelty. They found that this process typically begins with the decision makers having little understanding of the problem situation, solution route, or solution. This is decision-making under ambiguity, with problem solution goals and constraints either missing, underdefined, or undefined. In an experiment conducted using MBA students and actuaries, four variables were manipulated: (a) role (consumer or firm), (b) ambiguity (present or absent), (c) probability of loss ($p = .10$, .35, .65, or .90) and, (d) type of respondent (actuaries or MBA students). The results fit the profile of the ambiguity model. For consumers, a preference for ambiguity was shown under high probability conditions and aversion to ambiguity under low probability conditions. Similar results held for the firms although to a lesser extent under the high ambiguity condition. They conclude that characteristics of the situation and roles people assume will determine their response in a positive or negative direction to an ambiguous problem solving situation (Hogarth & Kunreuther, 1992). This work builds on work by Kahneman and Tversky (1969) on decisions under risk and risk attitudes towards losses and gains regarding the decisions of an opponent.

In summary, it is important to keep in mind that there are major differences between solving well-defined problems and ill-defined problems. One of the major differences in ill-defined problems occurs in the beginning because decision makers are faced with a decision-making task where the problem is not clear, the goals are not specified, and the constraints on both the specific problem and within the environment of that problem are not clearly defined. Faced with this situation, the decision maker must reach some understanding of the problem construction, which involves problem definition and recognition and consideration of the goals and constraints, before a solution can be attempted. When this same situation is faced by the members of a group, this task becomes even more daunting, as each member will bring to the table a different paradigm for problem clarification. Agreement must be reached on these important variables before a solution can be attempted (Mumford, Reiter-Palmon, & Redmond, 1994).

This look at problem construction provides the final piece of the puzzle we will be working with in this current research. People are faced with the need to make decisions and thus solve problems every day. Most of these problems are complex which can contribute to the difficulty of arriving at sound decisions. Frequently in the business environment, people work in groups, pooling information and skills. Any tools that can be utilized to enhance the decision making process should be made available to facilitate job performance. The computer is such a tool. The problem lies in the lack of empirical data providing support for the efficacy of the use of computers for problem solving over traditional face-to-face discussion and problem solving. This study will endeavor to clarify the performance enhancement achieved through the use of the computer. Although this issue of group performance enhancement in the electronic environment has been studied over the past few years, the area of performance on ill-defined problems has not been well-developed. The use of such real-life scenarios should increase the generalizability of the findings, giving important information to the decision-making community on ways to facilitate the solution of the problems they face each day. The use of electronic brainstorming appears to bring together the positive elements of the nominal group structure (generation of ideas and solutions with minimal apprehension, blocking, and social loafing) and the positive elements of face-to-face brainstorming (synergistic interactions wherein members share ideas and build on them)(Dennis & Valacich, 1993). This synergistic effect is believed to occur as a result of members bringing different knowledge and skills to the table (Steiner, 1972).

Purpose of the Study

The research described above suggests that there will be differences in quality of solution and number of factors generated for complex problems, depending on the conditions under which a subject is working. Due to conflicting information in the research data, the direction of the difference with regard to originality of problem solution cannot be specified. Exploratory analysis will be conducted on this dependent variable. The time needed to arrive at a final solution under the different conditions is another factor that could be expected to vary with condition. To bring all of these variables together for examination, subjects will be assigned randomly to computer and non-computer conditions working either individually or in groups of three in a 2 X 2 factorial design. The following hypothesis will be tested in this research.

Hypothesis 1: It is predicted that the quality of solutions generated will be a function of the interaction between use of computer and whether participants worked independently or in groups. Specifically, it is predicted that computer use will have no effect on the quality of solutions generated by individuals. In contrast, computer use will differentially affect solution quality for groups such that those groups using a computer will generate higher quality solutions than those groups not using a computer.

Hypothesis 2: It is predicted that the number of new factors generated will be a function of the interaction between use of computer and whether participants worked independently or in groups. Specifically, it is predicted that computer use will have no effect on the number of new factors generated by individuals. In contrast, computer use will differentially affect the number of new factors generated for groups such that those groups using a computer will generate more new factors than those groups not using a computer.

Hypothesis 3: The time needed for groups to generate a final solution will be significantly longer than the time needed for individuals.

Method

Participants

One hundred and sixty-one students from undergraduate psychology classes at the University of Nebraska at Omaha were recruited to participate in this study. Participants ranged in age from 16 through 61 with a mean age of 24 years, and a standard deviation of 6.7. Forty-eight males and 113 females participated in this research. The mean college grade point average reported was 3.27 for all participants. Fifteen Freshmen, 37 Sophomores, 39 Juniors, 48 Seniors, 9 Postgraduates, and 1 High School student taking an advanced course, participated in this study. Twelve participants did not report their grade level. Participants received extra credit in return for their participation.

All participants were randomly assigned to one of four treatment conditions; group computer, group non-computer, individual computer and individual non-computer (see Table 1). Participants were clearly informed whether they would be working alone or in a group and also informed whether they would be working on a computer or with paper and pencil as they were taken to their work stations prior to the beginning of the study.

Setting and Apparatus

GroupSystems (GS) software was used in the group and individual computer conditions. GS was developed by J. F. Nunamaker and colleagues at the University of Arizona. This system is currently marketed by Ventana Corporation of Tucson, Arizona. This software provided the computer system

Table 1

Participant's Random Assignment

Media	3-Member Groups	Individuals
Computer	19 (57)[a]	23
Non-Computer	19 (57)[a]	24

[a] - number in parenthesis indicates total number of individuals

necessary to facilitate computer-based group and individual problem solving (Nunamaker, et al., 1991).

The research room was designed to house four computers all linked via the GS software. The first computer allowed the researcher to configure the other three computers to be linked or independent. Using the group configuration, participants could communicate with other members of their group, exchanging information on factors, ratings and solutions as well as making comments to each other in their effort to reach consensus on a final solution. Using the individual configuration of the GS software, individuals working on the computer only had access to their own information.

Although the computers were in close proximity to each other, large, solid partitions were installed between work stations which dissuaded participants from viewing or talking with each other.

Procedures

Although procedures differed strategically, most of the instructions were the same for all participants. For clarity, this study can be divided into three phases: Pregroup, group and Postgroup (see Table 2).

Phases of Research

Pregroup Phase.

All participants were instructed to read Clara's problem (see Appendix A) and to generate a list of all key pieces of information (factors) either presented or

Table 2

Phases of Study

	Phase 1 **Pregroup**	**Phase 2** **Collaborative**	**Phase 3** **Postgroup**
Condition			
1)Individual Non-Computer	*Task 1	Completion of Leisure Survey	**Task 2/independent solution
2) Group Non-Computer	*Task 1	Face-to-face collaboration on problem solving and consensus solution	**Task 2 /consensus solution
3)Individual Computer	*Task 1	Completion of Leisure Survey	**Task 2/independent solution
4) Group Computer	*Task 1	Computer collaboration on problem solving and consensus solution	**Task 2/consensus solution

*Task 1: All individuals regardless of condition, generate a factor list, importance ratings and initial solution

**Task 2: All individuals regardless of condition, review and revise factor list, importance ratings and write final solution . Complete satisfaction and computer surveys & are debriefed implied that should be considered when attempting to solve this problem. Participants were provided with an importance rating scale and asked to rate each factor on their list for importance in arriving at a final solution. All participants were then instructed to write the best solution they could generate for Clara's problem. This completed the pre-group phase of the study for all participants as they were all working as individuals up to this point.

Collaboration Phase.

Groups. Those assigned to work in groups either on the computer or face-to-face were instructed to consult with each other at this time, exchanging information on the factors, importance ratings and solutions generated during the pre-group phase. Group participants were given an opportunity to revise their own factor list and importance ratings independent of other members of the group. Group participants were also asked to reach consensus on the final problem solution.

Individuals. Those assigned to work as individuals either on the computer or with paper and pencil, were instructed to complete a Leisure Activity Survey (see Appendix B). This assignment was designed to provide the individual participants with an activity that would be roughly equivalent in length to the collaboration phase of the group participants.

Postgroup Phase.

Again, working alone, all participants were given an opportunity to revise their factor list and importance ratings and to generate a final solution to Clara's problem. For the group participants, this final solution was reached through consensus. Prior to debriefing, all participants were asked to complete the

Satisfaction Survey and the Computer Experience Survey (see Appendixes C and D). A detailed summary of the procedures that differentiate conditions is provided in Appendixes E-H.

Dependent Variables

All subjects were given one problem to solve. The problem was written so as to be ambiguous and ill-defined, i.e., with more than one possible solution. A pre-group (initial) solution and a post-group (final/consensus) solution were generated by all participants as well as an initial factors list and a revised factor list. Quality, number of new factors generated and time served as dependent variables in this analysis.

Quality ratings. Quality was considered to be a complex concept composed of three separate variables: appropriateness, originality and resolving power. Appropriateness was defined as providing a viable solution to the problem that was realistic, practical, feasible and socially appropriate. Originality was defined as the degree to which the solution was not structured by the problem presented and the degree to which the solution extended past this structure. The definition includes the degree of novelty and uniqueness of the solution. Resolving power was defined as the degree to which the solution addressed and resolved the underlying conflicts presented in the problem (Reiter-Palmon, et al., 1997). Appendix I presents details of the quality rating scales used in this study.

Ratings were obtained using a modification of Hennesey and Amabile's (1988) consensual rating technique. Two subject matter experts (SME's) were trained in the use of these rating scales and were given both the stimulus materials and the participants individual and consensus solutions. The SME's were asked to rate the appropriateness, originality and resolving power of the solutions without knowledge of the specific manipulations.

An intraclass correlation coefficient (ICC) was calculated to determine interrater reliabilities (Shrout & Fleiss, 1979). Numerous versions of the ICC calculation applicable to specific situations are available. Because each of the targets (scores) were rated by the same two judges, a two-way mixed model utilizing the following equation

$$ICC = (BMS-EMS)/BMS$$

where BMS represents the between-target mean square and EMS represents the residual or error within-target mean square was employed for calculation of the ICC. Although the interrater reliabilities were weak (Appropriateness, ICC=.66; Originality, ICC=.63; Resolving Power, ICC=.51), consensus was reached on all items without the necessity of a third party tie breaker. Consensus ratings were used in all analysis.

Appropriateness, originality and resolving power ratings were made on all pre-group (initial) and post-group (final) solutions.

New factors generated. The number of new factors generated under each condition was also counted. Only the new factors generated, when participants were given an opportunity to revise their original factor list, were counted.

Time. Time was also used as a dependent variable. Time was measured from the time the researcher began reading initial instructions to time the participant handed-in the completed questionnaires and protocols. The researcher noted all beginning times and all ending times based on time elapsed on a watch. The difference, or total time on task was recorded by the researcher on the front of each participants protocol.

Additional Measures

Computer Questionnaire. Data was also collected on variables considered to be possible sources of variability and thus alternative explanations for results. A survey was developed for completion by all participants in order to determine the participant's computer experience (see Appendix D). This survey contained two sub-scales in an attempt to tap into actual computer experience and participants' emotional reaction to computer interaction. Reliabilities were strong: computer experience -full scale (Alpha=.92) computer experience-affect (Alpha = .90), computer experience-factual (Alpha = .86). This separation of attitude toward computers and computer factual experience has been recognized as an important distinction that could impact computer performance (Hudiburg, 1989; Ballance & Ballance, 1992). The survey was completed by all participants at the end of the study just prior to debriefing.

Problem Solving Process Questionnaire. An additional post-session questionnaire queried the participants perception of the computer software system and problem solving format (see Appendix C). This questionnaire was a modification of a survey developed by Dennis and Valacich (1993). The purpose of this questionnaire was to determine participants' perception of group interaction variables that have been previously found to have an influence on group productivity. These variables include production blocking, evaluation apprehension, synergy and stimulation, free riding and overall satisfaction. As stated previously, production blocking occurs when an individual in a group must wait their turn and cannot immediately express his or her idea because someone else is expressing an idea at that particular moment. Evaluation apprehension relies on the notion that when in the presence of others, people become concerned with succeeding or failing at a task. This heightened concern is translated into enhanced drive which can lead to improved performance on well-learned tasks, and degraded performance on novel tasks. Synergy and stimulation refers to the combined cooperative activity or force that occurs when individuals work together in a group. This combined energy can lead to a synergistic situation where the productivity of the group is greater than the sum of the productivity of the individual within the group. Synergy occurs when a group participant is motivated to create new ideas based on the ideas expressed by others in the group (Dennis & Valacich, 1993). Although some of the synergy questions in this survey had been previous used as a measure of synergy, the specific wording also lends itself to an interpretation of task involvement or task enjoyment. Social loafing, also known as free riding, occurs when an individual in a group is content to work with less effort than they would if they were working alone, knowing all group members will get credit for the group contribution. The overall satisfaction portion of the survey taps into general satisfaction with the process that participants were engaged in. The modifications to the original questionnaire included changes in wording to make the survey more specific to this study and also included the addition of one or two questions to each category.

The reliability of five of the perceptual measures included in this survey were shown to be adequate: production blocking (Alpha=.84), evaluation apprehension (Alpha=.73), synergy and stimulation (Alpha=.79), satisfaction (Alpha=.86), and free riding (Alpha=.74). Perception of whether participants had sufficient time was also measured using a modification of a scale previously found to be reliable (alpha = .84), but it proved less homogeneous in this study (alpha = .61).

Analysis

All analyses were conducted using SPSS for Windows, 6.0 utilizing the Base, Advanced and Professional programs, with both prewritten and custom syntax.

Data Sets

Two data sets were used for analysis purposes in this study, which will be described below.

Full Data Set.

The full data set contained data for all individuals who participated in the study. Due to the nature of the design, unequal cell sizes exist in this data set. Each of the group conditions contains data from 57 individuals compared to the non-group cells which contain approximately 24 individuals. As it was appropriate for certain analysis to be run on the full data set, tests for homogeneity of variance were conducted for each analysis. Simple main effects were calculated for all significant interactions in order to determine the exact nature of the interaction. The following analyses were run on the full data set. The full data set was used for these analyses because this data was generated independently by each individual in the study.

Initial solution quality ratings. Using the full data set, a 2 X 2 factorial design was used to analyze the between group differences in the initial solution for appropriateness, originality and resolving power. This analysis was designed to examine the effect of the independent variables, group (group vs. individual) and media (computer vs. non-computer) on the quality of the initial problem solution generated prior to consensus or changes.

Number of new factors generated. During the postgroup phase of this study, all subjects, working independently, were given the opportunity to revise their factor list. This revision included the opportunity to add new factors. The number of new factors generated during this postgroup phase were counted. As all individuals had the opportunity to revise their factor lists independently, the full data set was used for this analysis. A 2 X 2 factorial analysis of variance was employed to examine the effect of the independent variables (group and media) on the dependent variable, number of new factors generated.

Satisfaction Survey subscales. General satisfaction, production blocking, free riding, evaluation apprehension, perception of time, and synergy and stimulation were analyzed using the full data set as all individuals completed the survey independently. Again, an analysis of variance was utilized to examine the effects of the independent variables (group and media) on these specific dependent variables.

Computer Survey subscales. The two subscales of the computer survey, affect and factual experience, were analyzed using the same process reported above for the satisfaction survey. An example of a question from the computer factual experience subscale would be, "I use a computer to do my homework." An example of a question from the computer affective experience subscale would be, "Using a computer makes me nervous." This survey is presented in Appendix D.

Group Data Set.

The group data set differs from the full data in several ways. In order to compare pre- and post-group quality ratings, the quality ratings for the initial solution in the group conditions were collapsed for each three-person group resulting in a mean initial quality rating per group. The quality scores for the final consensus solution in the group conditions are reported directly as was time for completion. This data was not useable in the full data set as the scores for the group members were not independent. Again, as with the full data set, simple main effects were calculated for all significant interactions in order to determine the exact nature of the interaction. The following analyses were run on the group data set.

Final solution quality ratings. Using the group data set, a 2 X 2 factorial analysis of variance was used to analyze the between group differences in the final solution for appropriateness, originality and resolving power. Again, this analysis was designed to examine the effect of the independent variables on the quality of the final solution.

Comparison of initial solution to final solution quality ratings. Using the group data set and a 2 X 2 X 2 factorial design analysis of variance with two between subjects factors (group and media) and one within subjects repeated measure (initial and final solution) analyses were conducted to determine if differences existed on quality ratings (appropriateness, originality and resolving power) between the initial and final solutions generated to the problem.

Time. The overall time taken to complete this study was recorded. Subjects working in groups had the same recorded time. As such, this information was not independent and therefore the group data set was used for this analysis. A 2 X 2 factorial design analysis of variance was used to examine the effect of the independent variables, (group and media) on the amount of time needed for completion of task.

Pilot Study

In an effort to work out any procedural kinks, 20 subjects participated in a pilot study. Based on information from debriefing interviews, the complexity of the problem was increased in order to avoid participants selecting obvious answers. The pilot study information was used during rater training.

Results

Results of all analysis conducted are reported below. Descriptive statistics including means, standard deviations and range for all dependent variables are reported below on Table 3. Correlations for quality ratings from the group data set are reported on Table 4. Correlations for the dependent variables in the full data set are reported on Table 5.

As seen in Table 4, there appears to be a positive correlation between all of the quality ratings: Appropriateness with Originality r=.32, p<.01; Appropriateness with Resolving Power, r=.50, p<.01 and Originality with Resolving Power r=.46, p<.01. In addition, a strong positive relationship is apparent between the two Computer Survey subscales, Computer Experience: Fact and Computer Experience: Affect, r=.79, p<.01 as well as among many of the Satisfaction Survey subscales.

When the group data set is used to calculate correlations the variables of interest are the mean initial quality ratings and the final consensus quality ratings. As can be clearly determined from correlations Table 5, a strong relationship exists between all quality ratings with the exception of the final appropriateness rating which appears to stand alone.

The two deviations from this pattern are the correlation between the final appropriateness rating and the final resolving power rating, r=.42, p<.01. and the correlation between the initial and final appropriateness ratings, r=.49, p<.01.

Table 3

Descriptives for Variables

Variable	M	SD	Range
Age	24.1	6.7	16-61
CGPA	3.3	.5	2-4
Comp. Exp. Factual	5.1	1.1	2-7
Comp. Exp. Affect	5.5	1.1	2-7
General Satisfaction	5.6	.9	2-7
Evaluation Apprehension	5.4	1.1	2-7
Free Riding	5.5	1.0	2-7
Perception of Time	6.0	1.0	2-7
Production Blocking	5.2	1.4	1-7
Synergy	5.1	1.0	2-7
Time	41.9	17.1	19-98
New Factors	.8	1.7	0-7
Appropriateness 1	2.5	1.0	1-5
Originality 1	2.8	1.4	1-6
Resolving Power 1	3.3	1.3	1-6

Table 4

Correlations: Dependent Variables - Full Data Set

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. Rating: Appropriateness1#	-											
2. Rating: Originality1#	.32**											
3. Rating: Resolving Power1#	.50**	.46**										
4. Time	-.08	.18*	-.04									
5. New Factors Generated	-.16*	-.12	-.05	-.02								
6. Computer Experience: Fact	-.06	-.03	-.14	.18*	-.12							
7. Computer Experience: Affect	-.06	-.006	-.12	.07	-.10	.79**						
8. Satisfaction	.12	.06	.02	.09	.09	-.12	-.02					
9. Evaluation Apprehension	.14	.23**	.08	-.04	-.09	.09	.19	.34**				
10. Free Riding	.16*	.06	.15	.04	.12	-.09	-.02	.50**	.44**			
11. Perception of Time	.18*	.07	.05	-.13	-.02	.12	.26**	.29**	.36**	.30**		
12. Production Blocking	.18*	.10	.095	.10	-.10	.12	.11	.10	.23**	.31**	.31	
13. Synergy	.10	.12	.02	.16	.06	.05	.02	.50**	.32**	.54**	.09	.21**

Note * - $p<.05$ Note** - $p<.01$ Note # Appropriateness 1=Appropriateness ratings on initial, pre-group solution. Originality 1=Originality ratings on initial, pre-group solutions. Resolving Power1=Resolving Power ratings on initial, pre-group solutions.

Table 5

Correlations: Quality Ratings - Group Data Set

Variables	1	2	3	4	5
1. Appropriateness Rating - Initial					
2. Appropriateness Rating - Final	.49**				
3. Originality Rating - Initial	.32**	.05			
4. Originality Rating - Final	.35**	.13	.60**		
5. Resolving Power - Initial	.46**	.20	.51**	.42**	
6. Resolving Power - Final	.23*	.42**	.28**	.29**	.52**

Note. * = $p < .05$. ** = $p < .01$.

Confounding Variable - Computer Experience - Full Data Set

It was important to verify that differences found in our analysis could not be attributed to variables other than our manipulations. Computer experience was considered to be one of these possible confounding variables. The computer survey was administered following the completion of the problem solving task. All participants completed this survey. A t-test was conducted to determine whether differences existed between those participants randomly assigned to work on the computer and those assigned to work with paper-and-pencil. This t-test for the full-scale computer survey displayed no significant differences between the computer and non-computer conditions $t(156)=1.60$, $p>.05$.

Analysis of Variance - Quality

Hypothesis 1: It is predicted that the quality of solutions generated will be a function of the interaction between use of computer and whether participants worked independently or in groups. Specifically, it is predicted that computer use will have no effect on the quality of solutions generated by individuals. In contrast, computer use will differentially affect solution quality for groups such that those groups using a computer will generate higher quality solutions than those groups not using a computer.

Pregroup quality ratings. As a first step in the testing of the hypothesis stated above, an analysis of variance was conducted on the initial pregroup solution quality ratings (appropriateness, originality and resolving power). No differences were predicted at this point, as all participants were working on their own and had not been subjected to group interaction yet. The analysis supported this homogeneity of ratings across conditions for the originality and resolving power quality ratings. However, the appropriateness ratings yielded a marginal main effect for group such that those individuals who were anticipating working in a group wrote solutions of lower appropriateness (M=2.44, SD=1.06) relative to those individuals who anticipated working alone for the entire study (M=2.74, SD=.90), $F(1,160)=3.01$, $p=.085$, (see Table 6 & 7) with 2% of the variance accounted for ($\eta=.02$). Cochran's test of homogeneity demonstrated an absence of heterogeneity in this analysis allowing us some confidence in these marginally significant results. A Cochran's test is being run for analysis using the full data set due to unequal cell size.

Postgroup quality ratings. The next step in the test of hypothesis one was to determine if there were differences in final quality ratings as a function of the independent variables (group and media). This analysis of variance was conducted on the group data set using solution arrived at by consensus in the group conditions and individually by those working alone. No significant main effects or interactions were found for any of the three quality variables (see Table 8 and 9).

Table 6

Pregroup Quality Ratings

Source	SS	DF	MS	F	P
Appropriateness					
Computer	.11	1	.11	.11	.743
Group	3.11	1	3.11	3.01	.085
Computer by Group	.07	1	.07	.07	.789
Originality					
Computer	.45	1	.45	.24	.627
Group	.12	1	.12	.07	.798
Computer by Group	.90	1	.90	.48	.49
Resolving Power					
Computer	1.12	1	1.12	.67	.413
Group	1.95	1	1.95	1.17	.28
Computer by Group	.30	1	.30	.18	.669

Table 7

Pregroup Quality Ratings - Full Data Set

Variable	M	SD
Appropriateness		
Group	2.44	1.06
Computer	2.39	1.06
Non-Computer	2.49	1.05
Alone	2.74	.90
Computer	2.74	.81
Non-Computer	2.75	.99
Originality		
Group	2.79	1.4
Computer	2.92	1.52
Non-Computer	2.65	1.26
Alone	2.85	1.3
Computer	2.82	1.47
Non-Computer	2.88	1.15
Resolving Power		
Group	3.2	1.32
Computer	3.16	1.39
Non-Computer	3.25	1.27
Alone	3.45	1.18
Computer	3.3	1.11
Non-computer	3.6	1.25

Table 8

Postgroup Quality Ratings

Source	SS	DF	MS	F	P
Appropriateness					
Computer	.16	1	.16	.18	.669
Group	1.05	1	1.05	1.18	.281
Computer by Group	.82	1	.82	.93	.338
Originality					
Computer	1.22	1	1.22	.65	.424
Group	1.59	1	1.59	.84	.361
Computer by Group	.45	1	.45	.24	.627
Resolving Power					
Computer	.07	1	.07	.04	.841
Group	1.16	1	1.16	.70	.406
Computer by Group	1.78	1	1.78	1.07	.304

Table 9

Postgroup Quality Ratings - Group Data Set

Variable	M	SD
Appropriateness		
Group	2.68	.96
Computer	2.9	1.05
Non-Computer	2.47	.84
Alone	2.6	.92
Computer	2.6	.78
Non-Computer	2.58	1.06
Originality		
Group	2.74	1.33
Computer	2.5	1.39
Non-Computer	2.9	1.27
Alone	2.98	1.4
Computer	2.9	1.38
Non-Computer	3.04	1.4
Resolving Power		
Group	3.26	1.29
Computer	3.0	1.5
Non-Computer	3.5	.96
Alone	3.32	1.29
Computer	3.35	1.15
Non-Computer	3.29	1.4

Repeated measure quality ratings. A final analysis comparing the initial solution with the final solution to determine if differences exist as a function of this repeated measure, group or media was run on the group data set. A significant interaction was found for group on the repeated measure for appropriateness $F(1,81)=4.49$, $p < .05$, with 5% of variance accounted for ($\eta = .05$). Figure 1 provides a graphic representation of this interaction. A simple main effects analysis revealed significance difference for groups such that their second or consensus solution were rated significantly higher on appropriateness ($M=2.7$, $SD=.96$) relative to the mean of the initial solution across group members ($M=2.44$, $SD=.62$), $F(1,83)=3.09$, $p=.08$ (see Tables 10-13). Four percent of the variance in the gain in appropriateness rating is accounted for through group ($\eta = .0359$). It is interesting to note that significant differences were not found between the groups on either the pregroup quality ratings or the postgroup quality ratings, however, a marginally significant increase or gain in quality of ratings occurred for groups from the pregroup to postgroup ratings relative to the gain shown by those working alone (see Figure 1).

Analysis of Variance- New Factors Generated

Hypothesis 2: *It is predicted that the number of new factors generated will be a function of the interaction between use of computer and whether participants worked independently or in groups. Specifically, it is predicted that computer use will have no effect on the number of new factors generated by individuals. In contrast, computer use will differentially affect the number of new factors*

Table 10

<u>Repeated Measure - Appropriateness Ratings</u>

Source	SS	DF	MS	F	P
AppRM	.10	1	.10	.27	.603
Gp X AppRM	1.63	1	1.63	4.49	.037
Cp X AppRM	.83	1	.83	2.28	.135
Gp X Cp X AppRM	.63	1	.63	1.73	.192

<u>Note.</u> Gp=Group; Gp1=Worked in Group; Gp2=Worked Alone;
Cp=Computer; Cp1=Worked on Computer; Cp2= Did not use Computer;
AppRM=Appropriateness Ratings (Repeated Measure - Pre- & Post-group Quality Ratings).

Table 11

<u>Repeated Measure - Originality Ratings</u>

Source	SS	DF	MS	F	P
OrigRM	.06	1	.06	.09	.764
Gp X OrigRM	.34	1	.34	.53	.468
Cp X OrigRM	1.61	1	1.61	2.52	.116
Gp X Cp X OrigRM	1.02	1	1.02	1.6	.21

<u>Note</u>. Gp=Group (Group vs. Alone); p=Computer (Computer vs. Non-Computer);
RPRM= Resolving Power (Repeated Measure) (Pre- vs. Post-Group Resolving Power Ratings).

Table 12

Repeated Measure - Resolving Power Ratings

Source	SS	DF	MS	F	P
RPRM	.04	1	.04	.06	.803
Gp X RPRM	.36	1	.36	.55	.459
Cp X RPRM	.03	1	.03	.04	.836
Gp X Cp X RPRM	1.57	1	1.57	2.4	.125

Note. Gp=Group (Group vs. Alone); p=Computer (Computer vs. Non-Computer); RPRM= Resolving Power (Repeated Measure) (Pre- vs. Post-Group Resolving Power Ratings).

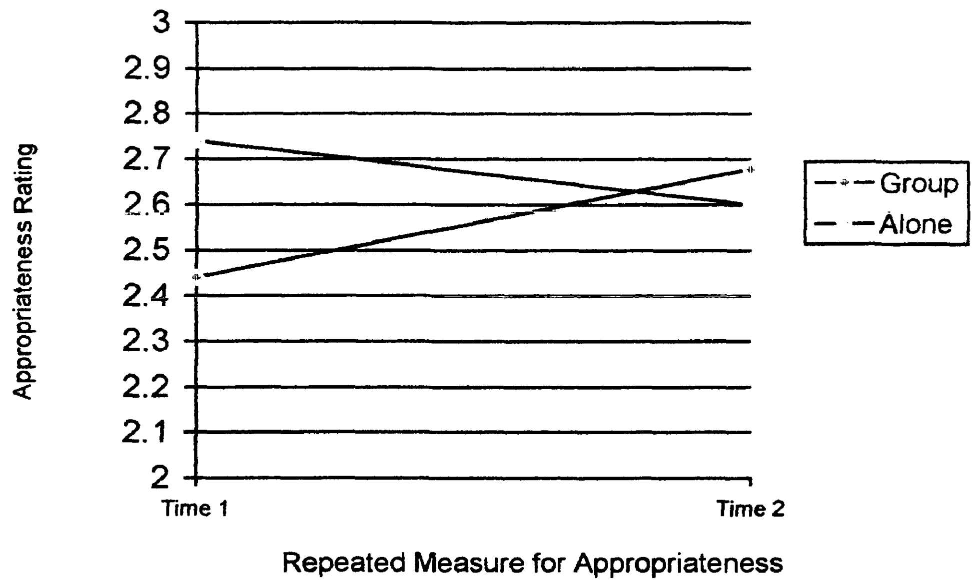


Figure 1. Repeated measure for mean appropriateness rating.

Table 13

Repeated Measure - Appropriateness Rating

	M		SD	
Variables	Time 1 App.	Time 2 App	Time 1 App.	Time 2 App.
Group	2.44	2.68	.62	.96
Alone	2.74	2.60	.90	.92

Note. Time 1 App.=appropriateness rating for initial problem solution. Time 2 App.=appropriateness rating for final problem solution.

generated for groups such that those groups using a computer will generate more new factors than those groups not using a computer.

Participants were given the opportunity to revise their factor list during the postgroup session of the study. The number of new factors that individuals added to their factor lists was counted. This new factor count was used as the dependent variable to determine the effect of the independent variables, group and media.

This analysis was run on the full data set as all factors were generated by individuals independent of each other. Again, Cochran's test of homogeneity was completed due to the concern regarding unequal cell size in this data set. The Cochran's test was significant , $\underline{C}(39,4) = .67$, $\underline{p} < .05$. As such the probability level should be lowered in order to avoid Type I interpretation error. For this reason, a probability level of $\underline{p} = .025$ was used for the analysis using this dependent variable. The analysis of variance as summarized on Table 14, indicated a significant main effect for group with participants working in a group generating significantly more new factors ($\underline{M} = .98$, $\underline{SD} = 1.8$) than those people working alone ($\underline{M} = .3$, $\underline{SD} = 1.12$), $\underline{F}(1,160) = 7.17$, $\underline{p} < .01$, ($\underline{\eta} = .04$). In addition, a main effect was found for media in that those people not working on the computer generated more new factors ($\underline{M} = 1.47$, $\underline{SD} = 2.14$) than those working on the computer ($\underline{M} = .09$, $\underline{SD} = .33$), $\underline{F}(1,160) = 19.92$, $\underline{p} < .01$, with 11 percent of the variance accounted for ($\underline{\eta} = .11$) Table 15 provided details of this analysis. The analysis of variance also indicates a marginally significant interaction between

Table 14

Number of New Factors Generated

Source	SS	DF	MS	F	P
Group	15.88	1	15.88	7.17	.008
Computer	44.10	1	44.10	19.92	.000
Group X Computer	10.73	1	1.73	4.85	.029
Simple Main Effects for New Factors Generated					
Cp within Gp1	84.25	1	84.25	36.48	.000
Cp within Gp2	3.72	1	3.72	1.32	.252
Gp within Cp1	5.28	1	5.28	1.88	.172
Gp within Cp2	57.22	1	57.22	23.08	.000

Note. Gp=Group; Gp1=Worked in Group; Gp2=Worked Alone;

Cp=Computer; Cp1=Worked on Computer; Cp2= Did not use Computer.

group and media was detected $F(1,160)=4.85$, $p=.029$, ($\eta=.03$). A simple main effects analysis was conducted to pinpoint the location of the significant mean differences. This analysis revealed a significant difference for media such when groups worked face-to-face ($M=1.84$, $SD=2.26$) they generated more new factors than groups working on the computer ($M=.12$, $SD=.38$), $F(1,160)=36.48$, $p<.025$. Nineteen percent of the variance in new factors generated is accounted for by non-computer groups ($\eta=.19$). In addition, a significant difference was detected for participants not working on computers such that those people working alone generated fewer new factors ($M=.58$, $SD=1.5$) than participants working in groups ($M=1.84$, $SD=2.6$), $F(1,160)=23.08$, $p<.01$, ($\eta=.13$). Figure 2 presents a graphic representation of this interaction. Table 15 displays the means for this analysis.

Analysis of Variance - Time

Hypothesis 3. The time needed for groups to generate a final solution will be significantly longer than the time needed for individuals.

Cochrans test of homogeneity demonstrated some problems in this area, $C(20,4)=.45$, $p<.05$ indicating heterogeneity of cells analyzed for time differences. For this reason, the level of significance was lowered to a probability level of $p=.025$ to compensate for the increase tendency to make a Type 1 interpretation error under these conditions. In an effort to determine the full nature of time as a factor in this study, an analysis of variance was conducted. The initial analysis of

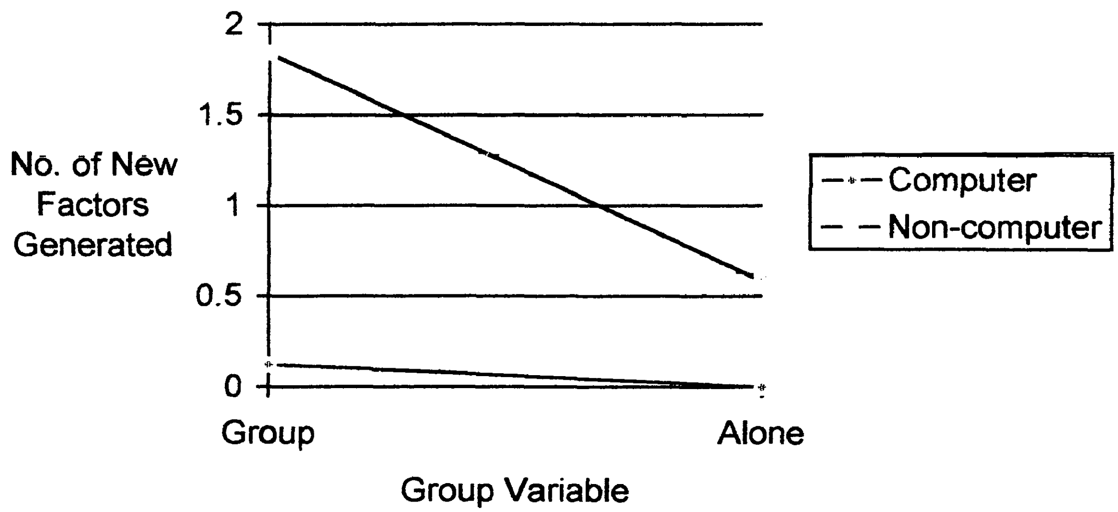


Figure 2. Group/media interaction for number of new factors generated.

Table 15

Number of New Factors Generated - Group/Media Interaction

Variable	M	SD
Group		
Group	.9825	1.8289
Computer	.1228	.3813
Non-Computer	1.842	2.2582
Alone	.2979	1.1212
Computer	.0000	.000
Non-Computer	.5833	1.529
Computer		
Computer	.0875	.3258
Group	.1228	.3813
Alone	.0000	.0000
Non-Computer	1.4691	2.1394
Group	1.8421	2.2582
Alone	.5833	1.5299

variance showed a strong interaction effect for group by media with twelve percent of the variance in time accounted for through this interaction (η=.12), $F(1,81)=11.25$, $p<.025$ (see Table 16 and Figure 3). Simple main effects demonstrate significant difference at three out of four of the analysis points.

For those participants working within groups, there was a significant difference in amount of time taken to complete the problem solving process such that those working on the computer took significantly longer (M=57.8 minutes) than did those working in face-to-face groups (M=35.5 minutes), $F(1,83)=25.50$, $p<.025$, with 24% of variance accounted for (η=.24). In addition, a strong significant difference occurred between those working alone on the computer relative to those working as a group on the computer, $F(1,83)=29.71$, $p<.025$, with 26% of the variance in time accounted for (η=.26). The group computer mean was 57.8 minutes as stated above while the those working alone on the computer took an average of 33.9 minutes to complete the task. A marginal difference also was found between those people not working on the computer, $F(1,83)=4.39$, $p=.039$, (η=.05). In this comparison, face-to-face groups took approximately 35.5 minutes to complete the task compared to 27.3 minutes on average for those working alone with paper and pencil (see Table 17).

Additional Measures

Computer experience using full data set. The Computer Experience Survey was completed by participants immediately following the computer

Table 16

Time for Completion of Task

Source	SS	DF	MS	F	P
Group	5433.70	1	5433.70	46.75	.000
Computer	4371.87	1	4371.87	37.61	.000
Group X Computer	1307.69	1	1307.69	11.25	.001
Simple Main Effects for Time					
Cp within Gp1	4730.95	1	4730.95	25.50	.000
Cp within Gp2	549.96	1	549.96	2.33	.131
Gp within Cp1	5305.97	1	5305.97	29.71	.000
Gp within Cp2	1010.78	1	1010.78	4.39	.039

Note. Gp=Group ; Gp1=Worked in Group ; Gp2=Worked Alone; Cp=Computer.;Cp1=Worked on Computer; Cp2= Did not use Computer.

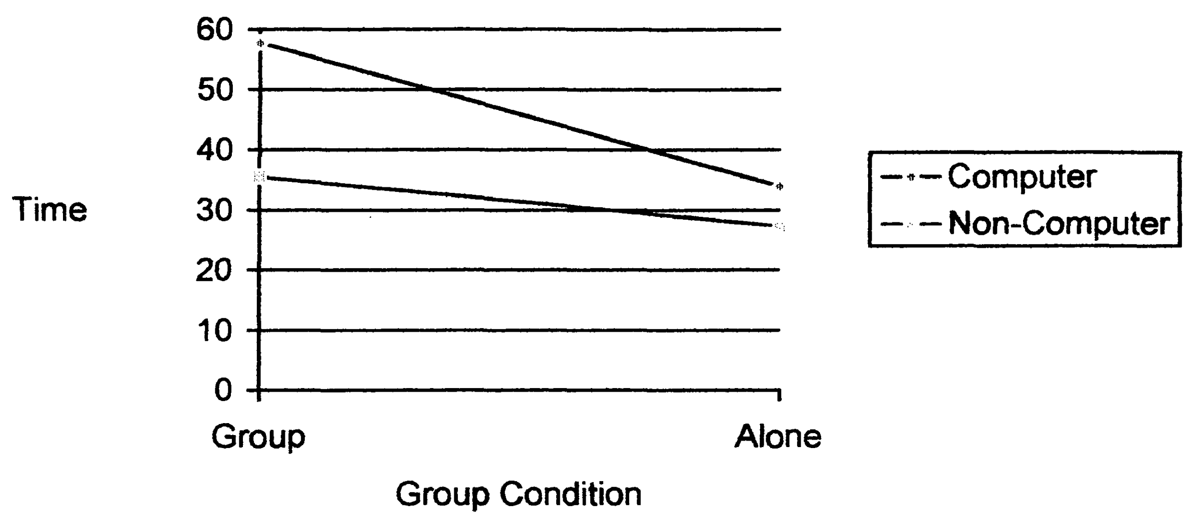


Figure 3. Time; Group/Media Interaction.

Table 17

Time in Minutes for Completion of Problem Solving Task

Variable	M	SD
Group		
Group	46.7	17.8
Computer	57.8	15.0
Non-Computer	35.5	12.9
Alone	30.5	7.9
Computer	33.9	9.06
Non-Computer	27.3	5.0
Computer		
Computer	44.7	16.9
Group	57.8	15.0
Alone	33.9	9.1
Non-Computer	30.9	10.1
Group	35.5	12.9
Alone	27.3	5.0

experience. For this reason, we considered the possibility that the immediacy of the computer experience may have influenced the computer survey responses. Therefore, a full analysis of this data was completed in order to determine all possible response differences.

The Computer Survey contained two subscales: Computer Experience (Factual) and Computer Experience (Affect). Cochran's test of homogeneity proved to be non-significant for this analysis, $C(39,4) = .31$, $p > .05$.

Factual computer experience. A significant interaction between group and media was revealed in this analysis, $F(1,157) = 7.64$, $p < .01$, ($\eta = .05$). This interaction is graphically depicted in Figure 4.

Simple main effects were conducted to determine the exact nature of the interaction depicted graphically above. A significant difference was confirmed for those working in groups such that the group members who worked on the computer reported more factual computer experience ($M=5.4$, $SD=.89$) than the groups working face-to-face not using a computer ($M=4.7$, $SD=1.18$), $F(1,157)=11.17$, $p<.01$, ($\eta=.07$). Table 18 provides clarification. In addition, when participants used the computer, there was a difference in reported factual computer experience such that those working alone on the computer reported less experience ($M=4.9$, $SD=1.17$) than those working in a group on the computer ($M=5.4$, $SD=.89$) (see Table 19). A higher mean rating indicates greater factual experience.

Table 18

Analysis of Variance Results - Computer Experience - Factual

Source	SS	DF	MS	F	P
Group	.01	1	.01	.01	.941
Computer	.78	1	.78	.69	.406
Group X Computer	8.58	1	8.58	7.64	.006
Simple Main Effects for Computer Experience - Factual					
Cp within Gp1	12.49	1	12.49	11.17	.001
Cp within Gp2	1.48	1	1.48	1.24	.267
Gp within Cp1	7.43	1	7.43	6.46	.012
Gp within Cp2	7.02	1	7.02	6.09	.015

Note. Gp=Group; Gp1=Worked in Group; Gp2=Worked Alone; Cp=Computer; Cp1=Worked on Computer; Cp2= Did not use Computer.

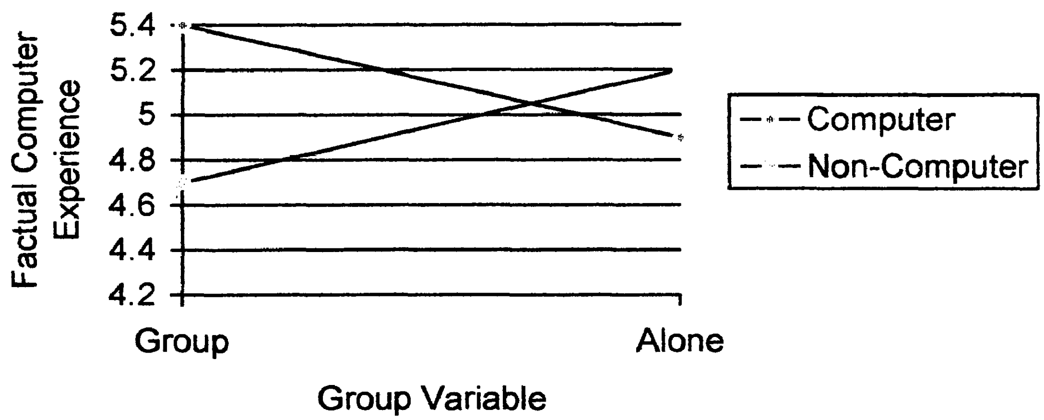


Figure 4. Interaction by group and media for factual computer experience

Table 19

Mean Response Rates: Factual Computer Experience

Variable	M	SD
Group		
Group		
Computer	5.4	.888
Non-Computer	4.7	1.18
Alone		
Computer	4.88	1.17
Non-Computer	5.23	1.01

Computer Experience: Affect. The questions on this subscale of the Computer Survey were designed to determine how participants felt about computer use in general. A significant interaction was found between the two independent variables, $F(1,157)=5.81$, $p<.05$, ($\eta=.04$). This interaction is depicted in Figure 5.

Simple main effects were analyzed in order to determine the exact nature of this interaction. A significant simple main effect was found for those participants working within groups such that when they working on a computer they reported more positive attitude toward computer use (affective measure) ($M=5.68$, $SD=.84$) compared to those working in face-to-face groups ($M=5.25$, $SD=1.32$), $F(1,156)$ 4.27, $p<.05$ ($\eta=.03$). A marginally significant simple main effect was also found for those participants who worked on the computer, ($\eta=.02$), $F(1,156)=3.76$, $p=.054$, (see Table 20). Those working in a group on the computer report more positive attitude toward computer use ($M=5.68$, $SD=.84$) than did those participants who worked alone on the computer ($M=5.19$, $SD=1.22$). In addition, a marginally significant simple main effect was also found for those participants who did not work on the computer, $F(1,156)=3.44$, $p=.066$, ($\eta=.02$). This main effect indicates that participants working alone reported more positive computer affect ($M=5.69$, $SD=.99$) than did participants who worked in face-to-face groups ($M=5.25$, $SD=1.32$) (see Table 21).

Table 20

Computer Experience - Affect

Source	SS	DF	MS	F	P
Group	.01	1	.01	.01	.922
Computer	.04	1	.04	.03	.858
Group X Computer	7.13	1	7.13	5.81	.017
Simple Main Effects for Computer Experience - Affect					
Cp within Gp1	5.25	1	5.25	4.27	.04
Cp within Gp2	2.89	1	2.89	2.32	.13
Gp within Cp1	4.64	1	4.64	3.76	.054
Gp within Cp2	4.25	1	4.25	3.44	.066

Note. Gp=Group; Gp1=Worked in Group; Gp2=Worked Alone; Cp=Computer; Cp1=Worked on Computer; Cp2= Did not use Computer.

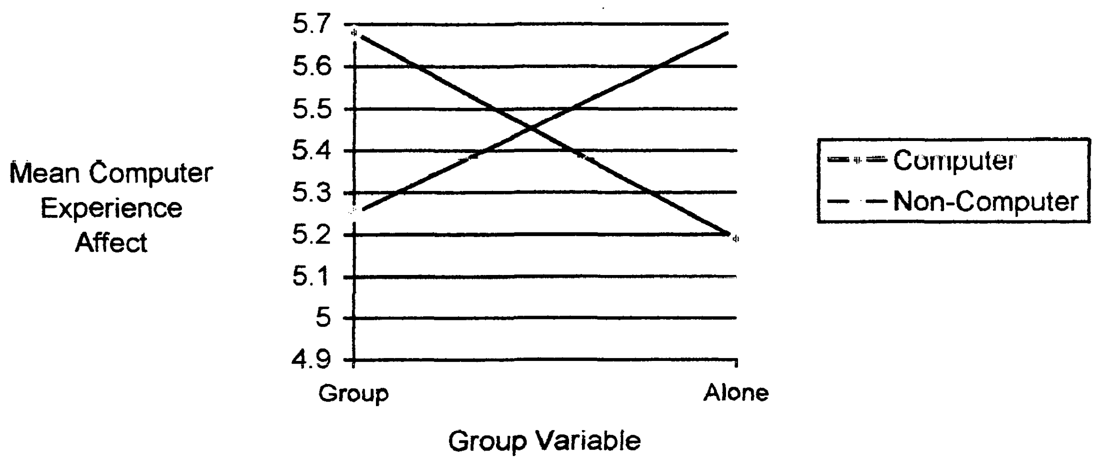


Figure 5. Interaction by group and media for affective computer experience.

Table 21

Mean Response Rates: Affective Computer Experience

Variable	M	SD
Group		
Group		
Computer	5.68	.8355
Non-Computer	5.25	1.3187
Alone		
Computer	5.19	1.2177
Non-Computer	5.69	.9945

Satisfaction Survey-Full Data Set

As stated earlier, the satisfaction survey contained six subscales: General Satisfaction, Evaluation Apprehension, Production Block, Free Riding, Perception of Time and Synergy and Stimulation. Each of these subscales will be address in the following analyses. The subscales were used one at a time as dependent variables to determine if response means differed systematically as a function of the independent variables, group and media. Table 22 displays the means for all satisfaction survey responses.

General satisfaction. Cochran's test of homogeneity was not significant for this particular analysis, $C(39,4)=.34583$, $p>.05$. A main effect for group was revealed in the analysis of variance, such that participants who worked in groups reported greater general satisfaction with the task process ($M=5.66$, $SD=.78$) relative to those participants who worked alone ($M=5.33$, $SD=.98$), $F(1,155)=5.14$, $p<.05$, ($\eta=.03$). Table 23 provided details of this analysis.

Evaluation apprehension. Cochran's test of homogeneity was non-significant, $C(39,4)=.31867$, $p>.05$. A significant interaction for computer by group was revealed through the analysis of variance, $F(1,155)=4.88$, $p<.05$, ($\eta=.03$). Figure 6 presents a graphic illustration of the relationship between the variables.

Simple main effects were conducted to determine the nature of the interaction effect (see Table 24). A significant difference was found in media for those participants working alone such that those working alone using paper and

Table 22

Mean Response Rates for Satisfaction Survey Subscales

Variable	M	SD
General Satisfaction		
Group	5.66	.783
Computer	5.56	.803
Non-Computer	5.76	.759
Alone	5.33	.982
Computer	5.3	1.05
Non-Computer	5.35	.935
Evaluation Apprehension		
Group	5.46	1.10
Computer	5.39	1.18
Non-Computer	5.54	1.03
Alone	5.36	1.08
Computer	4.85	1.12
Non-Computer	5.82	.83
Production Blocking		
Group	5.05	1.41
Computer	5.22	1.18
Non-Computer	4.88	1.61
Alone	5.41	1.17
Computer	5.4	1.19
Non-Computer	5.43	1.16
Free Riding		
Group	5.53	.957
Computer	5.43	.975
Non-Computer	5.63	.937
Alone	5.34	1.036
Computer	5.15	.953
Non-Computer	5.2	1.096
Perception of Time		
Group	5.89	1.06
Computer	5.8	1.09
Non-Computer	6.0	1.03
Alone	6.33	.843
Computer	6.18	.91
Non-Computer	6.46	.772
Synergy & Stimulation		
Group	5.15	1.04
Computer	5.26	1.1
Non-Computer	5.04	.96
Alone	5.02	1.02
Computer	4.75	1.13
Non-Computer	5.27	.854

Note. Scale ranged from 1 to 7 with 7 reflecting: Gemeral Satisfaction; 7= Most positive satisfaction; Evaluation Apprhension; 7=Lowest apprehension; Production Blocking 7=lowest blocking effect; Free Riding 7=lowest sense of free riding; Perception of Time 7=Not enough time; Synergy & Stimulation 7=highest task involvement.

Table 23

Satisfaction Survey; General Satisfaction Subscale

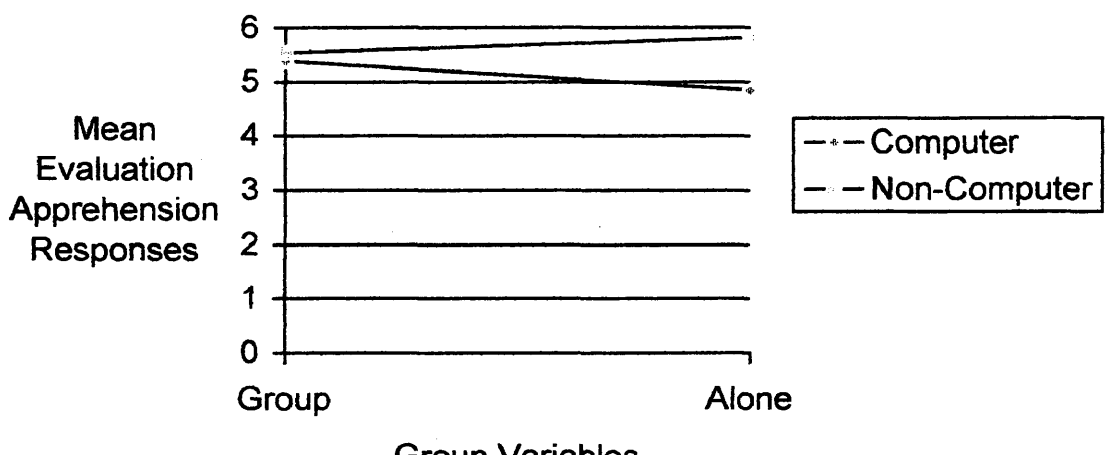
Source	SS	DF	MS	F	P
Group	3.69	1	3.69	5.14	.025
Computer	.48	1	.48	.68	.412
Group X Computer	.17	1	.17	.23	.629

Table 24

Satisfaction Survey: Evaluation Apprehension Subscale

Source	SS	DF	MS	F	P
Group	10.11	1	10.11	8.81	.003
Computer	.52	1	.52	.45	.501
Group X Computer	5.6	1	5.6	4.88	.029
Simple Main Effects					
Cp within Gp1	.58	1	.58	.48	.49
Cp within Gp2	10.65	1	10.65	9.35	.003
Gp within Cp1	1.56	1	1.56	1.3	.256
Gp within Cp2	.17	1	.17	.14	.706

Note. Gp=Group Gp1=Worked in Group Gp2=Worked Alone
Cp=Computer Cp1=Worked on Computer Cp2= Did not use Computer



Note. A high rating (6) indicates less apprehension, low rating (1) high apprehension

Figure 6. Group by media interaction for mean evaluation apprehension responses on the satisfaction survey. A rating of 6 indicates less apprehension.

pencil to complete the problem solving task were less apprehensive (M=5.82, SD=.83) than those working alone on the computer (M=4.85, SD=1.12), $F(1,157)=9.35$, $p<.01$, (η=.06).

Perception of time. Cochran's test of homogeneity was non-significant, $C(39,4)=.32491$, $p>.05$ giving confidence to traditional significance levels for this analysis. Table 25 shows that a significant main effect was found for group, $F(1,155)=5.78$, $p<.05$, (η=.04). An examination of the means demonstrates that participants working alone felt less time urgency (M=6.33, SD=.84) than did participants working in a group (M=5.8, SD=1.06). This effect held true regardless of whether the task was completed on the computer or with paper and pencil.

Synergy and stimulation. The test of homogeneity proved to be non-significant for this analysis of variance, $C(39,4)=.3098$, $p>.05$. This provides confidence in the results of this analysis which demonstrated a significant interaction between group and media. Figure 7 graphically depicts this interaction.

The simple main effects analysis revealed a marginally significant result such that for those working on a computer, participants who worked in a group perceived a greater sense of synergy (M=5.26, SD=1.1) than did those individuals working alone (M=4.75, SD=1.1), $F(1,157)=3.58$, p=.06, (η=.02)

Table 25

Satisfaction Survey; Perception of Time Subscale

Source	SS	DF	MS	F	P
Group	5.83	1	5.83	5.78	.017
Computer	1.83	1	1.83	1.81	.18
Group X Computer	.05	1	.05	.05	.82

(see Table 26). Due to the specific nature of the questions, these results can be said to reflect amount of task involvement or task enjoyment (see Appendix C).

Production Blocking and Free Riding. The analysis of variance failed to detect any differences in the survey responses for production block or free riding as a function of group or media (see Tables 27 and 28).

Table 26

Satisfaction Survey: Synergy and Stimulation Subscale

Source	SS	DF	MS	F	P
Group	.62	1	.62	.59	.445
Computer	.67	1	.67	.64	.425
Group X Computer	4.44	1	4.44	4.24	.041
Simple Main Effects					
Cp within Gp1	1.43	1	1.43	1.35	.247
Cp within Gp2	2.92	1	2.92	2.78	.097
Gp within Cp1	3.73	1	3.73	3.58	.060
Gp within Cp2	.87	1	.87	.82	.365

Note. Gp=Group; Gp1=Worked in Group; Gp2=Worked Alone; Cp=Computer; Cp1=Worked on Computer; Cp2= Did not use Computer.

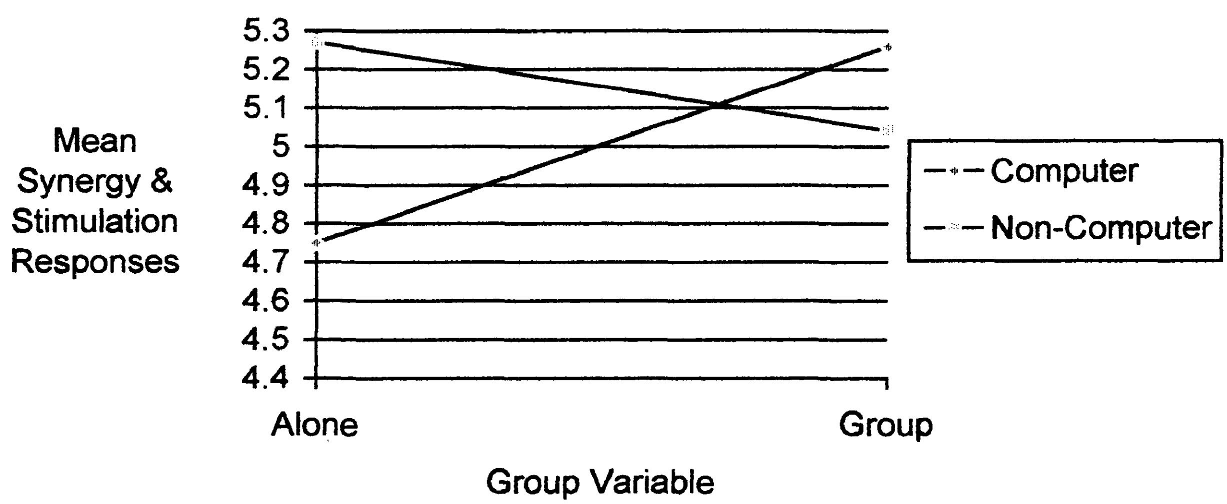


Figure 7. Group by media interaction for mean synergy and stimulation responses on Satisfaction Survey. Can be interpreted as task involvement with a high rating indicating greater involvment (synergy & stimulation).

Table 27

<u>Satisfaction Survey; Production Blocking Subscale</u>

Source	SS	DF	MS	F	P
Group	4.3	1	4.3	2.37	.126
Computer	.83	1	.83	.45	.501
Group X Computer	1.16	1	1.16	.64	.426

Table 28

<u>Satisfaction Survey; Free Riding Subscale</u>

Source	SS	DF	MS	F	P
Group	1.20	1	1.20	1.26	.263
Computer	2.70	1	2.70	2.82	.095
Group X Computer	.24	1	.24	.25	.617

Discussion

It is important at this point to change the focus of the discussion from a micro perspective to a macro perspective. It is sometimes difficult to evaluate complex results when the focus is on the minute statistical details. For this reason, a broader focus will be adopted in order to discern the meaningfulness of these results as an integrated body of information. Results will be summarized and linked with past research in an effort to gain a better understanding of complex problem solutions under varying conditions.

The effect of computer/group interaction on problem solving was investigated in this study. A comparison was made, utilizing networked group software, between those individuals working together via computer linkup and those working face-to-face. In addition, individual productivity was examined under similar circumstances.

Hypothesis 1: Quality of Solutions Generated

Quality, defined as a tripartite concept which includes the appropriateness of the solution, originality of the solution and the resolving power of the solution was the focus of Hypothesis 1 in this study. Utilizing a research design wherein all subjects worked as individuals during the pre-group phase, it was anticipated that there would be no differences in the quality of the solutions generated at this juncture. This proved to be the case for the originality and resolving power ratings for this initial solution, however, the appropriateness ratings displayed a surprising result. The participants who knew they would eventually be working and sharing information with others in their group, generated initial solutions which were of lower appropriateness than those participants who knew they would continue to work alone. Although this pre-solution was lower, the gain in the appropriateness rating for the post-group consensus solution for those working in groups was marginally higher than the change experienced by those working alone. Although no significant differences were detected in either the appropriateness of the initial solution, or in the appropriateness of the final solution, we do see a marginally significant difference in the gain in quality as measured by appropriateness for those people working in groups.

This depression of the pre-group initial solution quality ratings is an interesting result. There appears to be what might be called an "anticipation" effect at work with these participants which resulted in lower appropriateness ratings for those solutions. This anticipation effect may possibly stem from social loafing (also known as free riding) which has frequently been shown to reduce an individual's contribution to the group. However, this group dynamic is typically detected within the group framework when an individual in a group is content to sit back and let others do the work knowing all will get credit for the group contribution. Social loafing suggests that participants do not perform up to their potential because they believe they will get credit for the group productivity regardless of their input. This group effect has been pinpointed as a reason for lowered group productivity (Gallupe, et al., 1994). The fact that participants were not yet working within the group environment suggests there may be something quite different at work here. The significantly higher level of synergy and stimulation reported by the computer group may have driven the improvement or gain displayed by all those working within a group. However, this would not explain the relative lower starting point for those anticipating working in a group. It appears that they chose to put less effort into their initial solution because they knew they would have an opportunity to collaborate in the future. For those working alone, this opportunity to collaborate was not an option as they knew from the beginning that the effort and product was their's alone.

The finding that differences in the appropriateness of the solutions was eliminated with the final solution points suggests that free riding was not a factor during the actual group interaction. The difference found between the initial solution rating and the final solution rating for appropriateness is a reflection of the group participants starting lower and ending higher than those participants working alone. This suggests that free riding did not occur. In addition, free riding was not detected through the satisfaction survey. This survey attempted to determine participants' perception of level of involvement which can be interpreted as a measure of free riding. The mean ratings indicated strong feelings of involvement for all participants in all conditions.

Hypothesis 2: Number of New Factors Generated

Again, the foundation for this hypothesis lies in the action of the negative group dynamics, free riding, production blocking and evaluation apprehension and the positive dynamic of synergy and stimulation. As the negative dynamics have been shown to decrease the productivity of people working in face-to-face groups, the computer linked work environment was designed to capture the synergy of the group interaction while eliminating the negative aspects of group interaction. In this way, when given the opportunity to do so, the computer group was expected to produce a greater number of new factors. This did not happen. In fact, just the opposite proved to be true in this study. The group working face-to-face, presumably under the burden of the negative group dynamics of free riding, production blocking and evaluation apprehension, proved to be the most productive in new factors generation. Overall, those working on the computer generated very few new factors. At least a partial explanation may be revealed through an examination of the computer group dynamics. As the participants in these computer group could communicate with each other only through the computer, a verbatim record was captured of their communications with each other. A review of these communications revealed several similarities among computer groups. While managing to stay focused on the task, their comments revealed an enjoyment of the computer communication process. This process is similar to on-line e-mail or the communication one would encounter through a computer chat line. The computer communication processes appears to be so engaging that at the end of each session participants had lost track of time and felt time pressure to reach consensus.

Based on the verbal feedback during debriefing and comments captured on the computer communication screen, I would hypothesize that the computer group failed to generate new factors because they ran out of time. Although this was not a "timed" exercise per se, in effect their perception of "running out of time" may have been a controlling factor. To recap the process, the participants arrived at consensus for solution, were instructed to turn back to their individual factor list for revision and then to the survey material. Very little revising of factor lists took place in this group and time appears to be the offender. The commentary reveals that it was not uncommon for at least one member of the group to be pushing the others to consensus toward the end of the session, due to time constraints. Comments recorded on the computer printout of the information exchange between group members point in this direction. This included mention of participants having to get to another class, go to lunch (getting hungry !), or just having other things to do which necessitated finishing the assigned task and "getting out of there."

Hypothesis 3: Time

The time issue is evident in the analysis that demonstrates a significantly longer time interval for completion of the task for groups in general and for the computer group condition in particular. Some of this may be accounted for by the need for the groups to reach concensus, some perhaps by the computer process itself. Although training time (apx. 2 minutes) for those using computers was not included in their total work time, the lack of familiarity with the work media may have increased time used for completion of the problem solving process. However, this doesn't account for the dramatic increase in time shown by the participants in the computer group over and above all other conditions, including those working alone on the computer. An additional 23 minutes, on average, was taken by computer groups over any of the other conditions. In addition, the Satisfaction Survey subscale on Perception of Time reveals that participants in the group conditions felt greater time pressure with regard to the problem solving process.

Some of the time difference may be accounted for based on procedural differences. A task assigned to the people working alone designed to give them a time interval during which they could think about the problem similar to those working in a group appears to have been a less time consuming activity (Leisure Activity Survey). Although exact times were not kept for this specific part of the activity, most individuals were able to complete this survey in less than five minutes. In general, based on observation of time on task, the group information exchange took longer than this. For this reason, we would expect the groups to be engaged in the overall problem solving task for a longer time. However, this factor alone cannot account for the dramatic differences in the time participants used for this study. Those on the computer appeared to choose to stay engaged in the performance of the task longer than all other conditions. Perhaps this willingness to stay engaged could be put to more productive use under different conditions. One could speculate that if the generation of new factors had been assigned as a group task rather than an individual task, the results would have been more productive.

Computer Experience

This survey was designed to tap into each individual's factual and affective computer experience. The survey was used in order to address the concern that results could be attributed to differences in computer experience that the individuals brought with them to the problem solving task. Of particular concern was that computer illiteracy could depress the performance of the computer participants. This does not appear to have happened. In fact, the computer survey sub-scale for factual experience indicated that the computer group was more experienced relative to other conditions. It was anticipated that there would be no differences in either factual or affective computer experience due to random assignment to the various conditions. Although the full computer survey supported this hypothesis, the sub-scale analysis revealed an unexpected result. These results showed that the people who worked in computer groups reported more computer experience and stronger positive affect toward computer useHowever, these additional findings are of interest as the computer experience survey was completed at the end of the problem solving task. Therefore, these results are possibly attributable to the study computer experience. Computer use was very salient in the minds of the computer group. The individuals working in the computer group had also reported high satisfaction with the problem solving process. In fact, this satisfaction level was significantly higher than the satisfaction level reported by people working in the other conditions. Comments made during debriefing also indicated these participants found the computer group experience to be interesting and fun. This experience appears to have had an impact on their reported factual and affective computer experience. Obviously, our purpose would have been better served had the computer experience survey been completed at the beginning of the problem solving exercise. This small format change would have likely provided us with a more accurate pre-study report on this variable.

It is important to remember that our main concern was that computer illiteracy might depress computer performance, as such, the report of more computer experience and stronger positive affect was not a concern for the analysis.

Implications of Findings

Today's focus on team activity coupled with computer networking, provided the impetus for this study. Although the original hypotheses were not supported, the findings of this study do provide important information that can be useful to business and industry. Communication plays an ever increasing role in the success and failure of business ventures in the information age. It is not unusual for the exchange of information and collaboration on a problem to be conducted via network computer communications. This focus on group interaction via computer either within a decentralized company or between companies with common goals, begs the question of whether this is an effective way to interact. This study indicates that problems can be addressed and solved as effectively via computer interaction. We see no deficit in the quality of problem solution when people were linked only through the computer. So, rather than physically bringing people together for a face-to-face conference, and incurring the associated costs, groups can collaborate through a computer linkup with confidence that their product will be as effective as those solutions that come out of face-to-face meetings. A major complaint in industry today is the number of meetings people are required to attend. Some of these meetings could presumably be replaced with computer problem solving. In this way, problems could be addressed by groups in real time or over a pre-specified time period at the convenience of participants. This access to the dialogue of problem solving provided by the computer environment allows for individual time management as well as group interaction.

This is not to say that people should be encouraged to stay at their computer having contact with others only rarely. The benefits of occasional face-to-face interaction cannot be understated including the members' growth and personal well-being (Sutton & Hargadon, 1996). This sense of well-being that springs from group interaction can quickly turn into stress, however, when meetings are strung end to end. It is interesting to note that the computer groups appear to have experienced some of these same group interaction benefits as reflected in the satisfaction survey without the time and resource availability limitations of physically moving to different meeting sites. Through the intelligent integration of computer group interaction into the corporate communication process, time control can be put back into the hands of the individuals involved.

Study Limitations

One of the major limitations of this study comes out of the inability of this research study to develop a computer group environment that incorporated more than three computers. Research indicates that many of the benefits of computer interaction are not evident until groups approach 12 to 15 in number (Dennis & Valacich, 1993). These researchers speculated that a critical mass of ideas is necessary in order for synergy to be triggered in a group. In groups of 12 to 15 participants, they believe this synergy is achieved. In this study, the limitation of groups to three members may have contributed to our inability to detect condition differences in the pre- and postgroup quality ratings. However, the fact that we did experience a gain in the appropriateness ratings demonstrates that a computer group environment is conducive to productive complex problem solving. With larger groups, perhaps more typical of the real world work environment, pulled together via computer, this productivity gain may be even more evident. Such real world groups would differ qualitatively as well as quantitatively from the research groups utilized in this study where there were no real consequences for task outcome and the group members brought relatively homogeneous skills to the task environment. Real world groups could be expected to bring diverse skills and knowledge to the task as well as motivation stemming from the consequences of their problem resolution.

A second limitation to this study was perhaps the actual problem presented to the participants for solution (Clara's problem). Although couched in student terms, this problem was selected in order to simulate the kind of complex problem faced by people in industry. Feedback from the pilot study indicated that students did not find the problem to be difficult to solve or particularly complex in nature. For this reason, the problem was revised, in an effort to increase the complexity. However, if the problem was still not complex enough, the problem may have stimulated multiple obvious solutions. With many obvious solutions available, the participants may not have made the effort to develop more creative problem solutions. The lack of variance in the originality of solutions is a strong indicator that creativity was not tapped in this study. Presentation of a problem of very high complexity, with no obvious solution, may have changed the nature of the problem solving process, forcing participants to become more creative in their approaches, which in turn could have provided the variance necessary to distinguish performance differences between groups. It is in this highly complex environment that group synergy is likely to boost productivity based on one group member working from an idea or even a small piece of an idea presented by another group member.

That the actual problem presented can have an effect of the participants and in turn the participants responses as been demonstrated in recent research.

This problem was drawn from a group of problems which had been tested for emotional impact on the participants as part of a taxonomy study (Scherer, Butler, Reiter-Palmon, & Weiss, 1994). Clara's problem was shown to be relatively innocuous with regard to emotional reactions, however, the level of complexity may have fallen short of that needed in this study to challenge the group mind. One could expect real world problems that would trigger or necessitate the bringing together of multiple sources of expertise to be of such complexity.

In retrospect, it appears that training of raters may also have been a weakness in this study. Although consensus data was used in the analyses, the initial ratings completed by the two raters displayed relatively low reliability. This indicates that the raters may have lacked a solid understanding of the rating concepts during the initial rating. A presumption of understanding, based on rater familiarity with the rating schema and a brief but intense training period, was perhaps misplaced. The consensus information could possibly have been a product of compromise in divergent ratings rather than a cognitively correct interpretation of the quality under scrutiny. This compromise in ratings may have diluted the variance for the quality ratings for problem solutions.

The placement of the computer survey at the end of the study also appears to have influenced the responses by participants, with the primacy of the computer experience having a particular impact. This is, however, only an error based on the original purpose. The placement of this survey at the end of the process provided unexpected valuable information regarding the positive aspects of the computer experience. When people actually work on the computer for group problem solving, they find the experience to be very positive which apparently influences their self-efficacy regarding computer use. This increased computer self-efficacy is reflected not only in the reported computer factual and affective responses but also in the high overall satisfaction reported by this group.

The influence of anticipated group participation, which may have led to social loafing or free riding for some of the subjects was a function of research design. This effect could have been eliminated had all subjects been told initially that they would be working on their own for this project. Later in the instructions, a change could have been introduced to the participants which would have linked some of them into groups. In this way, anticipation of group interaction would not have been a factor.

Future Research

The similarity found in the quality of problem solutions regardless of group or media is a positive finding. But, it is just a starting point. Field research which utilizes existing computer networks within and between companies, with the capability of linking large groups in complex problem solving may be a better test of the original hypothesis. This hypothesis suggested that computer linked groups would actually produce higher quality problem solutions because they were not subjected to the negative group dynamics of free riding, production blocking and evaluation apprehension.

Typically, groups are brought together when any individual working alone would have a difficult time solving the actual problem. The group members will bring different skills, knowledge, experience and perspectives to the problem solving activity. This diverse group make-up working on a highly complex problem may be exactly what is needed for the generation of high quality solutions. It is difficult to approximate these real world group dynamics in the laboratory. A field study could more closely approximate the conditions faced by problem solvers in their day to day efforts to "get the job done".

The perception of time factor revealed in this study and the potential for impact on quality may be another fruitful source of future research. As it appears that people may impose time constraints even when the researcher does not, a study directed specifically at actual and perceived time could provide information that would be applicable to the work environment.

Past research also suggests that working in face-to-face groups leaves participants with a feeling of well-being. I would suggest that this satisfaction turns to stress as the number of meetings increases. Where is the pivot-point located which turns the positive aspects of face-to-face interaction into a stressor. This research could reveal the nature of the balance that should be promoted between face-to-face work groups and electronic work groups.

An analysis of group process based on the dialogue captured during the computer group exchange would also be of interest. Would group size influence the dynamics of the communication exchange? Do those groups who communicate at greater length produce a higher quality final product? Are participants actually responding to other group member's ideas or building on their own ideas?

The complexity of computer interaction could also be explored through a research design that controlled the nature of communication between group participants. A simple statement to the effect that computer group interaction facilitates problem solving fails to delve into the richness of the dynamics of the media. The groupware program could be configured to simulated the variance found in the natural work environment. These configurations might include: a read only condition, waiting sequentially for an opportunity to respond or timed entry to other group participant's ideas.

The computer experience survey results could also provide fodder for future research. Did these results actually occur because of the placement of the survey following the computer experience? Would we get similar results if placement of the survey was manipulated with some participants completing it immediately prior to, or perhaps a week following the actual study?

In the current study, the importance of the decision or solution to the problem was not manipulated. It is possible that had emphasis been place on the importance of generation of new factors or the importance of the final solution, our results would have been different. When the importance level is left up to the individual participants, each brings a different impetus to the situation. Decision importance is certainly a variable that influences people mandated to make decisions in the work environment. Could the added stress of importance actually undermine the quality of the final solution?

The anticipation effect found in this study may also be an interesting study in itself. Is this effect common to all individuals who anticipate working in a group and under what conditions is it most prevalent? Can this effect be isolated and can attributions regarding the source of this effect be teased out? Is this effect a complex blending of social loafing, free riding and evaluation apprehension?

This study appears to bring to mind many avenues for future research, while also serving to provide a little more information to guide these ventures.

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Appendix A

Stimulus Problem: Clara

Problem Description

Clara's Problem

Clara, a junior pre-med student, is working part-time and taking a 15 hour credit load at school. Clara enjoys her pre-med courses very much, but they are difficult and time consuming. Her current job as a "gopher" at an architectural design firm requires her to work 25 hours a week which really cuts into her available study time. In fact, she is barely getting "C's" in two of the classes she needs for her major. The pay in her present job is good, and she enjoys the work, although she is not getting a lot of practical experience. Clara does not want to drop any of her classes as she needs them to graduate so that she can be admitted to medical school in the coming year. Up until now, Clara has been able to work at her job and still get good grades, but the difficult courses she is taking now require much more of her time. Clara needs to work in order to finance her education. Clara is not sure how to solve her problem.

Appendix B

Leisure Activities Survey

Participant No.__________

In this inventory we are interested in your extra-curricular activities and accomplishments. For each item mark in the corresponding shadow box the answer that best describes you. Do not count school assignments unless specified to do so.

Please use the following scale to answer the items.

A=never
B=once
C=2-3 times
D=4-5 times
E=6 or more times

How often have you constructed something that required scientific knowledge, such as radio, telescope, or other scientific apparatus?

How often have you presented an original mathematics paper to a professional or special interest group?

How often have you entered a project or paper into science competition?

How often have you applied math in an original way to solve a practical problem?

How often have you written an original computer program?

How often have you won an award for a scientific project or paper?

How often have you entered a mathematical paper or project into a contest?

How often have you had a scientific paper published?

How often have you dissected a plant and/or animal. Remember - not in school?

How often have you solved statistical/mathematical problems with a computer?

How often have you attended summer math/science programs?

How often have you had a scientific project publicly displayed or exhibited?

How often have you participated in scientific research project?

Leisure Activities 1

Participant No.___________

A=never
B=once
C=2-3 times
D=4-5 times
E=6 or more times

How often have you participated in a scientific/math club or organization?

How often have you worked as a laboratory assistant?

How often have you worked as an editor for a school literary publication?

How often have you had a piece of literature (e.g.. poem, short story) published in a school/university publication or professionally?

How often have you written poetry?

How often have you written lyrics to a song?

How often have you won an award for something you wrote?

How often have you participated in a writers' workshop, club, or similar organization?

How often have you written a short story?

How often have you written something humorous, such as jokes, limericks, satire, etc.?

How often have you painted an original picture?

How often have you made a sculpture?

How often have you received an award for artistic accomplishment?

How often have you drawn cartoons?

How often have you drawn a picture for aesthetics reasons?

How often have you taken and developed your own photographs?

How often have you constructed a puppet or put on a puppet show?

How often have you designed and made your own greeting cards?

How often have you cooked an original dish?

Leisure Activities 1

Participant No.___________

A=never
B=once
C=2-3 times
D=4-5 times
E=6 or more times

___ How often have you made a ceramic craft?

___ How often have you won an award in musical competition?

___ How often have you performed regularly as a professional musician?

___ How often have you had any music that you have composed or arranged receive a professional performance?

___ How often have you written music for lyrics?

___ How often have you belonged to a community/professional musical organization?

___ How often have you set up your own experimental conditions or laboratory?

___ How often have you won an award in math competition (math league, math club)?

___ How often have you had artwork or craftwork publicly exhibited?

___ How often have you designed and constructed a craft out of wood?

___ How often have you designed and made a piece of clothing?

Appendix C

Satisfaction Survey

Participant No ________
Satisfaction Survey

Please circle the number that best expresses your answer to the question

*How do you feel about the process by which you generated ideas?
Very Dissatisfied — Very Satisfied
1 2 3 4 5 6 7

**How do you feel about the problem solutions?
Very Dissatisfied — Very Satisfied
1 2 3 4 5 6 7

*All in all, how did you feel?
Very Dissatisfied — Very Satisfied
1 2 3 4 5 6 7

***How do you feel about the process by which you weighted the factors?
Very Dissatisfied — Very Satisfied
1 2 3 4 5 6 7

***How do you feel about the opportunity to review and revise the final solutions?
Very Dissatisfied — Very Satisfied
1 2 3 4 5 6 7

*When you thought of an idea,
Could you express it immediately — Did you have to wait to express it
1 2 3 4 5 6 7

*Did you express you ideas
Soon after you thought of them — After waiting for awhile
1 2 3 4 5 6 7

***This process made it easy for me to immediately express my thoughts?
Strongly Agree — Strongly Disagree
1 2 3 4 5 6 7

***Waiting was not a problem in this problem solution process.
Strongly Agree — Strongly Disagree
1 2 3 4 5 6 7

*Did you feel any apprehension about generating your ideas?
A lot of apprehension — Neutral/ Undecided — No apprehension
1 2 3 4 5 6 7

**How at ease were you during the problem solving?
Definitely not at ease — Neutral/ Undecided — Very at ease
1 2 3 4 5 6 7

***I was nervous about what others would think of my answers
Strongly Agree — Strongly Disagree
1 2 3 4 5 6 7

***I felt like I would be evaluated on the quality of my information.
Strongly Agree — Strongly Disagree
1 2 3 4 5 6 7

**How much do you feel you participated in this problem solving session?
Not much at all — Neutral/ Undecided — A lot
1 2 3 4 5 6 7

*How satisfied are you with your own performance on this task?
Very Dissatisfied — Neutral/ Undecided — Very Satisfied
1 2 3 4 5 6 7

***I didn't have to contribute much to this process.
Strongly Agree — Strongly Disagree
1 2 3 4 5 6 7

***I felt very involved with the problem solving process.
Strongly Agree — Strongly Disagree
1 2 3 4 5 6 7

*How stimulating did you find this task?
Not Stimulating — Neutral/ Undecided — Very Stimulating
1 2 3 4 5 6 7

**How interesting was this task?
Very Uninteresting — Neutral/ Undecided — Very Interesting
1 2 3 4 5 6 7

*How motivated were you to generate quality ideas?
Definitely Not Motivated — Neutral/ Undecided — Very Motivated
1 2 3 4 5 6 7

***Participating in this problem solving process was exhausting
Strongly Agree — Strongly Disagree
1 2 3 4 5 6 7

***I was bored very quickly by this problem solving process
Strongly Agree — Strongly Disagree
1 2 3 4 5 6 7

**For this task, did you
Have as much time as you needed — Want more time
1 2 3 4 5 6 7

*Considering all the ideas you thought of, did you
Have time to express all your ideas — Not have time to express all ideas
1 2 3 4 5 6 7

***I always felt rushed to move on to the next part of the problem solving process
Strongly Agree — Strongly Disagree
1 2 3 4 5 6 7

***I had sufficient time to complete each part of this problem solving process
Strongly Agree — Strongly Disagree
1 2 3 4 5 6 7

* Original survey question (Dennis & Valacich, 1993)
** Modification of original survey question
*** New survey question added for this study

Appendix D
Computer Experience Survey

Computer Experience and Attitude Survey

I enjoy working on a computer
Strongly Agree Strongly Disagree
1 2 3 4 5 6 7

I wish computers had never been created
Strongly Agree Strongly Disagree
1 2 3 4 5 6 7

I use a computer
a) always
b) almost every day
c) only every few days
d) only once a week
e) only a few times a month
f) only a few times a year
g) never

If available, I would use a computer for writing letters.
Almost Always Almost Never
1 2 3 4 5 6 7

I enjoy learning new computer software applications.
Strongly Agree Strongly Disagree
1 2 3 4 5 6 7

I consider computers to be user-friendly in general.
Strongly Agree Strongly Disagree
1 2 3 4 5 6 7

You have to be a genius to understand how to use most computer programs!
Strongly Agree Strongly Disagree
1 2 3 4 5 6 7

I would apply for a job that required computer expertise.
Strongly Agree Strongly Disagree
1 2 3 4 5 6 7

I use a computer to do my homework.
Strongly Agree Strongly Disagree
1 2 3 4 5 6 7

Computers make more work than they save.
Strongly Agree Strongly Disagree
1 2 3 4 5 6 7

I am comfortable working on a computer.
Strongly Agree Strongly Disagree
1 2 3 4 5 6 7

I consider myself to be experienced in the use of computers.
Strongly Agree Strongly Disagree
1 2 3 4 5 6 7

I would rather write an assignment out by hand than use a computer word processor.
Strongly Agree Strongly Disagree
1 2 3 4 5 6 7

When I use a computer, I am afraid I will make a mistake and this makes me apprehensive!
Strongly Agree Strongly Disagree
1 2 3 4 5 6 7

I find a computer to be an indispensable tool in my work.
Strongly Agree Strongly Disagree
1 2 3 4 5 6 7

Using a computer makes me nervous.
Strongly Agree Strongly Disagree
1 2 3 4 5 6 7

If available to me, I would use the Internet to access information.
Frequently Never
1 2 3 4 5 6 7

When I use a computer, something usually goes wrong.
Strongly Agree Strongly Disagree
1 2 3 4 5 6 7

I have used a computer for,

1) never
2) less than 2 months
3) 6 months
4) at least 1 year
5) at least 2 years
6) more than 2 years
7) seems like forever

I am very comfortable using a computer

Strongly Agree				Strongly Disagree		
1	2	3	4	5	6	7

Indicate the operating systems you have used

DOS _____
WINDOWS _____
OS/2 _____
UNIX _____
NEXI _____
MAC/OS _____
VMS _____

Appendix E
Research Condition: Paper and Pencil/Alone

SOCIAL PROBLEM RESEARCH

This packet will present a complex social problem, which will be referred to as Clara's problem. I will be asking you to write down key pieces of information or factors that might be important to consider when searching for a solution to this problem and also to assign an importance rating to each of these factors.
For example: Imagine that your have a friend named James. James has been offered a contract to play professional football in his sophomore year in college. What should he do? Some of the factors or key pieces of information that need to be considered might be: 1) James is currently in college 2) he's been offered a contract 3) the value he places on his education 4) his need for money. In other words, factors can include possible outcomes the person might want to achieve, relevant information present (explicit), relevant information not presented but understood (implicit), factors that would present limitations or restrictions to the problem solution, personal values that may need to be considered in the problem solution, personal control over the problem solution, risk factors, impact of solution, etc. More specific information on importance will be giving in your written instructions in the packet, but for this example, the fact that James was actually offered a contract may be a very important piece of information and might be rated as I0, some other piece of information may not be quite as important and you may want to rate it as a 7, a third piece of information may also warrant a rating of 7. The ratings are based on your perception of how important that piece of information is to the solution of the problem. Are there any questions about factors or importance ratings?

Please work through this packet in the order presented. You are being asked to follow the steps as outlined below:

Step 1) Please read Clara's problem.

Step 2) Turn the page and read the all directions presented at the top of the next page.

Step 3) Following the directions on this page before proceeding to the next page.

Step 4) Continue to work through the packet, reading directions on each page and completing the task before moving to the next page.

Step 5) Upon completion, please double check that your Participant Number is clearly written on each page that you have worked on.

Step 6) Put the packet back in order and bring the packet to me.

Thank you for your assistance with this research

Gini Collins
I/O Ph.D. Student

Upon completion of this page please turn the page and proceed.

⇨

Problem Description

Clara's Problem

Clara, a junior pre-med student, is working part-time and taking a 15 hour credit load at school. Clara enjoys her pre-med courses very much, but they are difficult and time consuming. Her current job as a "gopher" at an architectural design firm requires her to work 25 hours a week which really cuts into her available study time. In fact, she is barely getting "C's" in two of the classes she needs for her major. The pay in her present job is good, and she enjoys the work, although she is not getting a lot of practical experience. Clara does not want to drop any of her classes as she needs them to graduate so that she can be admitted to medical school in the coming year. Up until now, Clara has been able to work at her job and still get good grades, but the difficult courses she is taking now require much more of her time. Clara needs to work in order to finance her education. Clara is not sure how to solve her problem.

Participant No..................

Factor and Importance Rating Sheet

With Clara's problem in mind, please list all the key information, either presented or implied that you might consider when attempting to solve this problem. Please do not list solutions - just list the individual pieces of relevant information that you read in this problem paragraph or which you can imply from the information presented in the problem paragraph.

After listing all of the key information, please go back to each factor and rate it for importance for the final solution. "How important is this piece of information when searching for a final solution to this problem."

Please rate each factor using a full scale from 1 to 10, with 1 as Least Important and 10 as Most Important. These importance rating numbers can be used for more than one factor. For example, if you believe that both factor 2 and factor 4 are Most Important then you would give them both a rating of l0.

LEAST IMPORTANT MOST IMPORTANT

1---------2---------3-----------4-----------5---------6---------7--------8---------9--------10

		IMPORTANCE RATING
1	______________________________	______
2	______________________________	______
3	______________________________	______
4	______________________________	______
5	______________________________	______
6	______________________________	______
7	______________________________	______
8	______________________________	______
9	______________________________	______
10	______________________________	______
11	______________________________	______
12	______________________________	______
13	______________________________	______
14	______________________________	______

Participant No....................

Best Solution Sheet

Having considered all the key information for Clara's problem, please write your best solution.

Please complete the Leisure Activity survey that follows this page. Read the instructions presented at the top of the page and complete the survey as directed. Be certain to enter your Participant Number in the upper right hand corner of each page. You may turn the page and begin.

Participant No..................

Revised Factor and Importance Rating Sheet

At this point, I would like to give you the opportunity to revise your factor list if you choose and also revise your importance ratings if necessary. This factor list can be revised by adding new factors, modifying existing factors or changing your importance ratings.

	KEY INFORMATION (FACTORS)	IMPORTANCE RATING
1	______________________	______
2	______________________	______
3	______________________	______
4	______________________	______
5	______________________	______
6	______________________	______
7	______________________	______
8	______________________	______
9	______________________	______
10	______________________	______
11	______________________	______
12	______________________	______
13	______________________	______
14	______________________	______
15	______________________	______
16	______________________	______
17	______________________	______
18	______________________	______

Participant No._________

REVISION OF BEST SOLUTION

The final task in this problem solving study is to revise your final solution if you want to.

Please turn the page and complete the two survey forms that follow. Upon completion, please check to be sure that you have written your participant number on every sheet.

Appendix F

Research Condition: Paper and Pencil/Group

SOCIAL PROBLEM RESEARCH

This packet will present a complex social problem, which will be referred to as Clara's problem. I will be asking you to write down key pieces of information or factors that might be important to consider when searching for a solution to this problem and also to assign an importance rating to each of these factors.
For example: Imagine that your have a friend named James. James has been offered a contract to play professional football in his sophomore year in college. What should he do? Some of the factors or key pieces of information that need to be considered might be: 1) James is currently in college 2) he's been offered a contract 3) the value he places on his education 4) his need for money. In other words, factors can include possible outcomes the person might want to achieve, relevant information present (explicit), relevant information not presented but understood (implicit), factors that would present limitations or restrictions to the problem solution, personal values that may need to be considered in the problem solution, personal control over the problem solution, risk factors, impact of solution, etc. Very specific information on importance will be giving in your written instructions in the packet, but for this example, the fact that James was actually offered a contract may be a very important piece of information and might be rated as I0, some other piece of information may not be quite as important and you may want to rate it as a 7, a third piece of information may also warrant a rating of 7. The ratings are based on your perception of how important that piece of information is to the solution of the problem. Are there any questions about factors or importance ratings?

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Gini Collins
I/O Ph.D. Student

Upon completion of this page please turn the page and proceed.

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Problem Description

Clara's Problem

Clara, a junior pre-med student, is working part-time and taking a 15 hour credit load at school. Clara enjoys her pre-med courses very much, but they are difficult and time consuming. Her current job as a "gopher" at an architectural design firm requires her to work 25 hours a week which really cuts into her available study time. In fact, she is barely getting "C's" in two of the classes she needs for her major. The pay in her present job is good, and she enjoys the work, although she is not getting a lot of practical experience. Clara does not want to drop any of her classes as she needs them to graduate so that she can be admitted to medical school in the coming year. Up until now, Clara has been able to work at her job and still get good grades, but the difficult courses she is taking now require much more of her time. Clara needs to work in order to finance her education. Clara is not sure how to solve her problem.

Participant No..................

Factor and Importance Rating Sheet

With Clara's problem in mind, please list all the key information, either presented or implied that you might consider when attempting to solve this problem. Please do not list solutions - just list the individual pieces of relevant information that you read in this problem paragraph
or which you can imply from the information presented in the problem paragraph.

After listing all of the key information, please go back to each factor and rate it for importance for the final solution. "How important is this piece of information when searching for a final solution to this problem."

Please rate each factor using a full scale from 1 to 10, with 1 as Least Important and 10 as Most Important. These importance rating numbers can be used for more than one factor. For
example, if you believe that both factor 2 and factor 4 are Most Important then you would give
them both a rating of l0.

LEAST IMPORTANT MOST IMPORTANT
1---------2---------3----------4----------5--------6---------7-------8--------9--------10

	IMPORTANCE RATING
1 ______________________________	______
2 ______________________________	______
3 ______________________________	______
4 ______________________________	______
5 ______________________________	______
6 ______________________________	______
7 ______________________________	______
8 ______________________________	______
9 ______________________________	______
10 ______________________________	______
11 ______________________________	______
12 ______________________________	______

Participant No....................

Best Solution Sheet

Having considered all the key information for Clara's problem, please write your best solution.

Please Wait!

When all members of your group have completed their best solution, discuss the problem, your factors and importance ratings. The goal of this discussion is for your group to reach consensus regarding a single best solution to Clara's problem.

The revision of your factors and importance rating sheet can be done individually. Following your discussion, review your own list and revise this list by adding new factors, revising factors or changing importance ratings.

When you have finished your discussion, please proceed to the next page and read the directions located at the top of the page.

Participant No..................

Revised Factor and Importance Rating Sheet

At this point, I would like to give you the opportunity to revise your factor list if you choose and also revise your importance ratings if necessary. This factor list can be revised by adding new factors, modifying existing factors or changing your importance ratings.

	KEY INFORMATION (FACTORS)	IMPORTANCE RATING
1	______	______
2	______	______
3	______	______
4	______	______
5	______	______
6	______	______
7	______	______
8	______	______
9	______	______
10	______	______
11	______	______
12	______	______
13	______	______
14	______	______
15	______	______
16	______	______
17	______	______
18	______	______

Participant No....................

Group Consensus Solution Sheet

The final problem solving task for this group is to arrive at an agreement regarding the best solution to this problem. All three members of the group must agree to the solution to Clara's problem. This consensus can be reached through an exchange of information regarding the solution with the other members of your team.

Appendix G
Research Condition: Computer/Alone

SOCIAL PROBLEM RESEARCH

This packet will present a complex social problem, which will be referred to as Clara's problem. I will be asking you to write down key pieces of information or factors that might be important to consider when searching for a solution to this problem and also to assign an importance rating to each of these factors.
For example: Imagine that your have a friend named James. James has been offered a contract to play professional football in his sophomore year in college. What should he do? Some of the factors or key pieces of information that need to be considered might be: 1) James is currently in college 2) he's been offered a contract 3) the value he places on his education 4) his need for money. In other words, factors can include possible outcomes the person might want to achieve, relevant information present (explicit), relevant information not presented but understood (implicit), factors that would present limitations or restrictions to the problem solution, personal values that may need to be considered in the problem solution, personal control over the problem solution, risk factors, impact of solution, etc. More specific information on importance will be giving in your written instructions in the packet, but for this example, the fact that James was actually offered a contract may be a very important piece of information and might be rated as l0, some other piece of information may not be quite as important and you may want to rate it as a 7, a third piece of information may also warrant a rating of 7. The ratings are based on your perception of how important that piece of information is to the solution of the problem. Are there any questions about factors or importance ratings?

We will now take a few minutes while I demonstrate some of the basics on the computer program you will be using for this exercise.

Please work through this packet in the order presented. Computer instructions will be given on each page. You are being asked to follow the steps as outlined below:
Step 1) Please read Clara's problem.
Step 2) Turn the page and read the all directions presented at the top of the next page.
Step 3) Following the computer directions on this page before proceeding to the next page.
Step 4) Continue to work through the packet, reading directions on each page and completing the task before moving to the next page.
Step 5) Upon completion, please double check that your Participant Number is clearly written on each page that you have worked on.
Step 6) Put the packet back in order and bring the packet to me.

DO NOT EXIT FROM THE COMPUTER PROGRAM!

Thank you for your assistance with this research
Gini Collins
I/O Ph.D. Student

Upon completion of this page please turn the page and proceed.

Problem Description

Clara's Problem

Clara, a junior pre-med student, is working part-time and taking a 15 hour credit load at school. Clara enjoys her pre-med courses very much, but they are difficult and time consuming. Her current job as a "gopher" at an architectural design firm requires her to work 25 hours a week which really cuts into her available study time. In fact, she is barely getting "C's" in two of the classes she needs for her major. The pay in her present job is good, and she enjoys the work, although she is not getting a lot of practical experience. Clara does not want to drop any of her classes as she needs them to graduate so that she can be admitted to medical school in the coming year. Up until now, Clara has been able to work at her job and still get good grades, but the difficult courses she is taking now require much more of her time. Clara needs to work in order to finance her education. Clara is not sure how to solve her problem.

FACTOR AND IMPORTANCE RATING

Please read all instructions on this page. Once all instructions have been read, please following the computer instructions step by step in order to carry out the instructions.

With Clara's problem in mind, please list all the key information, either presented or implied that you might consider when attempting to solve this problem. Please do not list solutions - just list the individual pieces of relevant information that you read in this problem paragraph or which you can imply from the information presented in the problem paragraph.

Computer Instructions

You will use the Add Idea dialog box to list these factors or key information.

1) Type a statement regarding a single piece of key information or a single factor that you might consider when searching for a solution to this problem.

2) Click on the SUBMIT button

3) Repeat steps 1 and 2 until you feel satisfied that you have listed all the important factors that need to be considered when solving this problem.

Upon completion of this task, please turn the page......

IMPORTANCE RATINGS

Please read all instructions on this page. Once all instructions have been read, please following the computer instructions step by step in order to carry out the instructions.

Instructions

After listing all of the key information, please go back to each factor and rate it for importance for the final solution. "How important is this piece of information when searching for a final solution to this problem"

Please rate each factor using a full scale from 1 to 10, with 1 as Least Important and 10 as Most Important. These importance rating numbers can be used for more than one factor. For example, if you believe that both factor 2 and factor 4 are Most Important, then you would give them both a rating of 10.

Least Important   Most Important
1----------2-----------3----------4-----------5---------6----------7----------8----------9----------10

Computer Instructions

1) In the Add Idea screen, double click directly on the first factor or key piece of information that you entered on the screen. This will open a comment box with your factor listed at the top of the page.

2) In the comment box, type in an importance rating number for that factor (from 1 to 10)

3) Click on the SUBMIT button

4) Click on the NEXT button to call up your next factor for rating.

5) Repeat steps 1 through 4 until all factors have been rated.

6) Click on the CLOSE button

Upon completion of this task,
please turn the page......

SOLUTION

Please read all instructions on this page. Once all instructions have been read, please following the computer instructions step by step in order to carry out the instructions

Instructions

Having considered all the key information for Clara's problem, please write your best solution.

Computer Instructions:

1) Double click on your last factor in your factor list. This will open the comment box where you entered your importance ratings and will add your solution under your rating as a new entry. Even though the window looks small, you can enter a length answer if you choose.

2) Type the word SOLUTION --- This will identify the information that you type in after as the solution to the problem.

3) Following the word SOLUTION, type in your best solution to Clara's problem.

4) Click on the SUBMIT button

5) Click on CLOSE button

Upon completion of this task, please turn the page......

REVISION OF FACTORS AND IMPORTANCE RATING.

Please read all instructions on this page. Once all instructions have been read, please following the computer instructions stcp by step in order to carry out the instructions

At this point I would like to give you the opportunity to revise your factor list if you choose and also revise your importance ratings if necessary. This factor list can be revised by adding new factors, modifying existing factors or changing your importance ratings.

Computer Instructions

1)Double click directly on the screen on the typed words of your first factor. This will open the comment screen and will display the factor at the top, plus your importance rating of that factor.

2) To enter a revision, type the revised edition of this factor in the dialogue box and also enter a new rating if you are not satisfied with the previous rating.

3) Click on SUBMIT button

4) Click on NEXT button to bring up your next factor and importance rating. Revise as needed.

5) Click on CLOSE button when your factor revisions are completed.

Upon completion of this task, please turn the page...... ⇨

REVISION OF BEST SOLUTION

Please read all instructions on this page. Once all instructions have been read, please following the computer instructions step by step in order to carry out the instructions

The final task in this problem solving study is to revise your final solution if you want to. In order to complete this revision, please follow the following computer instructions.

Computer instructions

1) Double click on the final factor to show your solution. Revise your solution by typing in your revised version into the dialogue box. Click on the SUBMIT button when you are satisfied with your final solution.

2) Click on the CLOSE button to end this task.

Upon completion of this task,
please turn the page......

Appendix H
Research Condition: Computer/Group

SOCIAL PROBLEM RESEARCH

This packet will present a complex social problem, which will be referred to as Clara's problem. I will be asking you to write down key pieces of information or factors that might be important to consider when searching for a solution to this problem and also to assign an importance rating to each of these factors.

For example: Imagine that your have a friend named James. James has been offered a contract to play professional football in his sophomore year in college. What should he do? Some of the factors or key pieces of information that need to be considered might be: 1) James is currently in college 2) he's been offered a contract 3) the value he places on his education 4) his need for money. In other words, factors can include possible outcomes the person might want to achieve, relevant information present (explicit), relevant information not presented but understood (implicit), factors that would present limitations or restrictions to the problem solution, personal values that may need to be considered in the problem solution, personal control over the problem solution, risk factors, impact of solution, etc. More specific information on importance will be giving in your written instructions in the packet, but for this example the fact that James was actually offered a contract may be a very important piece of information and might be rated as "l0", some other piece of information may not be quite as important and you may want to rate it as a "7", a third piece of information may also warrant a rating of "7". The ratings are based on your perception of how important that piece of information is to the solution of the problem. Are there any questions about factors or importance ratings?

We will now take a few minutes while I demonstrate some of the basics on the computer program you will be using for this exercise.

Please work through this packet in the order presented. You are being asked to follow the steps as outlined below:

Step 1) Please read Clara's problem.
Step 2) Turn the page and read the all directions presented at the top of the next page.
Step 3) Following the directions on this page before proceeding to the next page.
Step 4) Continue to work through the packet, reading directions on each page and completing the task before moving to the next page.
Step 5) Upon completion, please double check that your Participant Number is clearly written on each page that you have worked on.
Step 6) Put the packet back in order and bring the packet to me.

DO NOT EXIT FROM THE COMPUTER PROGRAM!

Thank you for your assistance with this research

Gini Collins
I/O Ph.D. Student

Upon completion of this page please turn the page and proceed.

FACTOR AND IMPORTANCE RATING

Please read all instructions on this page. Once all instructions have been read, please following the computer instructions step by step in order to carry out the instructions.

With Clara's problem in mind, please list all the key information, either presented or implied that you might consider when attempting to solve this problem. Please do not list solutions - just list the individual pieces of relevant information that you read in this problem paragraph or which you can imply from the information presented in the problem paragraph.

Computer Instructions

You will use the Add Idea dialog box to list these factors or key information.

1) Type a statement regarding a single piece of key information or a single factor that you might consider when searching for a solution to this problem.

2) Click on the SUBMIT button

3) Repeat steps 1 and 2 until you feel satisfied that you have listed all the important factors that need to be considered when solving this problem.

Upon completion of this task,
please turn the page......

IMPORTANCE RATINGS

Please read all instructions on this page. Once all instructions have been read, please following the computer instructions step by step in order to carry out the instructions.

Instructions

After listing all of the key information, please go back to each factor and rate it for importance for the final solution. "How important is this piece of information when searching for a final solution to this problem"

Please rate each factor using a full scale from 1 to 10, with 1 as Least Important and 10 as Most Important. These importance rating numbers can be used for more than one factor. For example, if you believe that both factor 2 and factor 4 are Most Important, then you would give them both a rating of 10.

Least Important   Most Important
1---------2----------3---------4----------5---------6---------7---------8---------9---------10

Computer Instructions

1) In the Add Idea screen, double click directly on the first factor or key piece of information that you entered on the screen. This will open a comment box with your factor listed at the top of the page.

2) In the comment box, type in an importance rating number for that factor (from 1 to 10)

3) Click on the SUBMIT button

4) Click on the NEXT button to call up your next factor for rating.

5) Repeat steps 1 through 4 until all factors have been rated.

6) Click on the CLOSE button

Upon completion of this task,
please turn the page......

SOLUTION

Please read all instructions on this page. Once all instructions have been read, please following the computer instructions step by step in order to carry out the instructions

Having considered all the key information for Clara's problem, please write your best solution.

Computer Instructions:

1) Double click on your last factor in your factor list. This will open the comment box where you entered your importance ratings and will add your solution under your rating as a new entry. Even though the window looks small, you can enter a length answer if you choose.

2) Type the word SOLUTION --- This will identify the information that you type in after as the solution to the problem.

3) Following the word SOLUTION, type in your best solution to Clara's problem.

4) Click on the SUBMIT button

5) Click on CLOSE button

Upon completion of this task, please turn the page......

ACCESSING INFORMATION FROM OTHER GROUP MEMBERS

Please read all instructions on this page. Once all instructions have been read, please following the computer instructions step by step in order to carry out the instructions

At this point, you can access the factors and importance ratings of the other members in your group. You can also access their solution. Please review their factors and importance ratings by following these simple instructions.

Computer Instructions

1) Notice the buckets located at the side of the Category screen. The top bucket contains your information. The other two buckets contain information generated by the other members of your group. To access this information, double click directly on a bucket. This will "tip" the bucket over and your teammates information will appear on your screen.

2) Review the information typed by one other member of your group.

3) Double click on an idea and you will see the rating that was made.

4) Work your way through all of the ideas and ratings of each member of your group.

5) Click on CLOSE to return to your original category screen.

Upon completion of this task,
please turn the page......

REVISION OF FACTORS AND IMPORTANCE RATING.

Please read all instructions on this page. Once all instructions have been read, please following the computer instructions step by step in order to carry out the instructions

At this point, I would like to give you the opportunity to revise your factor list if you choose and also revise your importance ratings if necessary. Your factor list can be revised by adding new factors, modifying existing factors or changing your importance ratings.

Computer Instructions

Be sure that your bucket is tipped over. If not, double click on your bucket to open your Add Idea screen.

1)Double click directly on the screen on the typed words of your first factor. This will open the comment screen and will display the factor at the top, plus your importance rating of that factor.

2) To enter a revision, type the revised edition of this factor in the dialogue box and also enter a new rating if you are not satisfied with the previous rating.

3) Click on SUBMIT button

4) Click on NEXT button to bring up your next factor and importance rating. Revise as needed.

5) Click on CLOSE button when your factor revisions are completed.

Upon completion of this task,
please turn the page......

CONSENSUS BEST SOLUTION

Please read all instructions on this page. Once all instructions have been read, please following the computer instructions step by step in order to carry out the instructions

The final problem solving task for this group is to arrive at an agreement regarding the best solution to this problem. All three member of the group must agree to the solution to Clara's problem. This consensus can be reached through an exchange of information regarding the solution with the other members of your team.

Computer instructions

This information can be exchanged by accessing your team members solution and making comments regarding this solution directed on their screen from your terminal. As you will recall, you can access their information by double clicking on their bucket. You can enter information on this screen in exactly the same manner that you entered information on your own ideas. This process will begin with your final revision of your own solution to Clara's problem.

1) Double click on the final factor to show your solution. Revise your solution by typing in your revised version into the dialogue box. Click on the submit button in order to make it available to the other group members.

2) Double click on the buckets of your group members to review their revised solutions. Enter comments regarding how well you agree with the others by typing comments in the their dialogue boxes from your terminal.

In this way, they will see your comments regarding their solutions and they can access your solution and give you feedback as well.

3) Continue this process of commenting to each other until you indicate your agreement with a solution and convey that agreement to the other members of your group through your type written messages.

4) Click on CLOSE button to return you to the original screen.

Upon completion of this task,
please turn the page......

Appendix I
Quality Rating Scales

Quality Rating Scales

Appropriateness

An appropriate solution is one that is realistic, practical, feasible, and socially appropriate.

1. Solution highly inappropriate
2.
3.
4.
5. Solution highly appropriate

Originality

The degree to which the solution is not structured by the problem presented and goes beyond it. The degree of novelty and uniqueness of the solution.

1. Very common response. Solution completely structured by problem as presented.
2. Solution less common but very structured by problem as presented.
3. Solution somewhat unique but very structured by problem as presented.
4. Solution relatively common but not structured by problem as presented.
5. Solution somewhat novel and unique and not structured by problem as presented.
6. Solution novel and unique, and not structured by problem as presented.

Resolving Power

Each problem presents an underlying conflict, which you will have before you. Remember to focus on the underlying conflict and not specific goals/objectives.

1. Solution doesn't do a very good job addressing any aspects/facets of the problem.
2. Solution addresses one aspect/facet of the problem moderately well.
3. Solution effectively addresses one aspect/facet of the problem.
4. Solution attempts to address the conflicting aspects/facets of the problem.
5. Solution resolves the conflicting aspects/facets of the problem moderately well.
6. Solution does a very good job resolving the conflicting aspects/facets of the problem.