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Problem-Based Learning(PBL) Approach to Teach Methods of Enhancing the Synergy of Decentralized Decisions

Suck-Chul Yoon*
Seoul National University
Seoul, Korea

Abstract

This paper demonstrates that a *Problem-Based Learning*(*PBL*) approach can be effective in teaching management-science students the methods of enhancing the synergy of an organization. Different from traditional direct approaches, an alternative instructional method that begins with an authentic problem without any prior preparation by students is called problem-based learning(PBL). Since its conception in North American medical schools, PBL has been adopted for the preparation of professionals in diverse fields such as engineering, law and business(Chun and Wong, 2000). To apply the PBL approach to management-science education, the professor presents a typical(3 source- and 4 destination-) transportation problem and asks the students to find a solution that can minimize the total transportation cost.

The professor advises the students to devise a thinking model(called a paradigm) that can make full use of the most economic route at first, and then, the second most economic route, and so forth. When the students have managed to arrive at a solution by this paradigm, the professor asks them to scrutinize the solution by exercising the Cartesian *doubt*(i.e., cogito ergo sum). When students become aware of a fallacy of the paradigm, the professor advises them to reason out what causes the fallacy to take place. Students will find out that the fallacy comes into being due to the fact that afore-made decisions constrain later-made decisions in the time stream.

In order to overcome the fallacy, the students are referred to the Hegelian Dialectic processes to reason out an *antithesis* or a new

* Professor of Operations Management and Management Science at College of Business Administration, Seoul National Universit(yoonsc@plaza.snu.ac.kr)

paradigm. This process of finding a better thinking model will be continued until the students come up with a most satisfactory or the most economic solution from the standpoint of the organization as a whole(called the total-optimum solution). Now, the students are asked to calculate the optimal solutions from the standpoint of each source or each subunit of the organization(called partial-optima). Now, the professor leads the students to discover a fact that the total-optimum comes into conflict with the partial-optima. The professor, then, asks the students to discuss how each subunit of an organization should behave in order to create the biggest synergy for their organization as a whole.

This process of problem-based learning will lead the students to understand the philosophical meaning of Cartesian *doubt* and Hegelian dialectic processes. Finally, the professor can ask the students to discuss and figure out how to work out the conflict between the partial-optima and the total optimum of the organization.

Keywords: Teaching Method, Problem-based learning(PBL), Management Science, Ideas of Descartes and Hegel, Total Optimum versus Partial Optima.

Introduction

United we stand, divided we fall is a slogan often used by leaders in organizations to emphasize the solidarity of the organization. But the question is; how can we achieve organizational solidarity? According to the *Oxford Advanced Learner's Dictionary of Current English*, solidarity means "unity resulting from common interests or feelings." However, individuals in an organization may have their own interests and feelings that might be different from those of their organization. Within a family, individuals can often sacrifice their own interests for the common interests or feelings of the family. However, when individuals move beyond the boundary of the family into other social organizations, their willingness to sacrifice individual interests for the sake of the organization as a whole becomes weaker. This state of affairs ultimately leads to a weakened organizational efficiency. However, in today's harsh climate of unlimited competition, enhancing organizational efficiency has become one of the most important goals for the organization to survive.

The objective of this paper is to present a problem-based learning(PBL) method(or the problem-based teaching method from the standpoint of professors) to teach management-science students how to enhance organizational efficiency when decisions are made by sub-units of the organization as a whole. Different from traditional direct approaches, an alternative instructional method that begins with an authentic problem without any prior preparation by students 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 presents a practical decision-making problem, named *Metrocity's Garbage Transportation Problem*.

1. Metrocity's Garbage Transportation Problem

Suppose that a metropolitan city, let's name it Metrocity, is made up of three boroughs. Let's call these boroughs A, B, and C, respectively. Let's assume that each of these three 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 the 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 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 the 3×4 matrix in Table 1 below. Now, our problem is that we must come up with a method of minimizing Metrocity's garbage

Table 1. Data on the Garbage Transportation Problem of Metrocity

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

transportation costs as a whole.

2. How to Find a Total-Optimum Solution?

The above problem can be easily solved using a computer program if the students have already learned the techniques of management science. However, in this article we would like to show that the problem could easily be solved through what is known as the Hegelian dialectic, a systematic process of thinking to improve the solution. According to Hegel, one paradigm(thesis) for solving a problem inevitably generates its opposite(antithesis), and their interaction leads to a new paradigm(synthesis). In order to solve the Metrocity's problem through the PBL process the professor leads the students in the following steps.

Step 1: Let the Students Adopt a Paradigm (called the First Paradigm)

Since the overall aim is to minimize the total transportation cost, the students are likely to adopt a paradigm that exploits 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, 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.

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: Let Students "Doubt" the Solution.

Now the professor reminds the students of the Cartesian idea of *doubt*, known as "cogito ergo sum." Observing Table 2 with the *doubt*, some students will discover that they are using the

Table 2. A Solution by the First Paradigm

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

most expensive route, that is, 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. After a deep thinking, 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 decisions that could be made at the later stage in the sequence of decisions could be 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 pre-empted by the earlier decision to transport Borough A's garbage to Incinerator Z(at the cost of $10).

Step 3: A Historical Example of the Fallacy of the First Paradigm

The professor asks the students to think about a historical example of the fallacy of the First Paradigm. Some smart students may reflect that what we called the Y2K problem(or the millennium-bug problem) was caused by the decisions of earlier computer programmers. They chose to use the last 2 digits only (instead of the full 4 digits) to represent years. As a result, with the year 2000 approaching, computer users were forced to spend big money to avoid the possible disaster for computers to confuse the year 2000 with the year 1900. Why did earlier programmer make such a stupid mistake? The students will say that at that time the memory space of the computers was so expensive that they wanted to save the cost by using the last 2 digits only.

At this stage of discussion the professor can define the concept of *short-term optimisation* in making decisions. Using the last 2 digits only was more economical(or optimal) to them for the short or immediate term. However, if they could have considered the cost of overhauling their software programs for the year 2000, putting up with a higher memory cost in the short term might have brought them a *long-term optimisation*. Now, let us examine business leaders who were smart enough to prefer long-term optimisation to a short-term optimal decision.

Step 4: Leaders to Pursue the Long-term Optimisation.

Since a going concern is supposed to last into the long future, it is likely for a *good* leader to think about the long-term future of his or her organization. The case of Sony is an example. 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). However, Morita made up his mind not to accept any orders that would not use Sony's brand name. Morita's long-term objective was to establish a global brand name for his company and he succeeded eventually. Morita's leadership made it possible for Sony to achieve its long-term goal by giving up its short-term opportunities to sell in large quantities through the buyer's brand. If Sony had wanted the short-term optimum(i.e., immediate growth in sales), the long-term objective to establish the global brand might have been sacrificed.

Step 5: Searching for a Second Paradigm

Having learned of the fallacy of the First Paradigm, the students are supposed to adopt an alternative Paradigm that can lead to a better solution. At this stage the professor may advise the students to refer to the Hegelian dialectic, a systematic process of thinking to improve the solution. According to the process, one paradigm(thesis), when it fails to function properly, 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 failure 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. The cost difference, for example, 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.

In view of the above discussion, 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

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

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

Table 4. The Solution Produced Through the Second Paradigm

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

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.

According to Table 6, the total transportation costs will be:

$5\times\$19 + 2\times\$10 + 7\times\$40 + 2\times\$60 + 8\times\$8 + 10\times\$20 = \$779$

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, excluding others, that is, the third, forth, etc. Thus, there is no guarantee that Table 4 will be the optimal solution.

Step 6: The Third Paradigm

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.

Interpreting Table 5, the total transportation costs can be minimized:

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

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

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

When Borough C sends 6 tons to Incinerator X and 12 to Incinerator Z.

The total transportation costs will be:

$5 \times \$19 + 2 \times \$10 + 2 \times \$30 + 7 \times \$40 + 6 \times \$8 + 12 \times \$20 = \$743$

The solution given in Table 5 is the same that can be obtained through the software package used in management science.

3. The Conflict Between the 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 as 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.

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.

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:

$$\$8 \times 8 + \$20 \times 10 = \$264. \tag{C}$$

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.

Now, the students will discover that the total-optimum solution represented by Table 7 does not correspond 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.

Today's companies must raise their organizational efficiency as high as possible to survive in this world of unlimited competition. One way for an organization to raise its efficiency is to achieve total optimum. We have seen, however, that a total optimum can, in general, come into conflict with some or all of the partial optima in the organization. In other words, total optimum can only be achieved through the concessions and sacrifices of partial optima. This leads us to conclude that a sagacious and persuasive leadership is needed (1) to identify the total optimum of the organization, and (2) to persuade subunits in the organization to sacrifice their partial optima for the benefit of the whole. Now, let us look at the following intriguing case histories.

<The Case of General Electric>

In the 1980s a medium-sized company in Asia, anonymously called ABC in this paper, began to expand into the synthetic diamond market. The first company to develop and market this innovative product was the American giant General Electric. Needless to say, when ABC began to cut in on General Electric's market General Electric sat up and took notice. General Electric alleged that ABC had stolen their know-how in producing synthetic diamonds. Their target was a Chinese engineer, a Mr. K., who was a former General Electric employee. At General Electric's instigation, an American government agency began surveillance on the enigmatic engineer during his visits to the U.S. The outcome was that the hapless Mr. K. was arrested at an airport in the U.S., and the documents he was carrying were seized for evidence. He then faced prosecution by the American government. General Electric demanded that ABC immediately stop all sales of the synthetic diamond, and pay compensation for all competing products that ABC had sold.

At that time, it so happened that the electric power supply company of the home country of ABC was one of General Electric's biggest clients for its electric power supply facilities. In view of this, Mr. J. Welch, General Electric's CEO, met with the president of the electric power supply company of the country. Mr. Welch inquired about the public opinion in the country surrounding the infamous General Electric vs. ABC case. The president of the power company noted that since General Electric was a big enterprise and ABC a small company, many people in the country would have a very bad impression of General Electric should it be overly cruel with ABC. Public opinion, the president pointed out, could result in a consumer group protest, indeed a social movement, which could well organize a successful boycott against all General Electric products.

Armed with this vital information, as soon as the sagacious Mr. Welch returned to the U.S., he called his top managers in the synthetic diamond division and emphasised that in the interests of General Electric as a whole they had no option but to be lenient in their case against ABC. The GE managers subsequently met with the president of ABC, and began negotiations. Their original bulldog approach of demanding an immediate end to all ABC's synthetic diamond sales, as well as compensation, was softened. Instead, they merely asked ABC to pay royalties on future production. The General Electric vs. ABC affair is a classic case of how partial optimum interests in a corporate subunit had to be subordinated to serve the total optimum interests of the organization as a whole.

<Korea's Park Chung-Hee and his Unity Campaigns>

The conflict between total optimum and partial optima can take place in any kind of organization, including non-profit organizations as well as governments. Let us now turn to the case of the Korean government under its president Park Chung-Hee. In the 1950s, 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 within 30 years Korea had attained the level of a developing nation. However, this success was not without negative consequences. It resulted in widening the gap between rich and poor, thereby threatening national unity.

Mr. Park now had 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. 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.

4. Limits to the Sacrifices of Partial Optima

The above two cases are examples of how partial optima of certain subgroups can be adjusted for the achievement of total optimum, regardless of the nature of the organization, whether profit or non-profit. However, no organization can sustain its survival and growth by unduly oppressing its subunits. In other words, in the event that the very existence of a subunit is in danger, the organization must relent and allow the subunit its partial optimum so that the organization as a whole may survive. The following case is one example of such an occurrence.

<The 1984 L.A. Olympic Games>

The 1984 Los Angeles Olympic Games Organization Committee, headed by Peter Ueberroth, had to stage the games without any financial assistance from the federal government which was not in a position to assist the committee since it was suffering from severe deficits at the time(Ueberroth, 1985). One of the ways to create the necessary funds for the games was to ask for donations from sponsoring companies and, in return, to give them a monopoly in the supply of certain goods or services. Among the items that would be needed during the Games was photo film. Our story revolves around the difficult decision-making process the L.A. Olympic Games Organization

Committee had to go through in deciding what company to grant official sponsorship for film.

The company with the longest tradition and history in making film is the American company Kodak, and, naturally, everyone expected that Kodak would be granted official sponsorship. Being the strongest candidate, Kodak had taken their position for granted and in a rather cavalier manner offered to donate one million dollars. The Olympic Games Organization Committee, however, had already come to the realization that they needed to secure at least four million dollars from a sponsoring film company.

Now comes the dilemma. It so happened that another suitor stepped into the ring, none other than the Japanese Dentsu Inc. with the handsome offer of seven million dollars for promotion of Fuji film. To sweeten the pot, they offered to develop all film for the Committee free of charge. At that time, the United States was in a trade deficit battle with Japan. Considering national pride and trade deficits, the L.A. Olympic Games Organizing Committee should have given sponsorship to the U.S. Kodak so as to achieve total optimum for the U.S.

However, the L.A. Games Committee decided in favor of Fuji film. The Committee simply could not afford to sacrifice their partial optimum, that is, the seven million-dollar donation to stage the games successfully. No one could blame the Committee for this decision, even though it went contrary to the interests of the U.S. as a nation.

5. Concluding Remarks

Different from traditional direct approaches, an alternative instructional method that begins with an authentic problem without any prior preparation by students 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). This paper has demonstrated that the PBL method, combined with the ideas of Descartes and Hegel, is very effective in teaching business students how to maximize organizational synergy of decisions made by subunits in a decentralized organization.

In a time of keen competition like today, business organizations need to enhance their synergy of decisions as high as possible. PBL method is capable of teaching business students how the decisions made by the subunits of an organization should be coordinated if the organization wants to maximize the synergy of the decisions. In order to coordinate the decisions made by the subunits, the leaders of the organization should be able: (1) to identify the idea of total-optimum for the organization as a whole, (2) to communicate the idea with the subunits of the organization, and (3) to develop a logical argument persuasive enough to make the subunits concede their partial optima.

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