Logical Reasoning to Generate Information and Knowledge

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Abstract

The objective of this paper is to show that the knowledge or information required for making better organizational decisions can be generated through the process of logical reasoning by the decision makers. The secondary objective of this paper is to demonstrate that the *problem-based learning (PBL) method* is an effective educational tool to teach business managers or students the efficacy of broadened time horizon and spatial awareness when making organizational decisions.

Key Words: Management Philosophy / Management Science / Teaching Method / Problem-Based Learning (PBL) / Optimal Decision Making

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Ⅰ. Introduction

In a time like today when most decisions are made more and more by decentralized sub-units within the organization, management philosophy to enhance the long-term effectiveness and the synergy of the decisions from the standpoint of the organization as a whole is needed. The objective of this paper is to show that the knowledge or information required for making better organizational decisions can be earned through the process of logical reasoning by the decision makers. The secondary objective of this paper is to demonstrate that the *problem-based learning (PBL) method* is an effective educational tool to teach business managers or students the efficacy of broadened time horizon and spatial awareness in organizational decision making. Different from traditional ones, an alternative learning method that begins with an authentic problem is called *problem-based learning (PBL)*. Since its conception in North American medical schools a few decades ago, PBL has been adopted for the preparation of professionals in diverse fields such as engineering, law and business (Chun and Wong, 2000). To introduce the PBL method, this paper has devised and present here a decision-making problem, named *Metrocity's Garbage Transportation Problem*.

Ⅱ. Metrocity's Garbage Transportation Problem

Suppose that a metropolitan city, named Metrocity, is made up of three boroughs and let's call them Borough A, B, and C, respectively. Let's assume that each of these boroughs generates a certain amount of garbage every day, and Metrocity runs four incinerators to dispose of the garbage. Let's call these incinerators W, X, Y, and Z, respectively. Since these incinerators are located at four different locations, the transportation costs of the garbage from the three boroughs to the four incinerators are all different. Let us assume that the daily capacity of each of the incinerators, the daily amount of garbage generated from each of the boroughs, and the unit cost of transporting one ton of garbage from each source to each destination are as shown in Table 1. Now, our problem is that we must come up with a method of minimizing Metrocity's garbage transportation costs as a whole.

〈Table 1〉 Data on the Garbage Transportation Problem of Metrocity

	Incinerator W	Incinerator X	Incinerator Y	Incinerator Z	Amount Generated
Borough A	$19	$30	$50	$10	7 tons
Borough B	$70	$30	$40	$60	9 tons
Borough C	$40	$8	$70	$20	18 tons
Incinerator Capacity	5 tons	8 tons	7 tons	14 tons	34 tons

Ⅲ. The PBL Process to Find an Optimum Solution to the Problem

The problem can be easily solved through a standard computer program developed in management science. However, this paper would like to show that we can solve the problem easily by a systematic way of thinking, let's call it a paradigm, to find the optimal solution.

In order to demonstrate the process of PBL method, suppose that a professor and his students are to solve the Metrocity's transportation problem through PBL method. The professor is expected to lead the students through the following steps.

Step 1: Adopting a Paradigm (called the First Paradigm)

The professor asks the students to adopt a paradigm, i.e., a systematic way of thinking, that will help find the solution to minimize the total transportation cost. Students will try to exploit the minimum-cost route as much as possible. The minimum-cost route in Table 1 is that of Borough C to Incinerator X at the cost of $8 per ton. The students will try to use this route to carry 8 tons of garbage, that is, the maximum capacity of Incinerator X. Now the next minimum-cost route is that of Borough A to Incinerator Z at the cost of $10 per ton, and they can use this route to carry 7 tons of garbage, the total amount generated by Borough A. The third minimum-cost route is that of Borough A to Incinerator W at the cost of $19 per ton. However, this route cannot be used since all the garbage from Borough A was already transported to Incinerator Z. Solving the problem in this sequence will ultimately produce Table 2.

〈Table 2〉 A Solution by the First Paradigm

	Incinerator W	Incinerator X	Incinerator Y	Incinerator Z	Amount Generated
Borough A				7 tons	7 tons
Borough B	2 tons		7 tons		9 tons
Borough C	3 tons	8 tons		7 tons	18 tons
Incinerator Capacity	5 tons	8 tons	7 tons	14 tons	34 tons

According to Table 2, the total transportation costs will be:
$7 \times \$10 + 2 \times \$70 + 7 \times \$40 + 3 \times \$40 + 8 \times \$8 + 7 \times \$20 = \$814$

Step 2: Discovering Shortcomings of Short-Sighted Decisions

Now the professor asks students to examine the solution shown in Table 2. After a while, some sagacious students will discover that they are using one of the most expensive routes, i.e., the route from Borough B to Incinerator W that costs $70 per ton. This discovery will lead the students to think that something must be wrong with their First Paradigm. The students will learn that the fallacy of the First Paradigm comes from the fact that afore-made decisions could constrain later-made decisions. In other words, many better routes that could be chosen at the later stage of the decision sequence were made unavailable, or pre-empted, by some earlier decisions. For example, the possibility of transporting the garbage of Borough A to Incinerator W (at the cost of $19) was made unavailable (or pre-empted) by the earlier decision to transport all of Borough A's garbage to Incinerator Z (at the cost of $10).

Step 3: Learning the Importance of Time Horizon and Spatial Awareness

At this stage of discussion the professor can remind the students of what we called the Y2K Problem (the millennium-bug problem) asking the students to criticize the idea of *short-term optimisation*, or a decision made in shorter time horizon. The Y2K problem was caused by the earlier computer programmers who wanted to minimize the memory and time cost in using their computers. In other words, they chose to use the last 2 digits only (instead of the full 4 digits) to represent years. However, with the year 2000 approaching, computer users were forced to spend bigger money to avoid the possible disasters arising from computers' confusion of the year 2000 with the year 1900. Why did earlier programmers make such a mistake? The students will say that at that time the memory cost of computers was so expensive that using the last 2 digits only seemed to be more economical (or optimal) to them for the short term. However, if they could have *broadened their time horizon* considering the advent of the year 2000, and *broadened their spatial awareness* considering the overhauling cost of the computer systems, they might have made the eventual long-term cost much cheaper.

Step 4: Searching for a Second Paradigm (Antithesis)

Having learned of the fallacy of the First Paradigm, the students will try to adopt an alternative Paradigm that can lead to a better solution. At this stage the professor may advise the students to refer to what philosophers call the dialectic process, a systematic process of thinking to improve the solution. According to the dialectic process, a paradigm (thesis), when it fails to be satisfactory to the decision maker, inevitably generates its opposite (antithesis), and their interaction leads to another (synthesis). Students will remember that the First Paradigm fails since it often pre-empts the second-best choice when the best choice is adopted. Hence, the students will learn that the fallacy of the First Paradigm could be avoided if they make use of the difference between the best and the second-best choices in their decision-making process. For example, the cost difference between the cheapest and the next-cheapest routes from Borough

A to incinerators is $9 since the cheapest one is $10 (to Incinerator Z) and the second-cheapest one is $19 (to Incinerator W). When the cost differences are calculated with respect to all boroughs and incinerators Table 3 will be obtained.

〈Table 3〉 The Cost Difference between the First and Second Cheapest Choice

	Incinerator W	Incinerator X	Incinerator Y	Incinerator Z	Cost Difference
Borough A	$19	$30	$50	$10	$ 9
Borough B	$70	$30	$40	$60	$10
Borough C	$40	$8	$70	$20	$12
Cost Difference	$21	$22	$10	$10	

In view of the dialectic process, the Second Paradigm to solve the Metrocity's Problem can be adopted as follows: Transport the garbage using the cheapest route with the largest cost difference (either row-wise or column-wise). According to Table 3, the largest cost difference is $22 (generated by Incinerator X with respect to Borough C), thus the first decision is to transport the garbage from Borough C to Incinerator X as much as possible. The next largest cost difference is $21 (generated by Incinerator W with respect to Borough A), thus the garbage from Borough A will be transported to Incinerator W as much as possible, and so on. The solution generated by the Second Paradigm will be given as Table 4.

〈Table 4〉 The Solution Produced Through the Second Paradigm

	Incinerator W	Incinerator X	Incinerator Y	Incinerator Z	Amount Generated
Borough A	5 tons			2 tons	7 tons
Borough B			7 tons	2 tons	9 tons
Borough C		8 tons		10 tons	18 tons
Incinerator Capacity	5 tons	8 tons	7 tons	14 tons	34 tons

According to Table 6, the total transportation costs will be:
5 × $19 + 2 × $10 + 7 × $40 + 2 × $60 + 8 × $8 + 10 × $20 = $779

The total transportation cost produced through the Second Paradigm is much better than that by the First Paradigm. However, the students should doubt the solution again since the Second Paradigm took into consideration only of the first and second cheapest costs, in other words, it did not *broaden the spatial awareness* considering the third, the fourth, etc. Thus, there is no guarantee that Table 4 will be the optimal solution.

Step 4: Adopting the Third Paradigm (Synthesis)

Thus, the students are supposed to try each unused cell of Table 4 by supposing 1 ton of garbage transported through the cell. For example, suppose we transport 1 ton of garbage from Borough B to Incinerator X. Then we have to subtract 1 ton from the cell of Borough C to Incinerator X, subtract another 1 ton from the cell of Borough B to Incinerator Z, and add 1 ton to the cell of Borough C to Incinerator Z. The result of this modification will result in a total cost reduction of $18 (=$30-$8-$60+$20). The students will easily verify that they can transport up to 2 tons of garbage from Borough B to Incinerator X, resulting in a cost reduction of $36. Students will find that no other cells are capable of further cost reduction. Thus, the final optimal solution is given as Table 5.

〈Table 5〉 Metrocity's Total-Optimum Solution to Minimize the Transport Costs

	Incinerator W	Incinerator X	Incinerator Y	Incinerator Z	Amount Generated
Borough A	5 tons			2 tons	7 tons
Borough B		2 tons	7 tons		9 tons
Borough C		6 tons		12 tons	18 tons
Incinerator Capacity	5 tons	8 tons	7 tons	14 tons	34 tons

Interpreting Table 5, the total transportation costs can be minimized:
When Borough A sends 5 tons to Incinerator W and 2 to Incinerator Z,
When Borough B sends 2 tons to Incinerator X and 7 to Incinerator Y, and
When Borough C sends 6 tons to Incinerator X and 12 to Incinerator Z.
The total transportation costs will be:
5 × $19 + 2 × $10 + 2 × $30 + 7 × $40 + 6 × $8 + 12 × $20 = $743
The solution given in Table 5 can be verified the same that can be obtained through the software package used in management science.

Step 5: Learning of Conflicts between Total and Partial Optima

The professor now asks the students to calculate the optimal solutions only from the viewpoint of each individual borough, and call them Partial Optima. On calculating three partial optima the students will find that there arise conflicts between partial optima and the total optimum (Table 5). Take, for example, the position of Borough A, which calculates that its costs are lowest if it sends all its garbage to Incinerator Z. Transporting this way will cost the Borough A only

$$\$10 \times 7 = \$70 \qquad \text{(A)}$$

However, according to Table 5, Borough A needs to send 5 tons to Incinerator W at the cost of $19 per ton, and 2 tons to Incinerator Z at the cost of $10 per ton, resulting in the total cost of $\$19 \times 5 + \$10 \times 2 = \$115$. This means that Borough A has to accept a cost increase of $45 ($115-$70) in order for all of Metrocity's costs to be minimized, in other words, if the *spatial awareness is broadened* to cover the whole organization.

Boroughs B and C fall in line with Borough A. With respect to Borough B, it would be optimal to send 8 tons of their garbage to Incinerator X with the lowest unit cost of $30, and send the rest (1 ton) to Incinerator Y with the next lowest cost of $40. Utilizing this option, Borough B could transport all of their garbage with the minimum cost (from their own standpoint) according to the following calculation:

$$\$30 \times 8 + \$40 \times 1 = \$280. \qquad \text{(B)}$$

However, according to Table 5, Borough B needs to send only 2 tons to Incinerator X and send 7 tons to Incinerator Y. Thus, the total cost needed for Borough B becomes $\$30 \times 2 + \$40 \times 7 = \$340$, which means that Borough B has to accept a cost increase of $60 ($340 - $280) in order for all of Metrocity's costs to be minimized, in other words, if the *spatial awareness is broadened* to cover the whole organization.

For Borough C, the best option is to send 8 tons to Incinerator X and 10 tons to Incinerator Z, resulting in the minimum cost of:

$$\$8 \times 8 + \$20 \times 10 = \$264. \qquad \text{(C)}$$

However, Table 5 shows that Borough C has to send only 6 tons to Incinerator X and 12 tons to Incinerator Z, resulting in the cost of $\$8 \times 6 + \$20 \times 12 = \$288$. Thus, Borough C must also accept a cost increase of \$24 (\$288 - \$264) in order for Metrocity's total garbage transportation costs to be minimized, in other words, if the *spatial awareness is broadened* to cover the whole organization.

Now, the students will discover as a truth that the total-optimum (as represented by Table 7) does not correspond automatically with the partial optima (of each borough) as described by equations (A), (B), and (C).

Some might argue that the conflict between the total optimum and partial optima could be attributed to the particularity of the problem. However, we can easily see the general validity of the conflict proposition. Suppose we relocate the incinerators in such a way that the aggregation of the partial optima may become identical to the total optimum: Sooner or later a similar conflict problem will occur, as random events such as demographic changes, regional development, and so on, take place. Ideally, the aggregation of all partial optima should constitute the total optimum. Unfortunately, such instances are generally difficult to achieve except by sheer coincidence: The conflict between total optimum and partial optima is a general phenomenon in all communities and organizations.

Ⅳ. Analysis of Cases

Today's companies must raise their organizational effectiveness as high as possible to survive in this world of keen competition. One way for an organization to raise its effectiveness is to search for the long-term optimum as well as the total optimum when making decisions. However, we have seen that a long-term optimum can, in general, be pursued at the sacrifice of short-term optima, and the total optimum can also, in general, come into conflict with some or all of the partial optima for the organization. This leads us to conclude that sagacious leaders should be able (1) to identify the long-term as well as the total optimum of the organization, and (2) to persuade the members or subunits of the organization to sacrifice their short-term as well as partial optima for the benefit of the long-term future as well as the competitiveness of the whole organization. Now, let us analyse some Asian historic cases in this regard.

Case 1: King Huangong in Chinese History:

In 681 BC, the king Huangong of Qi Kingdom in China won a war against the kingdom of Lu. A ceremony was prepared for Huangong to take over the land of Sui, the most fertile region of Lu, as spoils of the war. King Huangong was sitting on a high platform, and the king of Lu was about to give his pledge to surrender Sui to Qi. Suddenly, General Caomo of Lu jumped onto the platform and put a knife to King Huangong's neck, and shouted, "Lu is so small that if Lu loses Sui, Lu can't sustain its people. Please promise not to take Sui." To save his life King Huangong could not but concede to Caomo's demand, and General Caomo came down the platform as if nothing had happened.

Now, King Huangong, feeling ashamed and unfair, considered arresting Caomo and declaring that his promise made under the threat was no longer valid. At this moment, Huangong's chief aid, Guanzhong, advised the king: "If you keep the promise even made under the threat, you will earn trust from the world." And he continued, "If you earn trust of the world, the value of the trust would be far more beneficial to your long-term political future than the land of Sui." Taking this advice, King Huangong decided to keep his promise.

In less than two years, Kingdom Chu, located in the southern part of China, grew strong and began expanding its territories to the north. Kings in the northern area met at Zhen to form an alliance. This was the "679 BC Zhen

Alliance." There, the kings of northern lands elected Huangong as their Commander since they could trust Huangong as a man of his words. Consequently, Huangong became one of the most powerful rulers in the Chunqiu period of Chinese history.[1] In short, Huangong chose to broaden the *time horizon* considering his political future, and *spatial awareness* considering the trust of other competing kings, and, as results, he achieved his long-term political success.

Case 2: The Late Chairman of Sony, Morita:

In 1956 Akio Morita, one of the two co-founders of Sony Corporation, went on a trip to the USA to develop the overseas market for transistor radios which Sony had just developed. A buyer in New York was willing to make an order for the Sony's products, but there was a catch. The buyer said, "We would like to take one hundred thousand units, but we have to put our brand name on the products" (Morita, 1986:92-93). Morita postponed the negotiation with the buyer in order to talk with his aids in Tokyo. People at the Tokyo headquarters preferred larger and immediate sales since Sony was in a financial hardship at that time. However, Morita, with his *broadened time horizon* considering the long-term growth of Sony, and *spatial awareness* considering the establishment of Sony's global brand, made up his mind not to accept any orders that would not use Sony's brand name. And Morita's leadership made it possible for Sony to pursue its long-term goal to establish the global brand at the sacrifice of short-term opportunity to sell in large quantities through the buyer's brand. About thirty years later, Morita reflected as follows: If Sony chose to take the short-sighted optimum at the time (i.e., immediate growth in sales), then the long-term goal to establish the global brand must have been sacrificed.

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1) Si Maqian ⟨Siji⟩(The History), "Cike Liezhuan Pian"(the 1st Chapter of the Collected Biographies of Asssins)

The Case of President Park Chung-Hee in Korea:

The conflict between total optimum and partial optima can take place in any kind of organizations, including national governments. Let us now turn to the case of Korea under its president Park Chung-Hee. In the 1960s, Korea was one of the poorest countries in the world, having just gone through the Korean War. The priority for Park, who had assumed power after a military coup-d'etat, was to bring economic development to Korea through industrialization. He began with a series of five-year economic development plans and as results Korea steadily came to attain the level of a developing nation. However, this success resulted in widening the gap between rich and poor, thereby threatening national unity.

President Park wanted to broaden his *time horizon* considering the long-term economic development of Korea, and also to broaden his *spatial awareness* considering the sentiment of the poor. Hence, he made up his mind to develop a strategy to cement national unity by ameliorating feelings of marginalisation among the poor. This he accomplished by suppressing the consumption of the rich. One example of how he deployed his campaign for national unity was to ban television programs broadcast in color, color televisions being the privilege of the rich only. Ironically, by the mid-1970s Korea had already become one of the leading nations in producing and exporting colour televisions. But since President Park forbade colour broadcasts, all Korean people, both rich and poor alike, had no choice but to watch black and white television until after the death of Park Chung-Hee in 1979.

Park Chung-Hee's national unity campaigns produced a ripple effect that went down as far as businesses. In companies that had factories without an air-conditioning system, for example, management offices also went without air-conditioning. This was done so that unity could be fostered and maintained between labor and management under the catch phrase "Let us, labor and management, work hard to overcome hardships together." After the death of President Park in 1979, however, the social campaigns that he had initiated and developed began to disintegrate. The consumption gap between the rich and the poor widened again, and the rich began to lose the trust of the poor. This became the root of the serious conflicts that arose between labor and management in the mid-1980s.

V. Concluding Remarks

Since most organizations are going concerns supposed to last into the long future, their leaders are expected to think about the long-term future of their organization and make decisions so that they can be optimal from the standpoint of the organization as a total. However, there are many obstacles to taking long-term optimal decisions. First of all, institutional systems such as financing methods through the stock market can negatively affect the practice of long-term oriented decision making. This will be especially true if the performance evaluation system for the leaders favors mostly short-term financial performance and the leadership tenure is relatively short.

There are obstacles to taking total-optimum decisions, too. In a time like today when democratization is a social trend, organizations are encouraged to decentralize their decision making processes. If decentralization is coupled with divisional profit-center systems, asking divisional leaders to take total-optimum decisions from the standpoint of the organization as a total becomes practically absurd.

In spite of these obstacles, however, broadened time horizon to take long-term optimal decisions as well as broadened spatial awareness to enhance the competitiveness of the organization as a total are needed in order for the organization to be competitive. We even have to modify the institutional systems in order for our organization to survive in an age of keen competition like today.

Organizational Culture Matters

Both the long-term as well as total optimum philosophy will take the willingness of the people within the organization to put up with "today's pain" for "tomorrow's gain" as well as sub-sector's sacrifice for the larger total's benefit.

Geert Hofstede interpreted this quality of the people as a culture.[2] Geert Hofstede measured the values of cultural orientation in terms of the preference of future to present, collectivism to individualism, etc., using a scale ranging from 0 to100. The top highest-score positions in the both measures were taken by East Asian countries: China, Japan, and South Korea.

Advanced economies have amassed a vast stock of equipment, plants, and many other intermediate capital goods. Clearly the whole Industrial Revolution and the factory systems were created by the conviction and philosophy that we could get higher efficiency by adopting long-term and total-viewed approaches. These approaches will continuously be needed for *developing countries* in Asia to build up their capital and technological capabilities in order to catch up with the advanced countries.

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