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Selected Collaborative Problem-Solving Methods for Industry

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Despite the availability of a wide range of problem solving methods, individuals continue to struggle with problems. Scientists attempt to address recurring economic, social, political, and organizational problems through the expansion of knowledge and theory. Goldratt (1990) hypothesized that every science goes through three phases of development: classification, correlation, and cause-effect. In the classification phase, a phenomenon is logically categorized resulting in a systematic identification. Examples include the location of stars or the phylum names of various plants and animals. In correlation phase, scientists determine *how* the phenomenon works through observations and rough calculations. Early astronomers used correlation to suggest elliptical solar orbits and modern physicists use it to estimate the location of an electron around the atom. When asked about his innovation, the Toyota *kanban* system, Dr. Taiichi Ohno replied, “My system does not make sense at all, but by God it’s working” (Goldratt, 1990, p.28). The third phase of cause-effect is characterized by the *why* question. Newton's methods created the science of astronomy and changed forever the way people view the stars. Cause-effect relationships advance logical explanations, predict future events, and forecast consequences. Theories and thinking based on cause-effect findings become recognized science (Goldratt, 1990) and move the field of inquiry from "art" to that of disciplined examination.

In problem solving, the root cause of the problem produces an undesirable effect. Any pursuit that does not seek the root cause leads only to the symptom of the problem and, by definition, solving a symptom will not solve a problem. Problem solvers identify root causes of problems to be able to predict future cause and effect relationships. The purposeful application of an analysis method can address complex problems using a structured approach rather than emotion or intuition.

Problem Solving Methods

The scientific method is the generally accepted framework for solving problems in Western culture. No discussion of problem solving methods would be complete without mentioning it. The scientific method has no particular inventor; it seems to have evolved over time based on the work of fifteenth-century scholars. It is, however, the basis for most problem solving approaches used today. The basic scientific method is as follows:

1. Define the problem
2. Formulate a hypothesis
3. Gather appropriate data
4. Test the hypothesis
5. Develop conclusions (Wilson et al., 1993, p. 74)

Another problem solving model, PDCA (Plan, Do, Check, Act), was developed by W. Edwards Deming (1986) who derived it from Shewhart (1986). It is a four-step process for continuous problem solving. The four stages of PDCA represent: (1) the analysis and planning of problem solving, (2) the actions taken to resolve the problem, (3) the evaluation of the results, and (4) the modification of activities that either confirm or disconfirm the desired results. PDCA is sometimes referred to as the Deming Cycle because he introduced the concept to the Japanese who subsequently named it after him (Cox, et al., 1995). The PDCA model represents a simplified version of the scientific method. Unfortunately, its simplicity misleads many problem solvers in that it leaves open the method of accomplishment.

Anderson and Fagerhaug’s (2000) problem solving model consists of problem identification, problem definition, problem understanding, root cause identification, root cause elimination, and symptom monitoring. This particular model represents a comprehensive and time-consuming approach to problem solving. As such, detailed models like this should be used only when the problem to be solved is worth the effort to solve them. In other words, they should not be used for easy problems (Brown, 1994).

Latino and Latino (1999) suggested a problem-solving model using the acronym PROACT, which stands for: PReserve event data; Order the analysis team; Analyze the data; Communicate findings and recommendations; and Track for results. Arcaro (1997) offered a six-step problem-solving model: (1) identify and select the problem, (2) analyze the problem, (3) generate potential solutions, (4) select and plan the solution, (5) implement the solution, and (6) evaluate the solution implementation. Wilson et al. (1993) selected an approach based on the scientific method that includes the following elements: set up appropriate reporting systems; define the criteria for problem selection; select candidates for analysis; select analysis techniques to be used; develop solutions; and test solutions. Finally, Sproull (2001) used ten steps to describe the process: (1) identify the problem, (2) describe and define the problem, (3) list the symptoms, (4) list the known changes (that occurred prior to the problem), (5) analyze the problem, (6) hypothesize possible causes, (7) test possible causes, (8) take action on the causes, (9) test and implement the solution, and (10) implement the appropriate controls.

While these methods share some common themes, their greatest similarity is that they all represent structured approaches to problem solving. While unstructured approaches such as intuition, networking, and prior experience may be valid for solving problems, they are also more subjective and less repeatable. Problem solving that is not repeatable has a higher potential for failure because practitioners will likely repeat the same mistakes to gain the intuition and experience necessary to solve them again. Likewise, unstructured approaches generally result in outcomes that address symptoms only. Consequently, why should people spend the time and effort to solve the same problems continually? Good problem solving techniques will generally uncover the real reason behind the effect.

Root Cause Analysis

According to Anderson and Fagerhaug (2000), "Root cause analysis is a structural investigation that aims to identify the true cause of a problem, and the actions necessary to eliminate it" (p. 10). It is the process of identifying causal factors using a structured approach with techniques designed to provide a focus for identifying and resolving problems. Root cause analysis provides objectivity for problem solving, assists in developing solutions, predicts other problems, assembles contributing circumstances, and focuses attention on preventing recurrences. Most often, root cause analysis techniques are utilized as input to the decision-making process. If root cause analysis is used in a reactive mode, it provides objective identification of organizational faults. In the proactive mode, root cause analysis identifies and prevents future mistakes. Wilson et al. (1993) wrote, "Root cause analysis, properly implemented, will tell you the real reasons for problems" (p. 20).

Rigorous root cause analysis may involve asking difficult or embarrassing questions about how an organization is managed (Dew, 1991). A characteristic of root cause analysis is to assume that bad decisions are based on erroneous logic, faulty assumptions, or obsolescent systems. The interest of root cause analysis is not who made the error, but why. Analysis methods that focus only on human error are generally not successful due to dwindling participation for fear of repercussions. If the root cause analysis process is flawed, decision errors will continue (Latino & Latino, 1999).

Graphic Displays

Use of graphic displays in the analysis of problems appears to have merit. When viewing graphics, a person first comprehends the overall structure (patterns, symmetry, trends of dots and lines), then focuses on what is interesting. Regardless, of nationality or culture, most people understand pictures. According to Mizuno (1988), human beings go through three stages of development starting as "contact beings" who exchange information through physical contact, such as the contact between an infant and mother. Contact beings then grow into "picture-beings" who understand information through pictures and drawings and finally become "character beings" that transmit information through written characters and symbols. As such, the human capability to understand graphic communication appears to be developmental. Therefore, tools that incorporate graphics emerge as powerful techniques because most people comprehend them quickly.

In 1977, computer theorist Yoshikawa (Mizuno, 1988) distinguished pictures with language from pictures that contain only drawings with the designation "graphics language." Within this designation, he identified four types: relational, network, column-row, and coordinate. Of the four types, the coordinate and column-row systems are the oldest and most structured. The other two types, relational and network, are more intuitive and allow greater degrees of freedom during use. Not surprisingly, relational and network system tools have become increasingly popular.

> *"As we move toward socio/technical systems, this graphic language may be used as a tool to assist the reader in integrating the social and technical requirements of his or her job. Effective communication of relevant data within and between work teams is essential to ensure successful results. …a strong graphic is worth more than a thousand words" (Moran et al., 1999, p. vii).*

Research by Hauser (1991) found that the number of constructs and density of relationships in a causal network display increases the perceived complexity of a system, but does not necessarily reduce understanding. A construct refers to the variables or nodes depicted in the display while a relationship refers to the connections made between the nodes, usually with arrows. In addition, Hauser discovered that clustering or grouping constructs into meaningful sectors and adding additional pictorial information, such as dotted lines, increased overall understanding of the display. Thus, it appears that causal network displays are appropriate for understanding complex problems and finding root causes.

Hitchins (2002) suggested there are three graphic archetypes for displaying cause and effect relationships. The first simply links the two together with an arrow, as shown in Figure 1A, where effect follows cause. The advantage of this display is that it is uncomplicated. The disadvantage is that relationships between multiple causes are not shown; i.e., there is no observable connection between one cause and another. The second archetype in Figure 1B builds relationships between causes and effects to form linear chains. The advantage of this display is that the logic can be traced while the disadvantage is that it does not show system dynamics. The third archetype in Figure 1C shows cause-and-effect with feedback loops. The advantage of this display is that it can describe non-linear and chaotic systems dynamics. The disadvantage is that it may appear counterintuitive and complicated.

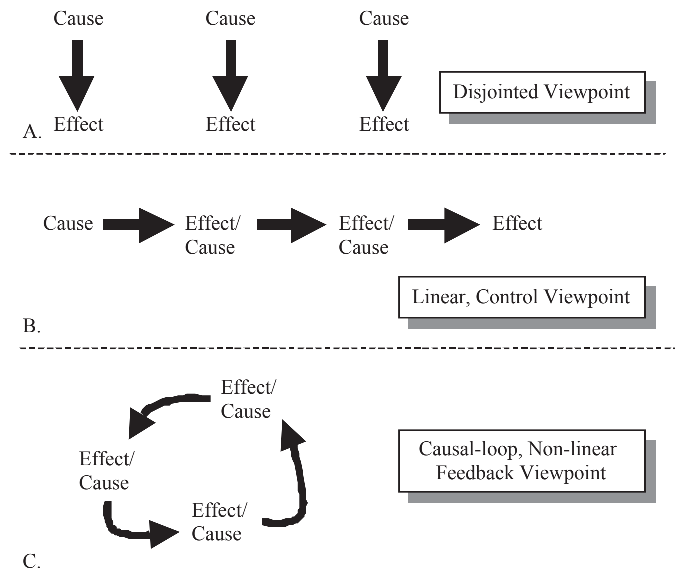

Figure 1. Cause and Effect Linkages

Collaborative Problem Solving Approaches

Avouris, Dimitracopoulou, and Komis (2002) asserted that the research on collaborative problem solving began by assessing the effectiveness of various independent variables such as group composition, media, and task structure. The next phase of problem solving research explored the role of group interaction and verbal processes. Thus, the focus shifted from attribute research design to the dynamics of the group itself. More recently, the research has concentrated on the analysis methodologies used and the quality of the group collaboration. Thus, popular research design has focused on the group, the method, and the output generated during problem solving process.

Groups appear to be able to deal with more complex types of problems because groups have a larger range of skills and abilities than a single individual (Finnegan & O'Mahoney, 1996). Groups also tend to operate more efficiently over time as they establish cohesiveness through established norms of behavior, increased interaction, and repetitive communication (Scholtes, 1988). The group dynamic, while time consuming, generally results in better solution outputs than solutions generated through individual analysis. Thus, the benefits of collaborative problem solving methods far outweigh the process inefficiencies (Hohmann, 1977).

In a study to develop a methodology for describing how emotional and cognitive processes affect group problem solving effectiveness, Khaimovich (1999) found two stages of analysis. The first stage involved the discovery of possible causes through brainstorming activity. The second stage involved the verification of the generated possible causes by examining the validity of causal links. Khaimovich found the verification of the causes to be problematic. Groups were content with their original ideas and reluctant to scrutinize the integrity of their models. Thus, problem-solving methods that provide mechanisms for verification are preferred.

Groupware and Collaborative Problem Solving

According to Bort (2003), virtual collaboration is the doorway to the next-generation of business. However, organizations that have experienced success in this area generally limit the scope by using custom-built software on a project-by-project basis. Web meetings and instant messaging are gaining popularity in organizations, but these collaboration types are fairly simple. Unfortunately, the technical requirements, speed, and bandwidth for collaborative software exceed the capacity of most desktop computers (Prisk & Dunn, 2002). Computerized collaboration also creates acceptance issues as organizations learn how to work without paper. This acceptance problem may disappear over time as future generations become more comfortable using virtual collaborative methods.

Of the current available methods, groupware seems to offer the most potential for virtual collaborative problem solving. The principle functions of groupware are for document sharing, computer conferencing or chat, e-mail and messaging, group or meeting scheduling, project management, idea organization, and team building through shared virtual work space (Zwass, 1998). Groupware systems can generally be categorized as synchronous, asynchronous, or a combination of both. Synchronous groupware applications support real-time communication such as instant messaging or chat. Asynchronous groupware applications store messages and transfer data to be viewed at the user's convenience such as e-mail and attachments (DeFranco-Tommarello & Deek, 2004). Each of these system types has its advantages. Synchronous groupware allows for lengthy discussions of diverse topics and expeditious solutions whereas asynchronous groupware provides time for personal reflection and careful response to archived entries that can be read at any time. Table 1 shows some of the current groupware packages and their collaborative features. Readers will note that many of the features found in collaborative and problem-solving software packages are also found in education and distance learning software.

Table 1. Groupware Functions and Features

Groupware Name	E-mail & Message Board	Document Sharing & Storage	IM & Chat	Meeting Tools	Project Mgmt.	Idea Organizer	Shared Work Space
Collaborative and Problem Solving Tools							
Groove	X	X	X	X	X	X	X
GroupSystems	X	X		X		X	X
Lotus Notes Domino	X	X	X	X	X		
Sametime		X	X				X
Quickplace	X	X	X			X	
WikiWeb	X	X					
Educational and Distance Learning Tools							
ElES	X		X				
Vitual-U	X	X	X				
Learning Space	X	X	X	X			X
WebCT	X	X	X	X			X
CoMentor	X	X	X				
Colloquia	X	X	X				
TopClass	X	X					
Blackboard	X	X	X	X			X

IM = Instant Messaging

Conclusion

The literature indicated that structured problem solving methods that incorporate graphic network displays for root cause analysis are an effective means for understanding and solving complex issues. The challenge for technologists is to develop and become proficient in problem analysis using virtual graphical approaches with geographically dispersed groups. Groupware has the potential of becoming a valuable resource for this type of problem solving. Technology professionals should carefully assess the requirements before selecting groupware and continue to evaluate both the technical and social climate before engaging in virtual problem solving activities. These assessments should be based upon the needs of the organization and the participating individuals. At present, groupware has the potential for facilitating virtual group problem-solving activity, but is limited by technological constraints and communication bandwidth. More research and socio-technological development is required before problem-solving by remotely dispersed groups will achieve its full potential.

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