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Problem Solving Mental Process: An Overview

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Abstract: ***Improving individuals' and groups' abilities to solve problems and make decisions is recognized as an important issue in education, industry, and government. Recent research has identified a prescriptive model of problem solving, although there is less agreement as to appropriate techniques. Separate research on personality and cognitive styles has identified important individual differences in how people approach and solve problems and make decisions. Human thinking, and in particular, the human ability to solve complex, real-life problems contributes more than any other human ability to the development of human culture and the growth and development of human life on earth. However, the human ability to solve complex problems is still not well understood, partly because it has for a long time been largely ignored by traditional problem-solving research in the field of psychology.***

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1. Hypothesis

The recent transition to the information age has focused attention on the processes of problem solving and decision making and their improvement (e.g., Nickerson, Perkins, & Smith, 1985; Stice, 1987; Whimbey & Lochhead, 1982). In fact, Gagne (1974, 1984) considers the strategies used in these processes to be a primary outcome of modern education. Although there is increasing agreement regarding the prescriptive steps to be used in problem solving, there is less consensus on specific techniques to be employed at each step in the problem-solving/decision-making process.

There is concurrent and parallel research on personality and cognitive styles that describes individuals' preferred patterns for approaching problems and decisions and their utilization of specific skills required by these processes (e.g., encoding, storage, retrieval, etc.). Researchers have studied the relationship between personality characteristics and problem-solving strategies (e.g., Heppner, Neal, & Larson, 1984; Hopper & Kirschenbaum, 1985; Myers, 1980), with Jung's (1971) theory on psychological type serving as the basis for much of this work, especially as measured by the MBTI (Myers & McCaulley, 1985).

One conclusion that may be drawn from these investigations is that individual differences in problem solving and decision making must be considered to adequately understand the dynamics of these processes (Stice, 1987). Attention must be paid to both the problem-solving process and the specific techniques associated with important personal characteristics. That is, individuals and organizations must have a problem-solving process as well as specific techniques congruent with individual styles if they are to capitalize on these areas of current research.

The purpose of this paper is to relate a model of the problem-solving process to a theory of personality type and temperaments in order to facilitate problem solving by focusing on important individual differences. Specific techniques that can be used in the problem-solving/decision-making process to take advantage of these differences are also identified. The integrated process is applicable to a variety of individual and group situation.

2. Introduction

Problem-solving is a mental process that involves discovering, analyzing, and solving problems. The ultimate goal of problem-solving is to overcome obstacles and find a solution that best resolves the issue. The best strategy for solving a problem depends largely on the unique situation. In some cases, people are better off learning everything they can about the issue and then using factual knowledge to come up with a solution. In other instances, creativity and insight are the best options. Problem solving is a process in which we perceive and resolve a gap between a present situation and a desired goal, with the path to the goal blocked by known or unknown obstacles. In general, the situation is one not previously encountered, or where at least a specific solution from past experiences is not known. In contrast, decision making is a selection process where one of two or more possible solutions is chosen to reach a desired goal. The steps in both problem solving and decision making are quite similar. In fact, the terms are sometimes used interchangeably.

Most models of problem solving and decision making include at least four phases (e.g., Bransford & Stein, 1984; Dewey, 1933; Polya, 1971): 1) an Input phase in which a problem is perceived and an attempt is made to understand the situation or problem; 2) a Processing phase in which alternatives are generated and evaluated and a solution is selected; 3) an Output phase which includes planning for and implementing the solution; and 4) a Review phase in which the solution is evaluated and modifications are made, if necessary. Most researchers describe the problem-solving/decision-making process as beginning with the perception of a gap and ending with the implementation and evaluation of a solution to fill that gap.

Complex Problem Solving: Historical Roots and Current Situation

Beginning with the early experimental work of the Gestaltists in Germany, and continuing through the 1960s and early 1970s, research on problem solving was typically conducted with relatively simple laboratory tasks that were novel to research participants. Simple novel tasks were used

for a variety of reasons: they had clearly defined optimal solutions, they were solvable in a relatively short time, research participants' problem-solving steps could be traced, and so on. The underlying assumption was, of course, that simple tasks, such as the Tower of Hanoi, capture the main properties of "real" problems, and that the cognitive processes underlying participants' solution attempts on simple problems were representative of the processes engaged in when solving real problems. Thus, simple problems were used for reasons of convenience, and generalizations to more complex problems were thought possible. Perhaps the best-known and most impressive example of this line of research is the work by Newell and Simon.

However, beginning in the 1970s, researchers became increasingly convinced that empirical findings and theoretical concepts derived from simple laboratory tasks were not generalizable to more complex, real-life problems. Even worse, it appeared that the processes underlying CPS in different domains were different from each other. These realizations have led to rather different responses in North America and Europe.

In North America, initiated by the work of Herbert Simon on learning by doing in semantically rich domains, researchers began to investigate problem solving separately in different natural knowledge domains (e.g. physics, writing, chess playing) thus relinquishing their attempts to extract a global theory of problem solving. Instead, these researchers frequently focused on the development of problem solving within a certain domain, that is, on the development of expertise. Areas that have attracted rather intense attention in North America include such diverse fields as reading, writing, calculation, political decision making, managerial problem solving, lawyers' reasoning, mechanical problem solving, problem solving in electronics, computer skills, game playing, and personal problem solving.

In Europe, two main approaches have surfaced, one initiated by Donald Broadbent in Great Britain and the other by Dietrich Drner in Germany. The two approaches have in common an emphasis on relatively complex, semantically rich, computerized laboratory tasks that are constructed to be similar to real-life problems. The approaches differ somewhat in their theoretical goals and methodology. The tradition initiated by Broadbent emphasizes the distinction between cognitive problem-solving processes that operate under awareness versus outside of awareness, and typically employs mathematically well-defined computerized systems. The tradition initiated by Drner, on the other hand, is interested in the interplay of cognitive, motivational, and social components of problem solving, and utilizes very complex computerized scenarios that contain up to 2000 highly interconnected variables (Lohhausen project).

Complex Problem Solving: A Definition

With the above considerations in mind, it is not surprising that there exist a wide variety of definitions of CPS that have little in common. Indeed, researchers in the area of problem solving have long been troubled by the absence of agreement on the exact meaning of many of the basic terms in the area. Any general conclusion regarding CPS, however, and any theoretical model of CPS can be meaningful only if all agree on what constitutes a problem and what constitutes CPS. For the rest of this article we define CPS as follows: CPS occurs to overcome barriers between a given state and a desired goal state by means of behavioural and/or cognitive, multi-step activities. The given state, goal state, and barriers between given state and goal state are complex, change dynamically during problem solving, and are non-transparent. The exact properties of the given state, goal state, and barriers are unknown to solvers at the outset. CPS implies the efficient interaction between solvers' and the situational requirements of the task, and involves solvers cognitive, emotional, personal, and social abilities and knowledge.

Readers should notice that this definition differs rather substantially from definitions that feature prominently in the North American tradition. John Anderson, as an example of the North American approach, has defined problem solving as "any goal-directed sequence of cognitive operations" regardless of whether the task is novel or familiar to the solvers, regardless of whether the task is complex, and regardless of whether a single barrier or multiple barriers exist between given state and goal state. Our definition, in contrast, constrains potential problems by requiring that they be (a) novel tasks that problem solvers are unfamiliar with, (b) complex, (c) dynamically changing over time, and (d) non-transparent. In order to solve these problems, solvers have to be able to anticipate what will happen over time, and have to consider side effects of potential actions.

In addition and in contrast to earlier, often implicit, views, CPS is not viewed as deterministic in the sense that any problem-solving activity will always lead to the solution of a problem. Rather, CPS may lead to an approximate solution that may advance the solvers but may not lead to actually solving the problem. For example, research participants performing the duties of the mayor of a computer-simulated town may, even after some practice, still not be able to generate the best possible solution to a given problem. In fact, many often computerized, tasks exist for which—due to the complex non-linear relations among the task variables—the optimal solution is unknown. Of course, the absence of an optimal solution, while theoretically reasonable and even desirable, poses a problem to experimenters who want to determine the quality of problem solvers' performances, and to those who use micro worlds for personnel selection purposes.

Consideration of Individual Differences:

Although there are a variety of ways to consider individual differences relative to problem solving and decision making, this paper will focus on personality type and temperament as measured by the MBTI.

Personality Type and Problem Solving

Researchers have investigated the relationship of Jung's theory of individuals' preferences and their approach to problem solving and decision making (e.g., Lawrence, 1982, 1984; McCaulley, 1987; Myers & McCaulley, 1985). The following is a summary of their findings.

When solving problems, individuals preferring introversion will want to take time to think and clarify their ideas before they begin talking, while those preferring extraversion will want to talk through their ideas in order to clarify them. In addition, Is will more likely be concerned with their own understanding of important concepts and ideas, while Es will continually seek feedback from the environment about the viability of their ideas

Sensing individuals will be more likely to pay attention to facts, details, and reality. They will also tend to select standard solutions that have worked in the past. Persons with intuition preferences, on the other hand, will more likely attend to the meaningfulness of the facts, the relationships among the facts, and the possibilities of future events that can be imagined from these facts. They will exhibit a tendency to develop new, original solutions rather than to use what has worked previously.

Individuals with a thinking preference will tend to use logic and analysis during problem solving. They are also likely to value objectivity and to be impersonal in drawing conclusions. They will want solutions to make sense in terms of the facts, models, and/or principles under consideration. By contrast, individuals with a feeling preference are more likely to consider values and feelings in the problem-solving process. They will tend to be subjective in their decision making and to consider how their decisions could affect other people.

The final dimension to be considered describes an individual's preference for either judging (using T or F) or perceiving (using S or N). Js are more likely to prefer structure and organization and will want the problem-solving process to demonstrate closure. Ps are more likely to prefer flexibility and adaptability. They will be more concerned that the problem-solving process considers a variety of techniques and provides for unforeseen change.

As a demonstration of how personality type can affect problem solving, McCaulley (1987) describes the problem-solving characteristics of two of the 16 MBTI types, ISTJ and ENFP.

In problem solving, ISTJ will want a clear idea of the problem (I) and attack it by looking for the facts (S) and by relying on a logical, impersonal (T), step-by-step approach in reaching conclusions. In contrast, ENFP will throw out all sorts of possibilities (N), seeking feedback from the environment to clarify the problem (E). Brainstorming (NP) will be enjoyed. The human aspects of the problem (F) are likely to be emphasized over impersonal, technical issues (T). To the ISTJ, the ENFP approach is likely to seem irrational or scattered. To the ENFP, the ISTJ approach is likely to seem slow and unimaginative.

Temperament

Kiersey and Bates (1978) provide another view of Jung's theory. These authors focus on four temperaments similar in many ways to those described in ancient times by Hippocrates and in the early 20th century by psychologists such as Adickes (1907), Kretschmer (1921/1925), and Spranger (1928). These temperaments can be useful in discussing individual differences related to problem solving and decision making since they are associated with fundamental differences in orientation to problem solving and goals to be addressed.

The first dimension considered in temperament is the one related to differences in the perceptual processes used in gathering information--the S-N dimension. Kiersey and Bates (1978) argue that S-N is the most fundamental dimension since all other dimensions depend on the type of information most preferred. The concrete-abstract dimension in Kolb's (1984) theory of learning style supports this proposal.

For individuals with a sensing preference, the second dimension to be considered (J-P) relates to the utilization of data--should they be organized and structured or should additional data be gathered. For Ns, the second dimension (T-F) relates to the evaluation of data by logic and reason or by values and impact on people. Therefore, the four temperaments are SP, SJ, NT, and NF.

The SP temperament is oriented to reality in a playful and adaptable manner. The goal of the SP is action, and the SP's time reference is the present. The SP wants to take some immediate action using an iterative approach to achieve the end result or goal. The SP's definition of the problem is likely to change in the process of solving it. Individuals of this temperament are not likely bound by original perceptions and want the freedom to change their perceptions based on new information. Sometimes lack of a coherent plan of action diverts the SP from the original problem.

An individual of the SJ temperament is oriented to reality in an organized manner, strives to be socially useful, and performs traditional duties within a structured framework. SJs are detail conscious, are able to anticipate outcomes, and prefer evolutionary rather than revolutionary change. SJs often need help in categorizing details into meaningful patterns and generating creative, non-standard alternatives.

The NT temperament approaches problem solving scientifically and is future oriented. NTs are likely to be interested in the laws or principles governing a situation. The prescriptive problem-solving/decision-making process described by researchers is oriented to the NT temperament. NTs tend to overlook important facts and details and need help considering the impact of solutions on people.

The NF temperament seeks self-discovery, which appears to be a circular goal, and is oriented to the future in terms of human possibilities. When engaged in the problem-solving process, NFs may rely on internal alternatives often interpreted as not grounded in reality or logic. They are often concerned with the integrity of solutions and strive to enhance personal development. NFs need help attending to details and focusing on realistic, formulated solutions.

The validity of the problem-solving process will be seen from different perspectives by each temperament. SPs will value their own experiences; SJs will value tradition and authority; NTs will value logic and reason; NFs will value

insight and inspiration. The challenge for using the problem-solving process described by experts is to utilize techniques and procedures that acknowledge individual differences and provide an opportunity for alternative perspectives to be considered.

Problem-Solving Techniques

It is not enough to describe a problem-solving process and to describe how individuals differ in their approach to or use of it. It is also necessary to identify specific techniques of attending to individual differences. Fortunately, a variety of problem-solving techniques have been identified to accommodate individual preferences. Some of these techniques are oriented more to NT and SJ individuals who tend to be more linear and serial, more structured, more rational and analytical, and more goal-oriented in their approach to problem solving. Other techniques are more suited to NF and SP individuals who demonstrate a preference for an approach that is more holistic and parallel, more emotional and intuitive, more creative, more visual, and more tactual/kinaesthetic. It is important that techniques from both categories be selected and used in the problem-solving process. Duemler and Mayer (1988) found that when students used exclusively either reflection or inspiration during problem solving, they tended to be less successful than if they used a moderate amount of both processes. This section offers some examples of both types of techniques; the next section will demonstrate how to integrate them into the problem-solving process to accommodate individual differences.

The following techniques focus more on logic and critical thinking, especially within the context of applying the scientific approach:

a) Analysis--the identification of the components of a situation and consideration of the relationships among the parts (Bloom, Englehart, Furst, Hill, & Krathwohl, 1956);
b) Backwards planning--a goal selection process where mid-range and short-term conditions necessary to obtain the goal are identified (Case & Bereiter, 1984; Gagne, 1977; Skinner, 1954); this technique is related to the more general technique of means-ends analysis described by Newell and Simon (1972);
c) Categorizing/classifying--the process of identifying and selecting rules to group objects, events, ideas, people, etc. (Feuerstein, Rand, Hoffman, & Miller, 1980; Sternberg, 1988);
d) Challenging assumptions--the direct confrontation of ideas, opinions, or attitudes that have previously been taken for granted (Bransford & Stein, 1984; Brookfield, 1987);
e) Evaluating/judging--comparison to a standard and making a qualitative or quantitative judgment of value or worth (Bloom et al., 1956);
f) Inductive/deductive reasoning--the systematic and logical development of rules or concepts from specific instances or the identification of cases based on a general principle or proposition using the generalization and inference (e.g., Devine, 1981; Pelligrino, 1985; Sternberg, 1988);
g) Thinking aloud--the process of verbalizing about a problem and its solution while a partner listens in detail for errors in thinking or understanding (Whimby & Lochhead, 1982);
h) Network analysis--a systems approach to project planning and management where relationships among activities, events, resources, and timelines are developed and charted. Specific examples include Program Evaluation and Review Technique and Critical Path Method (Awani, 1983; Handy & Hussain, 1969);
i) Plus-Minus-Interesting (PMI)--considering the positive, negative, and interesting or thought-provoking aspects of an idea or alternative using a balance sheet grid where plus and minus refer to criteria identified in the second step of the problem-solving process (de Bono, 1976; Janis & Mann, 1977);
j) Task analysis--the consideration of skills and knowledge required to learn or perform a specific task (Gagne, 1977; Gardner, 1985).

The following problem-solving techniques focus more on creative, lateral, or divergent thinking (e.g., de Bono, 1983; Prince, 1970; Wonder & Donovan, 1984):

a) Brainstorming--attempting to spontaneously generate as many ideas on a subject as possible; ideas are not critiqued during the brainstorming process; participants are encouraged to form new ideas from ideas already stated (Brookfield, 1987; Osborn, 1963);
b) Imaging/visualization--producing mental pictures of the total problem or specific parts of the problem (Lazarus, 1978; McKim, 1980; Wonder & Donovan, 1984);
c) Incubation--putting aside the problem and doing something else to allow the mind to unconsciously consider the problem (Frederiksen, 1984; Osborn, 1963);
d) Outcome psychodrama--enacting a scenario of alternatives or solutions through role playing (Janis & Mann, 1977);
e) Outrageous provocation--making a statement that is known to be absolutely incorrect (e.g., the brain is made of charcoal) and then considering it; used as a bridge to a new idea (Beinstock, 1984); also called "inside outs" by Wonder and Donovan (1984);
f) Overload--considering a large number of facts and details until the logic part of the brain becomes overwhelmed and begins looking for patterns (Wonder & Donovan, 1984); can also be generated by immersion in aesthetic experiences (Brookfield, 1987), sensitivity training (Lakin, 1972), or similar experiences;
g) Random word technique--selecting a word randomly from the dictionary and juxtaposing it with problem statement, then brainstorming about possible relationships (Beinstock, 1984);
h) Relaxation--systematically relaxing all muscles while repeating a personally meaningful focus word or phrase (Benson, 1987); a specific example of the more general technique called "suspenders" by Wonder and Donovan (1984);
i) Synthesizing--combining parts or elements into a new and original pattern Bloom et al., 1956; Sternberg, 1988);
j) Taking another's perspective--deliberately taking another person's point of view (de Bono, 1976; referred to as "be someone else" by Wonder and Donovan (1984);
k) Values clarification--using techniques such as role-playing, simulations, self-analysis exercises, and structured controversy to gain a greater understanding of

attitudes and beliefs that individuals hold important (Fraenkel, 1977; Johnson & Johnson, 1988; Kirschenbaum, 1977).

Integrating Techniques into the Problem-Solving Process:
The problem-solving techniques discussed above are most powerful when combined to activate both the logical/rational and intuitive/creative parts of the brain (Wonder & Donovan, 1984). The following narrative will provide an example of how these techniques can be used at specific points in the problem-solving process to address important individual differences. The techniques will be presented within the context of a group problem-solving situation but are equally applicable to an individual situation. The terms in parentheses refer to personality dimensions to which the technique would appeal.

The Input Phase
The goal of the Input phase is to gain a clearer understanding of the problem or situation. The first step is to identify the problem(s) and state it (them) clearly and concisely. Identifying the problem means describing as precisely as possible the gap between one's perception of present circumstances and what one would like to happen. Problem identification is vital to communicate to one's self and others the focus of the problem-solving/decision-making process. Arnold (1978) identified four types of gaps: 1) something is wrong and needs to be corrected; 2) something is threatening and needs to be prevented; 3) something is inviting and needs to be accepted; and 4) something is missing and needs to be provided. Tunnel vision (stating the problem too narrowly) represents the major difficulty in problem identification as it leads to artificially restricting the search for alternatives

Brainstorming is an excellent technique to begin the problem-solving process. Individually, participants quickly write possible solutions (introversion, perception), share these alternatives as a group in a non-judgmental fashion, and continue to brainstorm (extraversion, perception). Participants then classify, categorize, and prioritize problems, forming a hierarchy of the most important to the least important (intuition, thinking)

The second step of the Input phase is to state the criteria that will be used to evaluate possible alternatives to the problem as well as the effectiveness of selected solutions. During this step it is important to state any identified boundaries of acceptable alternatives, important values or feelings to be considered, or results that should be avoided. In addition, criteria should be categorized as either essential for a successful solution or merely desired

Brainstorming can also be used during this second step. Participants quickly write possible criteria for use in evaluating alternatives (introversion, perception). These factors generally fall into the following categories: 1) important personal values, attitudes, and feelings to be considered (sensing, feeling); 2) important values, attitudes, and feelings to be considered in context of the work group, organization, community, society, etc. (extraversion, intuition, feeling); 3) practical factors that relate to how an alternative should work (sensing, thinking); and 4) factors that logically flow from the statement of the problem, relevant facts, or how the solution should fit into the larger context (intuition, thinking). Values clarification techniques can be very useful in generating criteria related to values, feelings, and attitudes. Role-playing and simulations are especially appreciated by SPs and SJs, who generally take a more practical approach to problem solving. Self-analysis exercises and structured controversy are more likely to appeal to NFs and NTs, who focus on principles and abstractions. In addition, the use of both deductive and inductive reasoning can be important in generating criteria. For example, logically generating criteria from the problem statement would use deductive reasoning, whereas combining several different values or feelings to form criteria would use inductive reasoning

After criteria are generated they are then shared in a non-judgmental manner using procedures suggested in values clarification strategies (extraversion, perception). Important criteria are placed into different categories, and a preliminary selection is made. Selected criteria are then evaluated in terms of their reasonableness given the problem statement (intuition, thinking, judging). Of course, these criteria can, and probably will, be modified based on important facts identified in the next step.

The third step is to gather information or facts relevant to solving the problem or making a decision. This step is critical for understanding the initial conditions and for further clarification of the perceived gap. Most researchers believe that the quality of facts is more important than the quantity. In fact, Beinstock (1984) noted that collecting too much information can actually confuse the situation rather than clarify it

The brainstorming technique could again be used in this step. As done previously, participants quickly write those facts they believe to be important (introversion, sensing) and then share them in a non-judgmental fashion (extraversion, sensing). These facts are classified and categorized, and relationships and meaningfulness are established (intuition, thinking). The techniques of imaging and overload can be used to establish patterns and relationships among the facts. The facts are analyzed in terms of the problem statement and criteria, and non-pertinent facts are eliminated (thinking, judging). The remaining facts and associated patterns are then prioritized and additional facts collected as necessary (thinking, perceiving).

The Processing Phase
In the Processing phase the task is to develop, evaluate, and select alternatives and solutions that can solve the problem. The first step in this phase is to develop alternatives or possible solutions. Most researchers focus on the need to create alternatives over the entire range of acceptable options as identified in the previous phase (Schnelle, 1967). This generation should be free, open, and unconcerned about feasibility. Enough time should be spent on this activity to ensure that non-standard and creative alternatives are generated.

Again, brainstorming is a technique that can be used first. Participants quickly write alternatives using the rules of

brainstorming (introversion, perception), then share the results in a non-judgmental fashion and develop additional alternatives (extraversion, perception). A number of the techniques mentioned above such as challenging assumptions, imaging, outcome psychodrama, outrageous provocation, the random word technique, and taking another's perspective can be used at this point to generate more creative alternatives. Those alternatives obviously unworthy of further consideration are eliminated (intuition, judging). It is possible to categorize or classify alternatives and consider them as a group, but care should be taken not to make the categories too complex or unwieldy. If the person or group is dissatisfied with the quantity or quality of the alternatives under consideration, a brief use of the progressive relaxation technique may be beneficial as well as the application of another, previously unused, creative technique. If dissatisfaction still remains, putting aside the problem (incubation) may be helpful.

The next step is to evaluate the generated alternatives vis-a-vis the stated criteria. Advantages, disadvantages, and interesting aspects for each alternative (using the PMI technique) are written individually (introversion, sensing, judging), then shared and discussed as a group (extroversion, sensing, judging). Most researchers advocate written evaluation, if only in the form of personal notes. After discarding alternatives that are clearly outside the bounds of the previously stated criteria, both advantages and disadvantages should be considered in more detail. An analysis of relationships among alternatives should be completed (i.e., is an advantage of one a disadvantage for another) and consideration should be given to the relative importance of advantages and disadvantages. Only those alternatives the majority considers relevant and correct are considered further.

The third step of the processing phase is to develop a solution that will successfully solve the problem. For relatively simple problems, one alternative may be obviously superior. However, in complex situations several alternatives may likely be combined to form a more effective solution (simply selecting one alternative will appeal to sensing, judging; combining one or more alternatives to make a new alternative will appeal to intuition, perceiving). A major advantage of this process is that if previous steps have been done well then choosing a solution is less complicated (Simon, 1969).

Before leaving this phase it is important to diagnose possible problems with the solution and implications of these problems (what could go wrong--sensing, judging; implications--intuition, perceiving). When developing a solution it is important to consider the worst that can happen if the solution is implemented. In addition, the solution should be evaluated in terms of overall "feelings." That is, does the alternative match important values as previously stated (feeling).

The Output Phase

During the Output phase a plan is developed and the solution actually implemented. The plan must be sufficiently detailed to allow for successful implementation, and methods of evaluation must be considered and developed. When developing a plan, the major phases of implementation are first considered (intuition), and then steps necessary for each phase are generated. It is often helpful to construct a timeline and make a diagram of the most important steps in the implementation using a technique such as network analysis (sensing, judging). Backwards planning and task analysis are also useful techniques at this point. The plan is then implemented as carefully and as completely as possible, following the steps as they have been developed and making minor modifications as appropriate (sensing, judging).

The Review Phase

The next step, evaluating implementation of the solution, should be an ongoing process. Some determination as to completeness of implementation needs to be considered prior to evaluating effectiveness. This step is often omitted and is one reason why the problem-solving/decision-making process sometimes fails: the solution that has been selected is simply not implemented effectively. However, if the solution is not implemented then evaluation of effectiveness is not likely to be valid.

The second step of this phase is evaluating the effectiveness of the solution. It is particularly important to evaluate outcomes in light of the problem statement generated at the beginning of the process. Affective, cognitive, and behavioural outcomes should be considered, especially if they have been identified as important criteria. The solution should be judged as to its efficiency (thinking, judging), its impact on the people involved (feeling, judging), and the extent to which it is valued by the participants (feeling, judging).

The final step in the process is modifying the solution in ways suggested by the evaluation process. Evaluation of the solution implementation and outcomes generally presents additional problems to be considered and addressed. Issues identified in terms of both efficiency and effectiveness of implementation should be addressed.

Considering Temperament

If the majority of the group is composed of a single temperament, the basic process can be modified to take advantage of the dominant attitudes. For example, if the majority of the group is composed of SPs, it is often useful to shorten the information collection and alternatives evaluation steps and move relatively quickly to an iterative process of identifying an appropriate solution through action. This identification might be done using psychodrama, building simple models or simulations, and trying out different alternatives. The entire group might brainstorm about the statement of the problem, pertinent facts, and criteria then form a subcommittee to conduct a more thorough analysis. Results could then be submitted to the whole group for consideration, and alternatives could be generated and evaluated. The subcommittee could then take the alternatives, develop a solution, and work out implementation details.

If the group contains a majority of SJs, care should be taken to proceed in a step-by- step, orderly manner, with ample time for consideration of all details at each step. The group

leader should consistently remind participants of where they are in the overall process since SJs sometimes focus too intensely on details and lose sight of the broader goal. During the alternatives generation phase, the group leader must be prepared to use any or all techniques for generating creative options since SJs are likely to select a traditional, familiar solution rather than formulate something new. Most importantly, the process must result in a careful, detailed plan of action that participants can follow to solve the problem. Following a step-by-step procedure is the strength of the SJs, and a properly developed solution is likely to be accurately implemented.

If the group is composed mainly of NTs, the group leader should be prepared to spend as much time as possible developing a model of the problem and its related elements. It is critical that group members have a common representation of the problem as this representation will guide the development and selection of alternatives. Careful consideration must be given to collection and discussion of all relevant details and facts as NTs are likely to consider the meaningfulness of the facts and details and often overlook those that conflict with their representations. Finally, and perhaps most importantly, care must be given to carefully analyze any alternative in terms of its impact on people. Consideration of others' perspectives in terms of values and feelings is often difficult for NTs since they tend to view the world in such a logical, analytical manner.

When the group is composed mainly of NFs, it will naturally focus on selecting alternatives that maximize possibilities in people. The same careful attention to facts and details necessary for NTs is also appropriate for NFs since NFs also focus on the significance of facts and details within their representation of the problem. Focusing on facts and details is also beneficial since it more likely results in solutions that can be realistically implemented. NFs are the prototype idealists and sometimes want to select theoretically possible alternatives that are difficult to implement given current circumstances. A process for monitoring implementation of the solution is also important since NFs sometimes do not pay attention to the details of managing the change process.

3. Summary and Conclusions

In general, there is a need to develop and use a problem-solving/decision-making process that is both scientific and considerate of individual differences and viewpoints. While the scientific process has provided a method used successfully in a wide variety of situations, researchers have described individual differences that can influence perspectives and goals related to problem solving. These differences can be used to identify appropriate problem-solving techniques used in each step of the problem-solving process.

The process described in this paper allows individuals to use a standard method in a variety of situations and to adapt it to meet personal preferences. The same process can be used in group situations to satisfy the unique perspectives of individual members. Decisions made in this manner are more likely to be effective since individuals can consciously attend to both personal strengths and weaknesses, while groups are more likely to select solutions that will both solve the problem and be acceptable to individual group members.

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