IIAI Open Conference Publication Series
IIAI Letters on Business and Decision Science
Vol. 001, LBDS027
DOI: https://doi.org/10.52731/lbds.001.027

Reconsideration of the Recursive Processing Model in the Problem Formulation and Solving Processes

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Abstract

In this study, we identified human cognitive processing in the problem formulation and solving process. In previous studies, this was a unidirectional process. Herein, we propose a model to realistically explain the recursion in the process of problem formulation and solving. Applying this model to real cases is a topic for future research.

Keywords: Problem formulation, Problem solving, Cognitive process, Recursion

1 Introduction

People deal with a variety of problems every day. To solve a problem, the problem formulator clarifies their objectives and solves the problem following these objectives. In this process, the problem formulator formulates the problem to clarify the objectives. Thereafter, the problem-solving process is undertaken.

The study of problems has been conducted by various researchers for a long time. First, what is a problem in problem formulation? Duncker said that " A problem arises when a living creature has a goal but does not know how this goal is to be reached. " [8]. This indicates that a problem exists when the current goal is known and the method for problem solving is unknown.

Based on this definition of a problem, Mayer categorized problem types as either typical or atypical [12] and as clearly (can be specified) or ambiguously defined. A clearly defined problem clearly defines the state of the problem, goal to be attained, and actions to be taken. The fact that a problem can be clearly defined indicates that it can be stylized. Conversely, an ambiguously defined problem is characterized by the solution method and procedure being unknown, which is characteristic of atypical problems, and the state and goals of the problem are generally ambiguous to begin with, rendering the problem more difficult to tackle [12].

Smith argued that these problems are caused by the perception of a gap between the ideal and reality [5]. As described above, the problems that problem formulators formulate to tackle exhibit many characteristics, although the previous studies introduced are subsequently reviewed herein.

However, there is a question as to if the problem to be tackled is truly recognized as a problem to be tackled by the problem formulator and if the problem formulator can formulate it. If the problem formulation is inadequate, the effort may be futile.

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Therefore, for the problem formulator, setting up a problem without first understanding what the problem is can sway the subsequent approach to problem solving. Drucker noted that " The most serious mistakes are not being made as a result of wrong answers. The truly dangerous thing is asking the wrong questions. " [11] . Thus, it is important to properly formulate problems.

We focused on the importance of problem formulation and conducted a survey on it. We identified issues that should be investigated regarding problem formulation and issues that should be considered. In this process, we considered that a one-time problem formulation and its solution may not necessarily eliminate the problem formulator's dissatisfaction. We figured that through repeated problem formulation and solving, problem formulators could approach a state in which they do not feel dissatisfied.

Therefore, we attempted to clarify how problem formulators formulate problems, focusing on human cognitive processing.

2 Previous Studies on Problem Formulation Models

2.1 Smith's Problem Formulation Model

Smith stated that a problem stemmed from the existence of a gap [5]. Smith viewed the problem-solving flow as two processes: problem formulation (identifying, defining, and structuring the problem) and problem solving (diagnosing and generating alternative solutions). For problem formulation, various methods have been proposed; the soft systems approach, represented by the soft systems thinking proposed by Checkland, is a typical method [10]. The latter is mainly an approach based on optimization theory using operations research (OR).

Smith broadly refers to problem solving as the entire problem-solving process (an action-oriented human thought process). Narrowly, it is the activity of taking a formulated problem as input and working toward its solution. Figure 1 illustrates this.

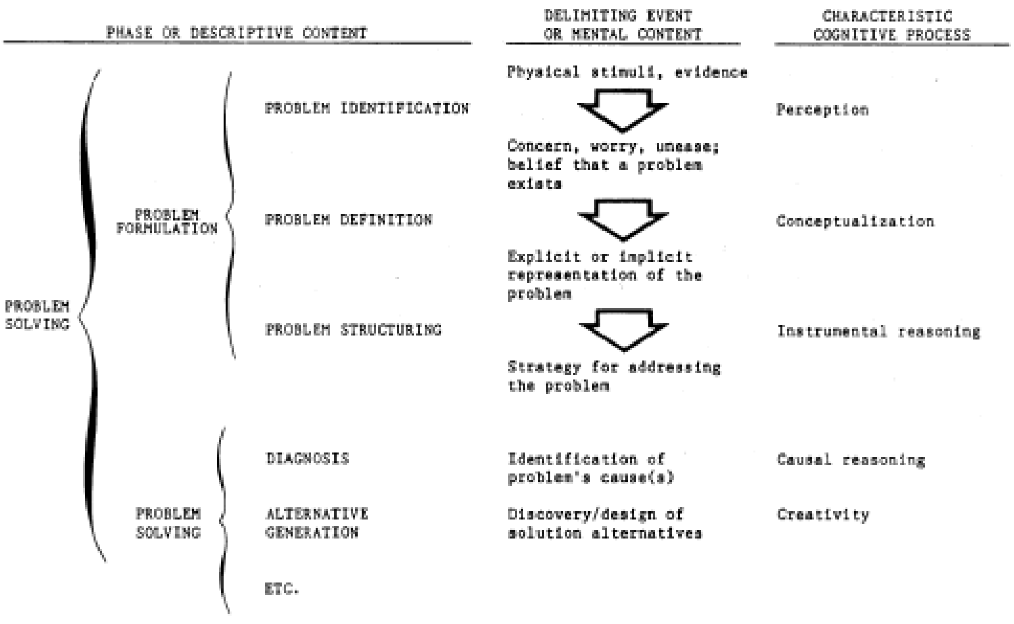

Figure 1: A model for problem solving.

The problem-solving process model is divided into two parts: problem formulation and (narrowly defined) problem solving. Problem formulation is divided into the problem identification, definition, and structuring phases. Problem solving includes the diagnostic and alternative generation phases.

Smith presents Figure 2 as a prescriptive model of how humans should perform problem formulation in this problem solving process model [4].

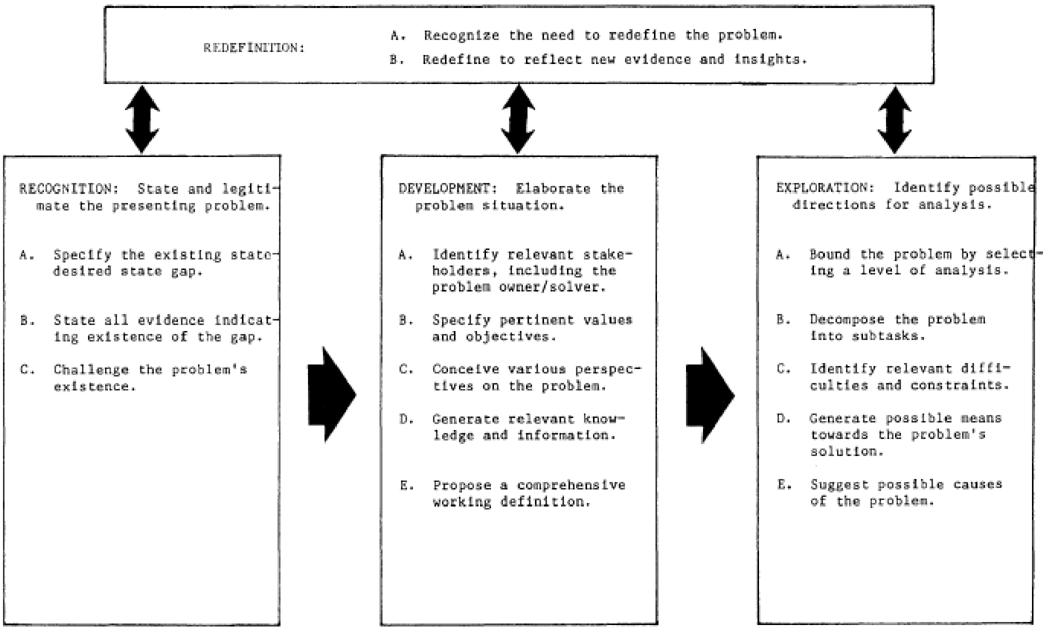

Figure 2: A prescriptive framework for problem definition.

In the recognition phase, which is the first phase of problem formulation, the problem formulator identifies the current problem and verifies its validity. What is identified as a problem in this phase can be thought of as an indication of a problem that arouses initial interest. The problem at this point is assumed to be one that may become important or change. At this point, Smith stated that the problem should be specified as a gap between the current and desired states [4]. In particular, he stated that it is more important to verify which gaps are identified as problems than to identify the exact problem.

Next, the development phase is the process of describing in detail the previously identified problem situation. It identifies the problem owner(s) (including the problem solver(s)), relevant stakeholders, and objectives and gaps in the problem.

The investigation phase identifies specific solutions. First, the problem formulator determines the level of analysis to be addressed. Based on this, the problem solver generates solutions by identifying the difficulty and constraints of the problem in the process of decomposing and subtasking the problem. Finally, the possible causes of the problem are identified.

A redefinition phase is performed relative to any of the phases. When a problem formulation activity is questioned, the need to redefine the problem is recognized, and the problem is redefined to reflect the new rationale and insights.

Smith's prescriptive model provides a specific approach to the traditional problem formulation model, suggesting the need to redefine problem recognition and perception.

In this model, the problem is considered from various perspectives, and the aspects of the problem are comprehensively clarified based on knowledge and values.

2.2 Tokita's Problem Formulation Model

Tokita describes problem formulation as "the process of conceptualization or concept formation", implying that "when we are confronted with an inconvenient situation, we feel that there is a problem, but the inconvenient situation is, so to speak, a sign of the problem, not the actual problem, and only when we abstract such signs to an extent and grasp them as concepts, we feel that we have finally recognized a problem" [9].

Based on this recognition, Tokita proposed a basic model for human problem formulation (Figure 3).

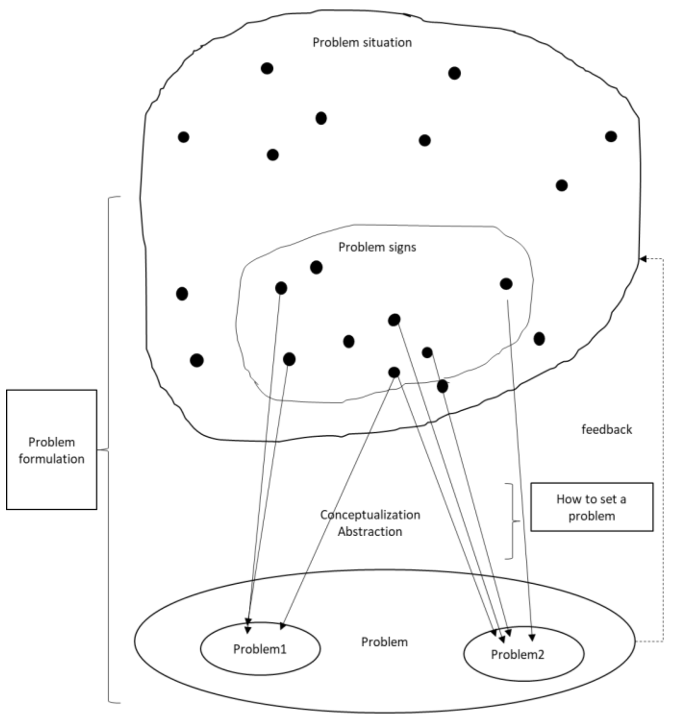

Figure 3: Tokita's basic model of problem formulation.

In this model, ● represents the individual situations in the external world of the problem formulator. This is a set; in the subset, things exist that make us feel uneasy, dissatisfied, worried, contradictory, ambiguous, difficult, or that we are deviating from the ideal. These things can be called signs of problems (i.e., problem elements) that make us think we have to do something (arouse our awareness of problems). The problem formulator selectively perceives these signs in the actual situation and forms a concept of the problem.

Based on this basic model, Tokita rejected the idea of viewing problems as gaps. Tokita argued that "a situation in which a solution is sought and structured is taken as a problem", and that the difference between the ideal and reality, which exists as a gap, is recognized as a problem only when it is recognized as a structured situation [9].

2.3 Problem Formulation Model of Imayoshi, Tabata, and Tokita.

Imayoshi, Tabata, and Tokita. [1] improved the basic model of problem formulation by Tokita. First, they introduced the following model based on the idea that a problem is subjectively recognized as a situation by the owner (or analyst) from the real world, as insisted by Tabata and Tokita [14].

If a person focuses on a situation (object), *O*, that exists in the real world, *W*, and perceives it as a system, the system, *s*, is a mapping and can be captured in map ϕ.

$$\phi_i : \{O \in W\} \longrightarrow s. \tag{1}$$

This model is based on the premise that (1) a problem has an owner. (2) There is a situation, *O*, as a precondition for the problem to occur. (3) The problem is perceived as a system, *s*. Thereafter, (4) the cognition is triggered when the degree of dissatisfaction, *D*, exceeds the criterion value, θ, of the owner, *i*. The problem is defined by the following equation.

$$Pr = \{s | D(s) \geq \theta, s = \phi_i(O), O \in W\}. \tag{2}$$

This equation defines s as a problem when *i* perceives ϕ_i a situation, *O*, in the real world, *W*, as *s*, and *D* with *s* exceeds θ. This is illustrated in Fig. 4. Imayoshi, Tabata, and Tokita., similar to Tokita, considered a problem not as a gap but as a situation. They insisted that the situation does not become a problem until the judgment of the owner of the problem on the situation is included.

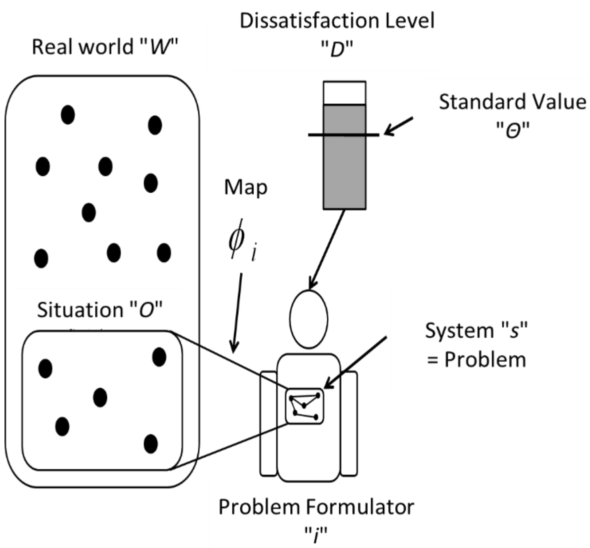

Figure 4: Problem recognition model of Imayoshi, Tabata, and Tokita.

Previous studies on problem formulation models have been reviewed above, and they represent the situation for problem formulation at a certain time and the components of problem formulation. However, as it is usually said that a true problem can be discovered after solving a problem [7], problem formulation does not end with a single problem formulation.

Therefore, in the next section, we propose a model that addresses the problems of conventional problem formulation models.

3 Proposal for a New Problem Recognition Model

We have confirmed the flow of the problem formulation process of human beings [1, 4-5, 9, 14]. However, Weinberg et al. noted that " You can never be sure you have a correct definition, even after the problem is solved." [3], and we occasionally begin problem solving without a clear problem formulation. Thereafter, the true problem may be recognized after the problem is solved. This can be thought of as the fact that human problem formulation is limited to a single problem formulation that leads to a solution, and that multiple problem formulations and solutions are repeated until the problem formulator no longer recognizes the problem as a problem. Fujita et al. mentioned this cyclical characteristic of problem formulation as follows. "A goal setting (which is simultaneously a problem definition) is interpreted in a related problem complex, and the goal is interpreted to clarify the meaning of the whole complex [13]. " Conversely, the model by Imayoshi, Tabata, and Tokita. is considered to be a cut-off point in the problem formulation model.

Therefore, we clarified why the cyclical characteristics of multiple repetitions of human problem formulation can occur, regarding the model by Imayoshi, Tabata, and Tokita. We propose a model that closely resembles real-world problem formulations.

First, an overview of the problem formulation process in the model by Imayoshi, Tabata, and Tokita. is as follows: the problem formulator recognizes a situation, *O*, in the real world, *W*, and perceives and maps *O* as system, *s*. The problem formulation model is developed based on the problem formulator's criteria. The problem is then defined as one when degree of dissatisfaction, *D* exceeds θ. This was expressed in the form of a flowchart (Figure 5).

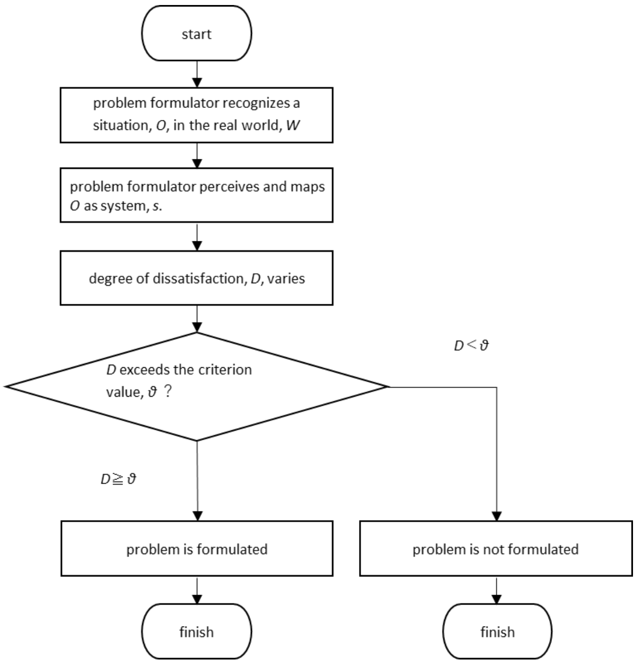

Figure 5: Flowchart of the problem recognition model by Imayoshi, Tabata, and Tokita.

Next, we investigated how it was possible to recognize the true problem after solving the problem formulation in the model by Imayoshi, Tabata, and Tokita.

Recognizing the true problem after solving a problem can be described as recognizing a problem in a different framework because the problem remains even after solving the problem once. Considering that Imayoshi, Tabata, and Tokita. defined the criteria for a problem as D exceeding θ, the process of becoming aware of a true problem after problem solving can be thought of as a state in which D remains above θ even after it fluctuates because of the problem solution. Therefore, it can be said that the process of discarding the system from situation O and setting a new problem is the process of formulating the true problem.

Based on this, Figure 6 shows a new problem formulation model based on the flowchart shown in Figure 5.

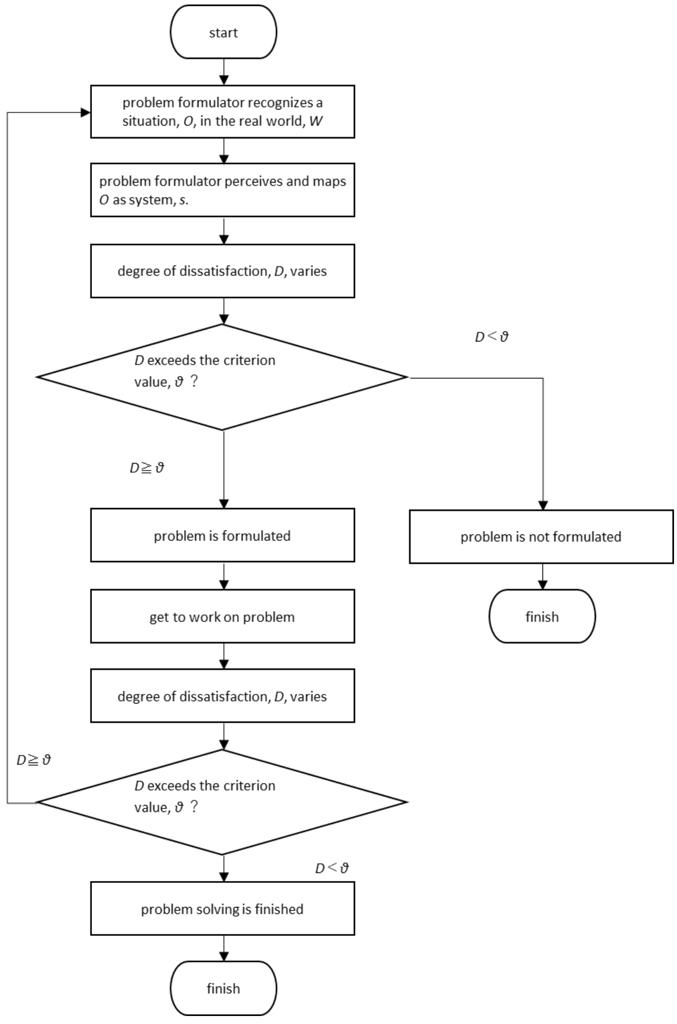

Figure 6: Flowchart based on the new problem formulation model.

The problem solving process in this model ends when the degree of dissatisfaction D falls below the criterion θ, which means that the problem formulator has solved the problem. This means that the problem formulator repeats problem formulation and problem solving until the dissatisfaction level D falls below the criterion θ. This expresses the cyclical characteristics of problem formulation, and it can be said that the problem solved when the dissatisfaction level D falls below the criterion θ is the true problem for the problem formulator.

4 Consideration

In this study, we focused on the cognitive processing of problem formulators when they formulate a problem and create a flowchart of the problem formulation process. Herein, we discuss the results through a comparison with previous studies.

The flowchart (Figure 5) based on Imayoshi, Tabata, and Tokita. describes the problem recognition process from the situation at a certain time, and the circularity of problem formulation does not occur here.

This is because the model by Imayoshi, Tabata, and Tokita. did not describe the process of problem solving but rather the problem definition and problem recognition associated with that definition. However, in problem solving, the following research results suggested the possibility of circularity and its causes. First, in general, there are good and bad definition problems in problem solving [6]. A well-defined problem is one in which all the information to formulate the problem (goals, constraints, and methods to solve the problem) is complete, while an ill-defined problem is one in which the information is incomplete or unclear [6]. Ill-defined problems are difficult to formulate and solve by a single procedure or by adapting a certain algorithm, owing to the incomplete information. Therefore, the original problem is solved by repeating the problem formulation in an exploratory manner, adding and updating information, and formulating a new problem based on the new information while sequentially solving the problem. This suggested the possibility of cyclicality in problem formulation because of what Simon calls limited rationality [7] and incomplete information, which can be expressed by the processes of recognizing the situation and problem formulation and their repetition (cyclicality) (Figur. 6).

Newell and Simon described problem solving as the act of searching for a path to move from the current to the target state and described a system that reaches the target state through the solution of several subgoals divided with respect to the original goal [2]. The problem is the gap between the current and target states, and the goal is to eliminate the gap by solving certain problems. Thus, when solving a problem, it is not possible to solve the problem all at once, but it is necessary to solve the problem stepwise, starting with small problems. This stepwise problem solving may cause a cyclical characteristic in the problem solving process.

In the flowchart proposed in this study, after solving a problem, if the level of dissatisfaction was not sufficiently low, another problem formulation was made, and the problem solving process was repeated. This corresponded to the process of solving a subordinate or real problem as pointed out by Newell and Simon [2] and may indicate that the flowchart created in this study can express the process of solving a subordinate problem and that of solving a major problem thereafter.

These points suggested that the flowchart created in this study could describe human problem-solving behavior to a certain degree. However, this flowchart did not allow us to determine if this problem-solving process was a true problem, and the possibility of reaching the true problem is unclear. The flowchart, which is the result of this research, should be verified by applying it to actual cases to verify its demonstrability.

5 Conclusions and Future Issues

Here, based on a study by Imayoshi, Tabata, and Tokita. [1] on the problem formulation process, we developed a flowchart that explains the human problem formulation process and extended it to present a new model that refers to the problem-solving process that can explain the cyclical characteristics of problem formulation. The model is discussed based on previous studies and was confirmed to exhibit a certain degree of validity. Furthermore, we confirmed that the true problem cannot be known from the beginning in problem formulation because of limited cognitive abilities. As a future issue, the problem formulator and solver may differ in the actual problem formulation and solving processes. In such cases, we will verify if this model can be applied to explain the problem. In addition, we will examine a method to determine whether D is caused by incorrect problem formulation or solving when D does not fall below θ, although the problem solver works in a circular process. In connecting the problem formulation and solving processes, we will also examine if the model can reflect the situation where the problem is recognized as a problem but was not started to be solved.

References

[1] A. Imayoshi, T. Tabata, and M. Tokita, “The Definition of a Problem in Problem Solving,” Japan Association for Management Proceedings of the 49th National Research and Presentation Conference, No. 54, pp. 76–77, 2012.

[2] A. Newell and H. A. Simon, Human problem solving, Prentice Hall, 1972

[3] D. C. Gaus and G. M. Weinberg, Are Your Lights On?: How to Figure Out What the Problem Really Is, Winthrop Publishers, Inc., 1982.

[4] G. F. Smith, “Defining managerial problems: A framework for prescriptive theorizing." Manag. Sci., Vol. 35, No. 8, pp. 963–981, 1989.

[5] G. F. Smith, “Towards a heuristic theory of problem structuring,” Manag. Sci., Vol. 34, No. 12, pp. 1489–1506, 1988.

[6] H. Kahney, Problem Solving: A Cognitive Approach, Open University Press, 1986.

[7] H. A. Simon, "The Sciences of the Artificial," pp. 28–29, 1997.

[8] K. Duncker, "On Problem-Solving," Psychol. Monogr., Vol. 58, No. 5, pp. i-113, 1945.

[9] M. Tokita, “A Robust Method for Problem Setting,” The Waseda journal of social sciences, No. 54, pp. 133–160, 1997.

[10] P. B. Checkland, “Systems Thinking, Systems Practice,” J. Wiley, 1981.

[11] P. F. Drucker, Men, Ideas, and Politics. Harvard Business Review Press, 2010.

[12] R. E. Mayer, “Problem Solving,” in D. Reinsberg, (Ed.) The Oxford Handbook of Cognitive Psychology, Oxford University Press, pp. 769–778, 2013.

[13] T. Fujita and M. Harada, "Kettei bunseki nyumon," Kyoritsu Shuppan, 1989.

[14] T. Tabata and M. Tokita, "Keiei shisutemugaku eno shōtai: nihon keiei shisutemu gakkai soritsu sanjisshunen kinen," Japan Association for Management, Nihon Hyoron sha, pp. 13–39, 2011.