

■ *Research Paper*

The Problematique: Evolution of an Idea

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A *problematique* is a graphical portrayal — a structural model — of relationships among members of a set of problems. It is a product of a group process whose design benefits from the writings of Aristotle, Abélard, Leibniz, DeMorgan, C.S. Peirce, and Harary. Contemporary scholars first conceived the idea of the *problematique* simply as a name for the array of problems confronting the world. It was then extended to represent a structural portrayal applicable to specific problematic situations. Having been tested in many such situations, it can now be viewed as a standard format of wide utility in many applications. An appropriate perspective on this type of structure arises from comprehending the history of its evolution. Copyright © 1999 John Wiley & Sons, Ltd.

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INTRODUCTION

A *problematique* is a structural model, a graphical device for enhancing human understanding and facilitating the development of action plans for correcting undesirable situations. It is comprised of brief statements representing problems and a pattern of interaction among them. The relationship portrayed is typically one of aggravation rather than causality since modern societal issues are not readily reduced to simple cause and effect relationships. The *problematique* is one component of a larger system for exploring and managing complexity. This larger system is called Interactive Management (Warfield and Cárdenas, 1994). While the *problematique* is only one of several key graphics types found beneficial in studying problematic

situations, it is the most prominent. The earliest applications of the *problematique* occurred in the late 1970s and early 1980s. Since then, many *problematiques* have been produced by groups and applied successfully to the interpretation of situations previously thought to be intractable. The concept of *problematique* has evolved from a metaphor to an operational concept, allied to the study and resolution of complexity. Thus, it seems appropriate to pause and record the evolution of an idea that has its roots in the foundations of Western philosophical thought.

PHILOSOPHICAL AND MATHEMATICAL FOUNDATIONS

This historical journey begins in the time of Aristotle and the invention of the syllogism, since that invention is the earliest known forerunner of the *problematique*. Aristotle (384–322 BC) is

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regarded as the earliest major logician and known for his insistence on rigorous scientific procedure and his method of demonstration by the syllogism and by dialectic, or reasoning from the opinions of others. A commonly cited syllogism, slightly modified, reads as follows:

Socrates **is** a man.
 Each man **is** mortal.
 Therefore Socrates **is** mortal.

The highlighted word 'is' in this syllogism is referred to as its 'copula'. The syllogism can take many forms, but each involves three basic components: two presumed statements of fact from which a third can be inferred.

The work of Gottfried Leibniz (1646–1716) signals a turning point in the development of formal logic. Leibniz was the first to use circles to represent statements of logic and to show relationships graphically. Leibniz also recognized that many assumptions were being made about language, in effect taking it as a given, while the validity of the syllogism clearly depends upon understanding in detail what each term from the natural language entails. Moreover, Leibniz recognized that the development of science was severely constrained by the acceptance of the natural language as the language of science. He prompted the idea that any science requires a designed language, carefully constructed to allow for more precise expression than the natural language might provide, in order that the relevant scientists can communicate their ideas in ways that allow them to be understood by and tested by other scientists (Bochenski, 1970).

Augustus DeMorgan (1806–1871) would make a significant contribution to such communication. He was apparently the first to symbolize the concept of relation in any general way (Lewis and Langford, 1959). He introduced a notation for relationships that could be substituted for the copula in the example syllogism. Leonhard Euler (1707–1783) had, independently of Leibniz, used circles to study the syllogism, although this approach is usually associated with Venn (1834–1923) in the scientific literature.^a Combining the

^aResearchers now know that Venn diagrams were previously used by Euler, being called Euler's circles and, as Bochenski (1970) shows in a photograph from Leibniz's research notebook, Leibniz was using such diagrams in advance of Euler.

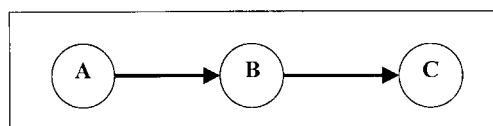


Figure 1. Representing a syllogism graphically

ideas of Leibniz, DeMorgan, and Euler, the example syllogism is represented graphically by a linear structure consisting of three circles and two arrows as shown in Figure 1. The three circles represent, respectively, statements A, B, and C. In this instance, the letter A represents 'Socrates', B represents 'man', and C represents 'mortal'. There is an arrow from A to B, representing the chosen copula 'is', and another arrow from B to C, also representing the chosen copula. By symbolizing the elements that the copula joins, one could replace the syllogism above by a generic form: $ARB, BRC, \text{therefore } ARC$. The first arrow and the circles to which it connects represent the statement ARB . The second arrow and the circles to which it connects represent the statement BRC . The inferred third statement ARC is represented by the directed path originating at A and terminating at C (having passed through B on the way).

The concept of inference inherent in the example syllogism is fundamental to the construction of the *problematique* in its modern form. As Bochenski (1970) indicates, DeMorgan was well aware of the significance of transitivity of the copula as a condition for validity of a syllogism.^b Charles S. Peirce (1839–1914) studied DeMorgan's theory of relations intensely and appears to have been the first to stress heavily the importance of transitivity in logic (Goudge, 1969). Peirce identified three major types of inference: deductive, inductive, and abductive. The first two are generally well known in science. The last one, abduction, was conceived by Peirce to create a name for the process of hypothesis formation. Peirce, as scientist–logician–philosopher, made major contributions to formal logic, as well as to the

^bBochenski, a member of the Dominican order, traced the developments in logic from about 500 BC up to about AD 1930. He offers numerous quotations from original sources, providing a perspective on the evolution of formal logic that is not apparent from any other author.

philosophy of science, and to the evolution of the problematique. *The Interactive Management process which produces a problematique can be viewed as a 'group abduction' and the problematique itself can be viewed as a structural hypothesis about the transitive nature of interrelated problems.*

A major contribution to the use of graphics as a language for working with relations occurred with the publication by Harary *et al.* (1965) of a book on structural modelling. This book is one of a very small number of mathematical works in which the products of two or more distinct fields of mathematical study are integrated to show how their combined strengths can make possible applications theretofore only dimly perceived. This jointly authored work, led by Frank Harary (1921–) demonstrated a strong connection among what might be called the mathematics of structure, a language that facilitates notations and operations that can encompass many, many components. Some of the key developments within this language are listed below:

- Graph theory (Leonhard Euler, 1707–1783)
- The theory of relations (Augustus DeMorgan, 1806–1871)
- An algebra of logic (George Boole, 1815–1864)
- A theory of matrices (Arthur Cayley, 1821–1895)
- A theory of sets (George Cantor, 1845–1918)

The work Harary led in carrying out an analytical integration of these various components was fundamental to the eventual development of the most recent form of the problematique.

OPERATIONALIZATION OF A METAPHOR

A series of events during the early 1970s led to a maturing of the problematique and the process by which it is developed. A prospectus entitled *The Predicament of Mankind* was presented to the Club of Rome in 1970 by Hasan Ozbekhan and Alexander Christakis.^c In it there is what appears

^cThe Club of Rome was started following a meeting convened in Rome in April 1968, by the Giovanni Agnelli Foundation and the National Academy of Lincei to discuss new approaches to the problems of world society. At the end of this meeting a number of those present, increasingly concerned about the symptoms of breakdown of our society that are appearing simultaneously with higher

to be an original and novel use of the term *problematique*. In introducing this term graphically, the authors used a sequence of drawings akin to what are popularly known as 'Venn diagrams', beginning with a drawing where each problem area is represented by a geometrical figure separate and removed from each other problem area (Figure 2).

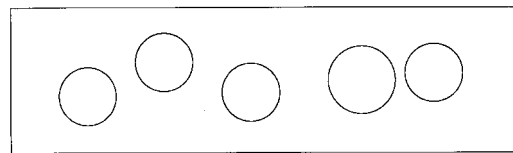


Figure 2. Representing unconnected problem areas graphically

In the next drawing in the sequence, growth, and movement of these areas is indicated, but the areas are still distinct, though moving toward one another (Figure 3). In the third drawing, the areas have grown still further and now overlap significantly (Figure 4). Thus, the idea of the problematique, as we use the term today, appears

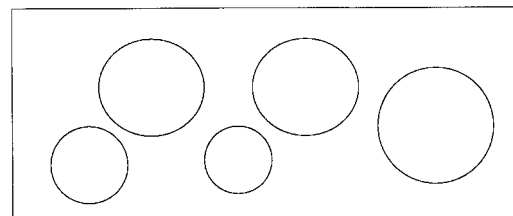


Figure 3. Representing problem areas that have enlarged and are almost encroaching upon each other

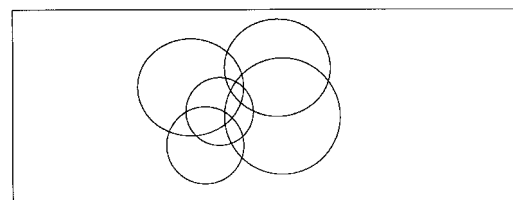


Figure 4. Representing mutually interacting problem areas

levels of prosperity and the ever-quickenning application of new technology, decided to continue to work together, and called their group *The Club of Rome* after the city of its origin. The Club was incorporated in March 1970, in Geneva, as a non-profit private association under the Swiss Civil Code, the Secretariat to be in Rome.

as the consequence of a steadily growing collection of problem areas which, over time, begin to run together and create, ultimately, a heavily interconnected group of problems. Each problem area becomes an element in a system of interacting problems that defies traditional problem-solving techniques. An example of such a system and the catastrophic effects of misguided intervention has been provided by Zamierowski *et al.* (1976).^d

An early member of The Club of Rome was the Battelle Institute of Geneva, an organization established at the end of World War II by the American parent, the Battelle Memorial Institute of Columbus, Ohio, to provide contract services to industry and government. After The Club of Rome had begun operations, Battelle established an internal research program entitled *Science and Human Affairs*. The Geneva component of this program used the term DEMATEL to represent its major thrust. This acronym stood for decision-making and testing laboratory. At the same time, the Battelle Columbus Laboratories initiated a project under the Science and Human Affairs banner entitled *Science Base*. That project was assigned to John N. Warfield, who had proposed to explore the scientific depths related to the description, diagnosis, and understanding of complexity, as involved in interrelated problem sets, with the ultimate aim of developing new processes that would enable design or redesign of large-scale systems. Partial results of the project appeared in a Battelle monograph entitled *Structuring Complex Systems* that set forth the theory of interpretive structural modelling.^e Interpretive structural modelling depends heavily upon the mathematics of structure. The work of Harary *et al.* (1965) provided much of the foundational thinking, but had to be augmented considerably, and the notation amended to reflect an orientation toward synthesis, which is essential for the purposes of model development. Interpretive

structural modelling also draws heavily upon the concept of transitive inference developed through the thought of DeMorgan and Peirce and put into Boolean matrix form by Harary *et al.*

The modern format of problematique resulting from Warfield's work inculcated several new design features. For example, boxes rather than circles are used to encapsulate brief prose statements of problems and line crossings are reduced to enhance readability.^f In addition, the relationship pictured is typically one of significant aggravation rather than the more commonly invoked causality. Finally, the relationship depicted by the arrow is included as a label within the display. The intent is to provide a graphic display that fulfills two basic requirements: first, to present a 'picture' of a problematic situation in a manner that minimizes cognitive overload; second, to facilitate interpretation, e.g. by direct translation of the display or portions thereof into prose when preparing written reports. An example of a simplistic problematique in its modern format is shown in Figure 5.

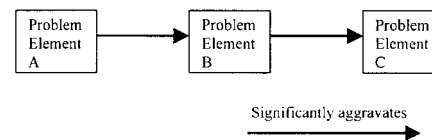


Figure 5. Graphical format of elementary problematique

Interpretation and translation of this example, based on the transitive nature of the copula, is as follows. Problem A aggravates problem B, which, in turn, aggravates problem C. By inference, problem A also aggravates problem C even though a direct link is not shown. From this we can intuit that aggravation builds, or propagates, as one moves along the path of arrows from left to right. Furthermore, resolving problem B

^dRaymond Fitz SM, PhD, of the University of Dayton, was the leader of the first computer-assisted application of interpretive structural modelling ever carried out. He also provided leadership in studying a major catastrophe in the Sahel region of Africa, involving deterioration of living conditions for nomads, expansion of the desert, and loss of vegetation.

^eThe monograph was published in 1974 with a more complete description appearing two years later in Warfield's *Societal Systems: Planning, Policy, and Complexity*.

^fResearch by Fertig (1980) led her to suggest that about eight words are normally appropriate for good communication concerning problems included in a problematique. Two papers have been published that are oriented toward making it easier to read structural graphics (Warfield, 1977; Tamassia *et al.*, 1981). The first stresses elimination of line crossings that make it difficult for the eye to follow paths through the structure. The second, emanating from a Fujitsu research laboratory and based, in part, on the first, offers an approach and methodology for developing a software package that assists in laying out a physical drawing.

does not eliminate the influence that problem A has on C.

PRACTICAL APPLICATIONS AND LESSONS LEARNED

One of the first problematiques ever developed arose from an industrial setting. The John Deere Company, in Waterloo, Iowa, was having problems with a manufacturing line for an expensive pump. Dr Robert J. Waller, then Dean of the School of Business at the University of Northern Iowa, proposed the use of interpretive structural modelling to engineers at Deere with the aim of trying to unravel the complexity associated with the pump manufacture. The problematique developed by the group led to the discovery of several problems requiring collective action (Warfield, 1994). This application is of historical interest because it demonstrated a clearly successful application of the problematique to a concrete industrial issue, and encouraged the continued development and use of the problematique in a much broader set of situations.^g

When the problematique began to be constructed as a common aspect of the description of problematic situations, it was supposed that the participants who created one using the Interactive Management process would be able to read and interpret it quite readily. However, experience has shown that misinterpretation occurs and that it is potentially devastating.

It is commonplace in engineering and in other disciplines to use diagrams comprised of diverse geometric shapes strung together with lines or arrows to depict precedence relationships. Participant familiarity with such displays seemed to reinforce a linear approach to problematique

interpretation. Such a finding, upon reflection, is not surprising given an educational system that relies primarily on prose for teaching and learning. Prose, by its very nature, is a linear means of communication. The problematique is a non-linear logic structure, which requires a different reading style. The problematique combines prose and graphics to facilitate parallel processing of information. It was quickly recognized that interactive management session participants required assistance in grasping the true meaning of the display. Initial efforts involved explaining the problematique to participants in terms of the problems lying at opposite ends of the structure. To use Figure 5 as an example, a problem at the extreme right was described as 'symptomatic', and one at the extreme left was described as 'fundamental'. An intermediate problem was seen as being affected by those on the left, and affecting those on the right. Later, the term 'root cause' gained popularity, and some enthusiasts began to describe the elements lying at the left as the root causes of the problematic situation.^h

None of these early forms of interpretation was commendable since the problematique is a tool for problem identification, a structural hypothesis developed through a computer-assisted group process. The problematique first displayed in this process is typically comprised of problems the group deems most important. Such a display might include 20–40 problems even though the group had initially identified a hundred or more. To assume that no other problem element lies further to the left or right of those included in the initial display is inappropriate. Even though the Interactive Management process had been designed to preclude premature closure when processing problems, it soon became clear that better ways of describing and interpreting the problematique were essential.

Warfield's years of research had led him to conclude that complexity is a state of mind, not a system parameter. In other words, the origin of

^gNotable examples of Interactive Management in action can be found in the work conducted by Dr Henry Alberts at the Defense Systems Management College, Dr Scott M. Staley at the Ford Motor Company, and Dr Alexander N. Christakis at the Food and Drug Administration. Development of interpretive structural models through the Interactive Management process has not been limited to the US Federal government. Dr Benjamin Broome has facilitated multiple Interactive Management sessions with a variety of North American Indian tribes. Professor A. Roxana Cárdenas has been instrumental in a number of applications carried out across Mexico, including developments in strategic planning for the State of Guanajuato by Dr Carlos Flores and his associates.

^hOngoing research concerning misinterpretation of the problematique by first-time viewers suggests that the misperceptions being encountered may be due to the positivistic philosophy ingrained in physical and social science curricula.

complexity resides in the mind of the individuals attempting to understand a system, not in the system itself (Warfield, 1995). This belief underlay his approach to the reduction of complexity through learning processes. The Interactive Management process by which a problematique is developed is essentially a facilitator-guided, computer-assisted, educational process. It frees knowledgeable individuals of process management responsibilities so that they can concentrate on substantive issues. The problematique that results from the Interactive Management process has shown itself to be a powerful vehicle for discovery of relationships previously overlooked or ignored. The empirical evidence gathered by observing and recording Interactive Management sessions led Warfield to develop a way to help prioritize investigation of problems (Warfield, 1995). Warfield has developed diagnostic tools, which involve computation of numerical values for each problem based on its structural features. The resulting metrics are intended to aid in determining how each problem element is to be treated. For example, a problem element chosen by many Interactive Management session participants as important, but found to be of little influence in the overall structure of the problematique, might be categorized as 'overrated' with action deferred until some later time. Conversely, a problem found to have high influence, but ranked low in importance by the group, might be categorized as 'underrated' and deserving of immediate, high-priority attention. Continued use of the Interactive Management process will provide opportunities to test the usefulness of such metrics in clarifying the meaning and intent of the problematique.

CONCLUDING REMARKS

Scholars and practitioners have made major contributions to the evolution of an idea that had its origins in antiquity. Modern development of that idea has proceeded from metaphor to

operational concept. There is ample evidence to suggest that the unaided human mind is incapable of coping effectively with modern societal issues. The problematique has proven to be highly effective in illuminating the structure that underlies problematic situations, thereby increasing the potential for successful human intervention.

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