Exploring the Usage of the DEMATEL Method to Analyze the Causal Relations Between the Factors Facilitating Organizational Learning and Knowledge Creation in the Ministry of Education

Sun Hyung Park
Department of Education
Dongguk University, Jung-gu, Seoul, 100-715, Korea

Il Soo Kim
Office of the President of Korea
#1, Cheongwadae-Ro, Jongno-Gu, Seoul, 03048, Korea

Seong Bum Lim
Department of Public Administration
Dankook University, Yongin-si, Gyeonggi-do, 16890, Korea

ABSTRACT

Knowledge creation and management are regarded as critical success factors for an organization's survival in the knowledge era. As a process of knowledge acquisition and sharing, organizational learning mechanisms (OLMs) guide the learning function of organizations represented by its different learning activities. We examined a variety of learning processes that constitute OLMs. In this study, we aimed to capture the process and framework of OLMs and knowledge sharing and acquisition. Factors facilitating OLMs were investigated at three levels: individual, group, and organizational. The concept of an OLM has received some attention in the field of organizational learning, however, the relationship among the factors generating OLMs has not been empirically tested. As part of the ongoing discussion, we attempted a systemic approach for OLMs. OLMs can be represented by factors that are inherent to the organization's system; therefore, prior to empirically testing the OLM generating factor(s), evaluation of its organizational integration is required to determine effective treatment of each factor. Thus, we developed a framework to manage knowledge and proposed a method to numerically evaluate factors influencing the OLMs. Specifically, composite importance (CI) of the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method was applied to explore the interaction effect of these factors based on systemic approach. The augmented matrix thus generated is expected to serve as a stochastic matrix of an absorbing Markov chain.

Key words: *Organizational Learning Mechanism, Learning Organization, DEMATEL, Knowledge Creation.*

1. INTRODUCTION

In the present knowledge era, managing knowledge and knowledge creation are regarded as critical success factors for an organization's survival. Additionally, these two factors are facilitated through organizational learning. Knowledge acquisition and sharing as a process of an organizational learning mechanism (OLM) get to the heart of the problem. According to Dey [1], knowledge is not value free, and there

are numerous and differing interpretations of reality. Language and action in social practice may be interpreted as knowledge.

Knowledge performance can be explained as the ability of an individual, group, and an organization to understand what they have learned [2]. An organizational learning process as an OLM can be strengthened by improving organizational learning capacity, identifying, distilling, and harnessing the information. However, the process of the OLM can be represented by factors that are inextricably interwoven within an organization's system. Thus, before we empirically test the factors generating and facilitating OLMs, we need to take into account the underlying operational mechanisms of organizational learning. In fact, despite the popularity of the organizational learning notion in the educational literature, it is still very broad and as such

hinders the educational ability to move beyond the conceptual level to a level of action and capability [3].

In recent years, the importance of organizational learning tools as intangible assets has increased rapidly. Public and private organizations should consider improving their dynamic performance to cope with these challenges. A smart organization is likely to effectively address a wide range of issues in public management in a complex environment. Therefore, combining the importance of assets with a systemized and scientific study of organizational learning is required to effectively manage the organization. The willingness to learn is an intangible asset and a complex concept involving various aspects such as cognitive science and group dynamics.

Adopting a systemic approach to construct a theoretical background can be a powerful advantage. Organizational learning is not a single process performed by the entire organization in a uniform fashion. Therefore, to study its nature and mechanism, we first take into account a theoretical approach. Organizational learning's operational mechanisms in the organizational process draw heavily on the psychology of individuals. According to Stewart [4], organizational learning is a type of collective cognition where individuals constantly make sense of the environment and negotiate with one another's learning experiences. Further, learning should not be treated as a separate endeavor that occurs only in classrooms or training settings. That is, learning does not apply to only one stratum of an organization's members alone, such as the lower ranks or the managerial functions.

From this, we can see that OLMs need to be considered. Finding the OLM makes it possible to transform individual level learning (micro level) into organizational level learning (macro level), and then use the frame of organizational learning as the base of further individual learning [5]. All of this is derived from finding and understanding the OLM. Most organizations have their own essential natures such as culture, history, and atmosphere. Learning is also part of these natures. Thus, finding the learning mechanisms and suggesting learning strategies are very important as these are intricately related to organizational survival.

To analyze this, this study identifies the factors generating the OLM within the organizational system and then attempts to find the interaction effect among the factors and transforms these into an influence relation based on a numerical framework. Researchers and managers of an organization can identify the factors affecting other factors, and the factors caused by others through a numerical influence relation. From this process, they can also find the dynamic behavior of factors, *i.e.*, having a relational effect on each other.

This study has two central ideas: firstly, the supporting factors generating the OLM are part of a systemic perspective, and secondly, the interaction effect of these factors can be explored using a extension of the Decision Making Trial and Evaluation Laboratory (DEMATEL)method. This study also copes with straightening the relation of these factors through the DEMATEL method. Applying a *composite importance* extension method, we can expect the augmented matrix to serve as a stochastic matrix of the absolving Markov chain.

Specifically, to find influence of the factors itself, composite importance method is taken into account to integrate with the DEMATEL method [6].

The remainder of the study is organized as follows: section 2 provides a literature review of the study, focusing on the factors of the OLM and DEMATEL method; section 3 develops the research design and methods; section 4 presents and discusses the results of the data analysis; and section 5 concludes.

2. ORGANIZATIONAL LEARNING AND LEARNING ORGANIZATION FOR KNOWLEDGE CREATION

Before we address the organizational learning mechanism that engenders organizational learning, we will briefly examine the preliminary literature on the conceptual difference between organizational learning and the learning organization.

The learning organization facilitates the learning of all its members and continuously transforms [7]. Popper and Lipshitz [8] also mentioned that organizational and learning organizations reflect more complexity through the notion and relationships. Organizational learning is defined as the development of insight, knowledge, and associations between past actions, the effectiveness of those actions, and future actions. Organizational learning is to be treated as cognitive and behavior changes.

The learning organization is one where people at all levels are continually increasing their capacity to produce results. According to Senge [9], the organizations where people expand their capacity to create desired results are where new and expansive patterns of thinking are nurtured, along with collective aspirations, and where people are continually learning to see the whole together. Based on his definition, a learning organization itself is a continuous process that produces knowledge and capacity for the organization. Steward [10] also stated that learning is natural, continuous, and inevitable, and spontaneously occurs within the organization as a dynamic system.

In particular, this phenomenon simultaneously emerges between individual and organizational levels with complex factors facilitating the dynamic relationships. Organizational learning cannot be facilitated only by improving an individual's competence. Knowledge is the result of learning through either a form of tacit or codified knowledge.

2.1 Knowledge creation

Nonaka [11] argued, "knowledge is a flow of message, derived from either the flow of information or the ways (perceptional, context-specific and purposeful) by which the information is organized or structured." Indeed, from this perspective he also proposed the definition and taxonomies of knowledge, that is, tacit knowledge and explicit knowledge.

Tacit knowledge is perceivable, but owing to its unstructured nature is difficult to pinpoint, model, or transfer because of its unstructured essence as being experience-based, intuitive, simultaneous, and analog. In addition, explicit knowledge differs from tacit knowledge because it embodies

structural characteristics that enable people to manipulate, organize, model, and transfer its essence (such as logical, sequential, and digital attributes). Tacit knowledge is deeply rooted in action, procedures, routines, commitment, ideas, values, and emotions [12]. Knowledge is recognized as a vital source of competitive advantage, and as a result, both explicit and tacit knowledge are needed. How such knowledge can best be gained is still unclear, and hence it is important to discover differing views on both explicit and tacit knowledge and their relationship. "Ba" is the continuously created generation mechanism that explains the potentialities and tendencies that can either hinder or stimulate knowledge creative activities [13].
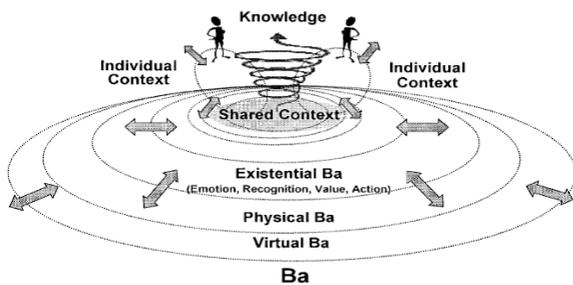

Fig. 1. Conceptual representation of *Ba*

2.2 Knowledge management

Knowledge management is the process of capturing collective expertise and intelligence inside and outside an organization and using it to facilitate innovation through organizational learning. Additionally, knowledge management is concerned with the exploitation and development of an organization's knowledge assets with a view to furthering its knowledge by explicitly managing documented knowledge.

Knowledge management (KM) is narrowly defined as an information technology system that dispenses organizational know-how. KM is in fact all of this and much more. KM is a highly multi-disciplinary field. It is a mix of strategies, tools, and techniques. KM makes use of mixed techniques from knowledge based system design, such as structured knowledge acquisition strategies from subject matter experts [14], and educational technology [15]. Popper and Lipshitz [8] state in their study that the facets of the organizational learning mechanism are structural and cultural facets.

3. ORGANIZATIONAL LEARNING MECHANISM

Argyris and Schon [16] defined "organizational learning" as a process of error detection and correction. Error here is any feature of knowledge or knowing that inhibits learning. Fiol and Lyles [17] defined learning as "the process of improving action through better knowledge and understanding." Dodgson [18] described organizational learning as the way firms build, supplement, and organize knowledge and routines around their activities and within their cultures, and adapt and develop organizational efficiency by improving the use of the broad skills of their workforce. Huber [19] also stated that learning occurs in an organization when through its processing of information the range of its potential behaviors changes.

A learning organization is a firm that purposefully constructs structures and strategies so as to enhance and maximize its effectiveness [18]. The concept of the learning organization has become popular since organizations want to be more adaptable to change. Learning is a dynamic concept and it emphasizes the continually changing nature of an organization. The focus is gradually shifting from individual to organizational learning. Just as learning is essential for the growth of an individual, it is equally important for an organization. Since individuals form the bulk of the organization, they must establish the necessary forms and processes to enable organizational learning in order to facilitate change.

However, according to Popper and Lipshitz [5], a collective level hypothetical construct can bridge the gap between learning in and by an organization. They also assert that two forms of organizational learning must be distinguished. Learning in an organization explains how individual learning becomes organizational. By contrast, learning by an organization is focused on anthropomorphism. This approach is the attribution of human form or qualities to nonhuman entities [5].

It is difficult to understand the relation among an organization's pattern of activities. Therefore, Popper and Lipshitz [5] also suggest the notion labeled OLM. As an operational mechanism of learning in an organization, the OLM heavily relies on individuals' psychological aspects as well as the organization's structural and other facets (i.e., cultural and contextual facets).

For studying organizational learning, we have to consider the context of the OLM, its analysis, and its integration. This is because integrated and dual-purpose OLMs can create synergy; they reduce the gap between learners and doers. Thus, the lessons learned will be implemented and such implementations will be closer to original intentions [20].

How to ingrain organizational learning relates to whether or not discoveries, inventions, and evaluations of individuals are embedded in the organization's theory-in-use or shared mental model [16]. To introduce this notion, Argyris and Schon borrow the mental model concept.

Organizational learning with concrete structural and procedural arrangement of actions by organizational members is understood so that learning is followed by observable change in the pattern of members' activities. Thus, we need to find the interaction effect between the factors that generate and facilitate the OLM.

4. LEVEL OF LEARNING

An organization cannot learn by itself, but rather through its members. Many scholars have focused on the relationships between individual learning and organizational learning. They also have focused on methods to facilitate organizational learning because it may control the organizational performance that results from learning.

The reason why organizations cannot find external learning methods suiting their purpose is that public and private

organizations have their own learning processes as well as divisions of labor. The performance from organizational learning cannot be achieved at only one level. According to March and Olsen [21], such learning is more than the sum of each division's learning. This study suggests more of a linkage of organizational learning and the learning cycle at each level: individual, group, and organization.

4.1 Organizational learning on an individual level

To facilitate the OLM, the members have to make an effort to revise and develop knowledge by gathering and elaborating information [20], [22]. In addition, Argyris and Schon [16] mentioned that learning takes place when new knowledge is translated into different behavior that is replicable. Moreover, some additional factors can also be considered as critical components in facilitating the OLM toward organizational effectiveness. With this process, we can actively address the learning process to create it. First, **PSYCHOLOGICAL SAFETY** critically serves as a key factor that facilitates the learning mechanism at an individual level. Lipshitz and Popper [20] mentioned that this is a state in which people feel safe enough to make errors and honestly discuss their opinions and how they feel. According to Edmondson [23], this factor has some advantages that can improve organizational performance: it can increase learners' willingness to report their mistakes, and serve as a critical linchpin between learning behavior and organizational performance. Second, **ORGANIZATIONAL COMMITMENT** is the state in which organizational members identify with the organization's goals and values and make no distinction between promoting its interests and their own [20]. Third, **COMMITMENT TO LEARNING** is a factor that is a very important element of the learning mechanism. In a rapidly changing environment, it can be regarded as the core component of the organization's ability. Dutton and Thomas [24] state that there are two types of learning: exogenous and endogenous. Fourth, in the learning process, the **INFORMATION COLLECTEDON AN INDIVIDUAL LEVEL** serves as a catalyst in the OLM. To collect information, each member finds the problem faced in the organization and decides what information will help solve it.

4.2 Organizational learning a group level

Many studies [25]-[27] state the importance of scanning units and boundary-spanning individuals as information gathering mechanisms. Moreover, at the group level, **KNOWLEDGE SHARING** can be significantly regarded as a key factor for team performance. Han [28] states that this process is achieved through communicating both internal and external knowledge to each other, which expands the benefit of knowledge sharing among members. **GROUP DEBATING** supports the sharing of information effectively among members as well. The effort to debate as an element of organizational learning is now widely accepted as essential for survival in increasingly volatile and competitive environments [29]. Specifically, these norms are the observed manifestations of a set of shared values that contribute toward a cultural facet that is conducive to productive learning. The members can store valuable information through group debating(**INFORMATION STORING**).

4.3 Organizational learning on the organization level

The structure and culture facets considered as the organizational level contain some key factors facilitating the OLM. Popper [8] suggested the following: tolerance for error, accountability, and an inquiring environment. Here, we briefly discuss the key factors consisting on the organizational level of the OLM. Learning inevitably generates errors, and those errors in the service of learning will not be punished, but indeed are valued as opportunities for learning(**TOLERANCE FOR ERROR**). **ACCOUNTABILITY** is regarded as two norms: learning and lessons learned. According to Beer and Spector [30], integrated and dedicated learning, which are learning diagnosis in the OLM that support continuous improvement itself, have a responsibility in the learning discussion. The **INQUIRING ATMOSPHERE** implies a willingness to accept a degree of uncertainty and to suspend judgment until a satisfactory understanding is achieved, and is similar to the value of intellectual curiosity (Popper et al., 2000).
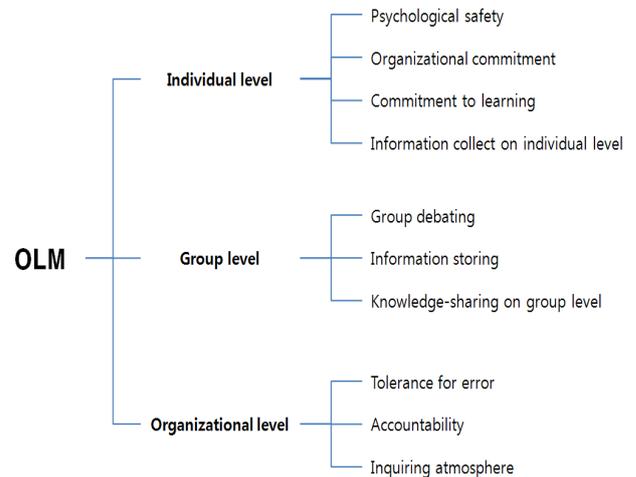

Fig. 2. Factors that facilitate OLM on each level

5. DATA ANALYSIS METHOD

After being developed, the DEMATEL method has been widely applied as a tool to find and solve cause and effect relationships among evaluation factors. This method was initially suggested by the Geneva Research of the Battele Memorial Institute to solve fragmented and antagonistic phenomena [31], [32]. It has the advantage of being practical and useful for visualizing the structure of complicated causal relationships. As such, the matrices of the digraph represent a contextual relation between the factors of the system that show the strength of influence with numerical representations. Furthermore, converting the relationship between cause and effect of criteria into the suggested system model could be considered a powerful advantage of DEMATEL.

The DEMATEL method is proposed as follows [33]. First, to cope with the ambiguity of human evaluation, we applied the crisp DEMATEL method. This method can adopt the linguistic

scale for group decision-making. To assess the different degrees of "influence"(*e.g.*, the extent to which these factors could affect each other in order to facilitate an organizational learning mechanism within the organization), five linguistic terms are suggested: {Very high influence, High influence, Low influence, Very low influence, and No influence}. On the basis of these five terms, the linguistic scale is adopted. Second, to evaluate the relationship between the suggested criteria, expert group members are required to make a set of pair-wise comparisons with the linguistic terms.

Step 1: To find and analyze the relations among the criteria, we classified the survey participants into four categories: male and female, researcher and administrator. The reason we take into account two gender and occupation criteria each is that the issue analyzed is critically related to the cognitive difference of the organizational learning mechanism.

Table 1. The demographic information of the respondents

Demographic information		Frequency	Percentage (%)
Gender	Male	40	63.5
	Female	23	36.5
Research career	Under 5 year	15	23.8
	5~10	4	6.3
	10~15	8	12.7
	15~20	19	30.2
	Over 20 year	17	27.0
Education level	University	22	34.9
	Master course	28	44.4
	Ph. D	13	20.6
Occupation	Researcher	36	57.1
	Administrator	27	42.9
	Other	-	-

Therefore the questionnaires with 10 criteria were designed on 3 level: individual, group, organizational level. The survey was taken among 63 participants at Ministry of Education of ROK(Republic of Korea) from March, 1, 2016 to March, 30, 2016 by asking the importance of each criterion with Likert-type five point scale, where 0 and 4 represent 'not important at all', and 'quite important', respectively. The number of valid questionnaire is 63. The demographic information of all participants is summarize in Table 1.

To evaluate the relationship between criteria suggested on system model, expert group members are required to make a set of pair-wise comparison with linguistic terms. To assess the difference degree of "influence", five linguistic terms are suggested.

" How much factors could affect each other in order to facilitate an organizational learning mechanism within the our organization ?" **Very high influence (4)** **High influence (3)** **Low influence (2)** **Very low influence (1)** **No influence (0)**	L1. individual level	L2. group level	L3. organizational level
L1. individual level		3	0
L2. group level	2		2
L3. organizational level	3	1	

Fig.3. Causal relation map

Step 2 : For each expert, an n*n non-negative matrix is calculated as $A^k = [a_{ij}^k]$, where k is the expert member of participating in evaluation process with $1 \leq k \leq m$. From the questionnaire, the direct/indirect relationships can be evaluated with each level.

$$\boldsymbol{D} = s^*A, \ \ s > 0 \tag{1}$$

Also

$$[d_{ij}]_{n \times n} = s[a_{ij}]_{n \times n}, \ \ \ \ s > 0, i,j \in \{1,2,\cdots,n\} \tag{2}$$

where $s = Min\left[\frac{1}{\max\limits_{1 \leq i \leq n}\sum_{j=1}^{n}|a_{ij}|}, \frac{1}{\max\limits_{1 \leq j \leq n}\sum_{i=1}^{n}|a_{ij}|}\right]$ (3)

and

$$lim_{m \to \infty} D^m = [0]_{n \times n} \ where \ D = [d_{ij}]_{n \times n}, 0 \leq d_{ij} \leq 1 \tag{4}$$

Total influence matrix T could be obtained by Eq.(5), in which, I is an identity matrix.

$$T = D + D^2 + \cdots + D^m = D(I - D)^{-1}, where \ m \to \infty. \tag{5}$$

Step 3 : Define r and c be n × 1 and 1 × n vectors representing the sum of rows and sum of columns of the total relation matrix T, respectively.

$$T = [t_{ij}], \ \ i,j = 1.2.\cdots,n. \tag{6}$$

$$r = [r_i]_{n \times 1} = \left(\sum_{j=1}^{n} t_{ij}\right)_{n \times 1} \tag{7}$$

$$c = [c_j]'_{1 \times n} = \left(\sum_{i=1}^{n} t_{ij}\right)_{1 \times n} \tag{8}$$

Where the superscript ' denote transpose, Supposer_i can be the sum of *i*th row in matrix T, thenr_i summarizes both direct and indirect effects given by factor i to the other factors. If c_j denotes the sum of *j*th column in matrix T, then c_j shows both

direct and indirect effects by factor j from the other factors. When $j = i$, the sum $(r_i + c_j)$ shows the total effects given and received by factor i. That is, $(r_i + c_j)$ indicates the degree of importance that factor i plays in the entire system. On the contrary, the difference $(r_i - c_j)$ depicts the net effect that factor i contributes to the system. Specifically, if $(r_i - c_j)$ is positive, factor i is a net cause, while factor is a net receiver or result if $(r_i - c_j)$ is negative.

From $(r_i + c_j)$ and $(r_i - c_j)$ position map, we could expect the attribute of participants. It also can be divided into the following 4 types [34].

a. $(r_i - c_j)$ is positive and $(r_i + c_j)$ large: the attributes serve as causes, and driving factors to solve the problems

b. $(r_i - c_j)$ is positive and $(r_i + c_j)$ small: the attributes are independent factors and influence a few factors.

c. $(r_i - c_j)$ is negative and $(r_i + c_j)$ large: the attributes are affected from other factors and cannot solve the problems itself.

d. $(r_i - c_j)$ is negative and $(r_i + c_j)$ small: the attributes are independent factors and affected from a few other factors.

Step 4 : In traditional DEMATEL method, the importance of each factor itself is not taken into account. Without the priority among factors, it is difficult to decide how much money, resources, time, and efforts are applied with strategic decision making. To overcome this problematique Tamura and Akazawa [6] suggested a new measure method called composite importance. This method is to be integrated original DEMATEL method with composed n dimensional column vector, here y^*.

Let normalize y^* as $y = \mu \cdot y^*$
Where $\mu = 1/(the\ largest\ element\ of\ y^*)$.   (9)

The importance of factor i itself the composite importance of each factor can be calculated as

$Z = y + Ty = (I + T)y$ (10)

They also suggest the method 5-grade evaluation, the *ith* element y_i^* is determined based on the answer of the respondents as

$y_i^* = 0$: if factor i is not important at all;
$y_i^* = 1$: if factor i is not important so much;
$y_i^* = 2$: if factor i is important;
$y_i^* = 3$: if factor i is very important;
$y_i^* = 4$: if factor i is quite important.

Step 5 : Set a threshold value alpha(α)

The threshold value alpha was computed by the average of the elements in matrix T, as computed by Eq.(9). This calculation served as a basis of threshold to eliminate less important relations in matrix T [35].

$$\alpha = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} [t_{ij}]}{N}$$ (11)

Since matrix T provides information on how one factor affects another, an essential decision making process is needed to set up a threshold value to filter out some negligible effect

6. RESULTS OF ANALYSIS

The DEMATEL technique was applied in this study for investigating the causal relations among theoretical extension components. Key success factors were identified by this method to help organizations focus on the learning mechanism and harmonizing it with the internal processes. We categorized the model to analyze the relationships between the factors based on gender and occupation on three levels (*i.e.*, individual, group, and organizational) and an overall level.

6.1 Male officer

The overall system model is shown in Figures 3~6. In these figures, arrows represent the direction of factors from i to j. If x_{ij} is greater than or equal to the threshold value, alpha, no arrows mean it is less than alpha. Additionally, each factor has a composite importance(CI) value. The value represents the importance of the factor itself, calculated from the total relation matrix, T. Under each factor, the values of $(r_i + c_j)$ and $(r_i - c_j)$ are shown below.

Fig. 4 shows the following information for the male officer of the Ministry of Education (MOE). The "organizational level" has the positive $(r_i - c_j)$ value, which means that the factor serves as the main influence factor that will also affect others at entire level. Moreover, it could play a central role between the other two factors. Specifically, the "organizational level" and the "group level" influence each other. An individual level factor obtains the negative $(r_i - c_j)$ value in Fig. 4, that is, the factor is a net receiver of the result. However, from the relationships, we cannot find the factor to need help in order to facilitate organizational learning. For this reason, we evaluate Eq. 9~10 composite importance of each factor. Here, the organizational level got the highest value of CI.

At the individual level, "psychological safety" obtained the highest value of $(r_i - c_j)$ that is, the factor is a main influence factor that will also affect others. Specifically, the factor also holds the highest value of $(r_i + c_j)$, that is, this factor has a strong connection with other factors.

The $(r_i - c_j)$ value of "group debating" at group level is high. Additionally, the $(r_i + c_j)$ value of "knowledge-sharing at group level" is high, which means that the value has a strong connection with other factors, and functions as a key factor within system model. Specifically, two factors, "group debating" and "knowledge-sharing at group level," affect each other. Moreover, "knowledge-sharing at group level" has a feedback loop from the threshold value of matrix T, that is, this factor generates a powerful influence to other factors and receives influence from them. The $(r_i - c_j)$ value of "information storing" is the lowest, that is, this is the main factor receiving influence from the other factors at the level. The composite

importance value of "group debating" is the highest(102.9). Therefore, this factor itself to be helped in order to facilitate organizational learning. This measure provides useful information in fixing the order of priority.

$(r_i - c_j)$ and $(r_i + c_j)$ values of "tolerance for error" are the highest, which means that the value has a strong connection with other factors and also exerts powerful influence at organizational level. The $(r_i - c_j)$ value of "accountability" is

the lowest, that is, this is the main factor receiving influence from other factors. Specifically, the "tolerance for error" and "inquiring atmosphere"$(r_i + c_j)$ value of almost all factors is high and shows a strong connection with the "accountability" factor. From Fig. 4, we find that male officers recognize that the factors related with psychological aspect could critically influence the factors of the system model in order to emerge and facilitate

Table 2. Total relation matrix(male officer)

L_i \ L_j	L_1	L_2	L_3	CI
Individual level(L_1)	7.90	8.02	7.79	74.63
Group level(L_2)	8.70*	8.15	8.25*	78.92
Organizational level(L_3)	8.76*	8.54*	7.98	79.49

α = 8.23

C_i \ C_j	C_1	C_2	C_3	C_4	CI
physical safety(c_1)	2.46*	2.63*	2.80*	2.79*	29.75
organizational commitment(c_2)	2.35	2.08	2.42	2.42	25.61
commitment to learning(c_3)	2.56*	2.48*	2.40	2.64*	28.16
information collect on individual level(c_4)	2.45	2.36	2.52*	2.29	26.88

α = 2.48

C_i \ C_j	C_1	C_2	C_3	CI
group debating(C_1)	11.02	11.61*	11.56*	102.91
information storing(C_2)	10.70	10.64	10.90	97.18
knowledge-sharing on group level(C_3)	11.32*	11.58*	11.19*	102.74

α = 11.17

| C_i \ C_j	C_1	C_2	C_3	CI
tolerance for error(C_1)	6.25	7.01*	7.14*	56.78
accountability(C_2)	5.72	5.80	6.20	49.27
inquiring atmosphere(C_3)	6.09	6.48*	6.27	52.90

α = 6.33

*> threshold value α
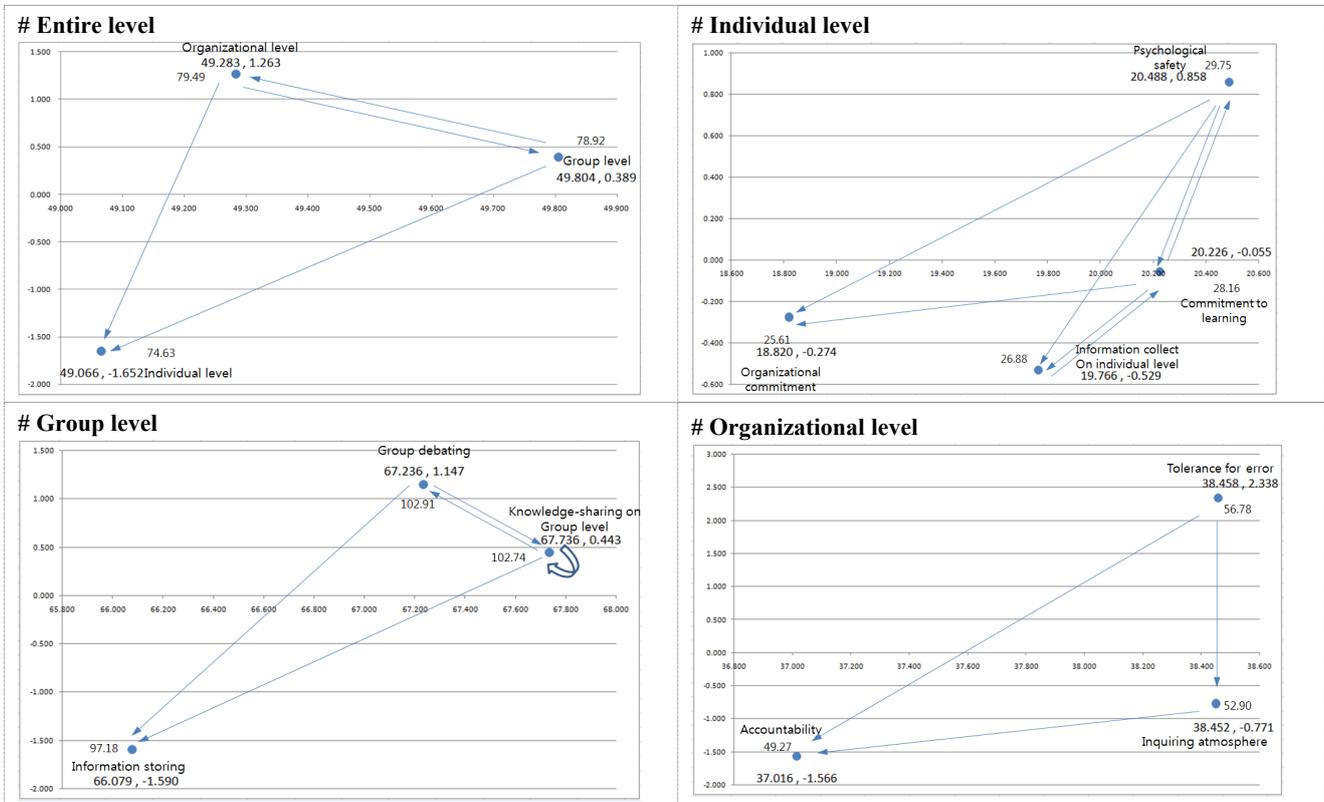
Fig. 4. Causal map(male officer)

6.2 Female officer

The $(r_i - c_j)$value of the "organizational level" obtained a positive value at entire level, that is, the factor serves as a main influence factor that will also affect others. Additionally, two factors, "organizational level" and "group level," affect each other. The $(r_i - c_j)$ value of the individual level registered a negative $(r_i - c_j)$ value, as shown in Fig. 5, that is, the factor is a net receiver of the result. The CI value is the highest (84.75). This type of pattern is similar to that of the male officer.

The $(r_i - c_j)$value of "information collection at individual level" was the highest, that is, the factor is a main influence factor that will also affect others. The $(r_i + c_j)$value of "psychological safety" is the highest, that is, the factor for facilitating the organizational learning mechanism could be the most central factor in this analytical model.

The $(r_i - c_j)$ and $(r_i + c_j)$values of "group debating" were the highest. From figure 5, the factor at group level critically serves as a key variable to facilitate the organizational learning mechanism. Additionally, this factor has the highest CI. This type of diagram serves as strategic map to help decision makers better understand the overall relations through graphic representations.

The $(r_i - c_j)$ value and CI of "tolerance for error" are the highest, which means that the value has a strong connection with other factors and has a powerful influence to be helped in order to facilitate organizational learning. Compared to the male officer, we found that the female officer also recognizes that the psychological aspect could critically influence, as a facilitator, on the system model in order to emerge and facilitate organizational learning.

Table 3. Total relation matrix(female officer)

L_i \ L_j	L_1	L_2	L_3	CI
Individual level(L_1)	8.64	8.75	8.53	78.98
Group level(L_2)	9.55*	9.00	9.11*	84.27
Organizational level(L_3)	9.60*	9.38*	8.82	84.75

α = 9.04

C_i \ C_j	C_1	C_2	C_3	C_4	CI
physical safety(C_1)	6.15*	6.07*	6.30*	6.09*	63.30
organizational commitment(C_2)	6.03*	5.48	5.93	5.72	59.37
commitment to learning(C_3)	6.33*	5.99	5.97	6.02*	62.48
information collect on individual level(C_4)	6.24*	5.89	6.12*	5.68	61.17

α = 6.00

C_i \ C_j	C_1	C_2	C_3	CI
group debating(C_1)	8.59	9.30*	9.13*	82.40
information storing(C_2)	8.47	8.51	8.66	78.27
knowledge-sharing on group level(C_3)	8.71	9.09*	8.59	80.68

α = 8.78

C_i \ C_j	C_1	C_2	C_3	CI
tolerance for error(C_1)	7.78	8.42*	8.38*	64.48
Accountability(C_2)	7.67	7.66	7.94	61.19
inquiring atmosphere (C_3)	7.88	8.19*	7.82	62.81

α = 7.97

> threshold value α

Entire level

Individual level
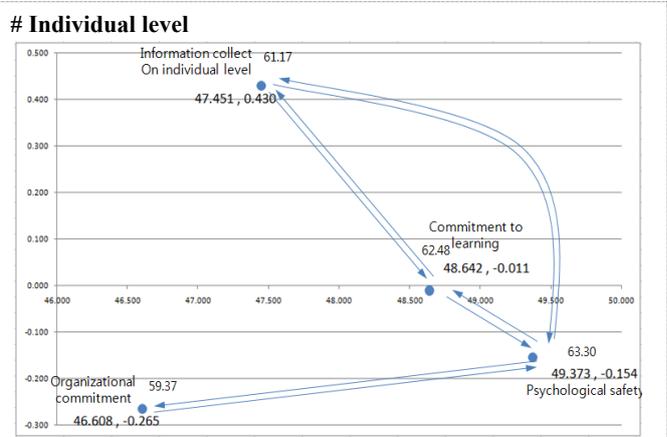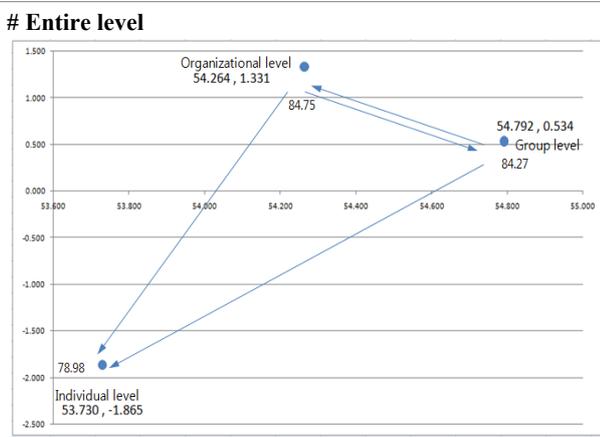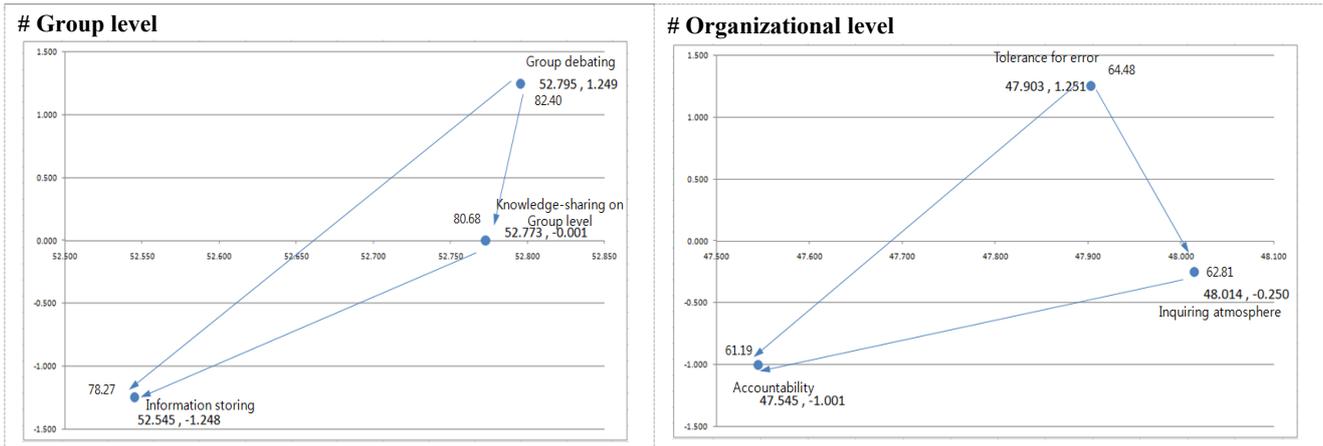
Fig. 5. Causal map(female officer)

6.3 Researcher

At the overall level, the $(r_i - c_j)$ value and CI of the organizational level are the highest, that is, this factor serves as a main influence factor that will also affect others. The $(r_i + c_j)$ value of the "group level" is also high, meaning that this factor has strong connections with other factors. From the value of $(r_i + c_j)$, "group level" can be seen as facilitating the organizational learning mechanism and serve as the most central factor in this analytic model.

The $(r_i - c_j)$ and $(r_i + c_j)$ values of the "individual level" in the researcher group are the highest, which means that the value has strong connections with others factors. Organizational commitment, information collection at individual level, and commitment to learning all have negative values. That is, these

factors receive an influence from the "psychological safety" factor.

The $(r_i - c_j)$ value of "group debating" is the highest. Additionally, the $(r_i + c_j)$ value of "knowledge-sharing at group level" is also high. These two factors are connected, being calculated from the threshold value of matrix T, which means that they serve as key variables to facilitate and emerge organizational learning at group level. This could be considered as the result of the CI of factors.

The $(r_i - c_j)$ value of "tolerance for error" is the highest. "Inquiring atmosphere" on the axis is also high. From the result, it can be said that in the researcher group the psychological aspect and factors controlling organizational climate are served as the most central factors in this analytic map.

Table 4. Total relation matrix(researcher)

L_i \ L_j	L_1	L_2	L_3	CI
Individual level(L_1)	10.36	10.54	10.19	98.67
Group level(L_2)	10.95*	10.46	10.44	100.96
Organizational level(L_3)	11.11*	10.95*	10.27	102.46

α = 10.59

C_i \ C_j	C_1	C_2	C_3	C_4	CI
physical safety(C_1)	2.68*	2.82*	3.01*	2.99*	31.69
organizational commitment(C_2)	2.56	2.26	2.63	2.63	27.46
commitment to learning(C_3)	2.79*	2.67	2.61	2.85*	30.03
information collect on individual level(C_4)	2.67	2.55	2.72	2.49	28.69

α = 2.68

C_i \ C_j	C_1	C_2	C_3	CI
group debating(C_1)	10.29	10.93*	10.84*	99.76
information storing(C_2)	10.08	10.05	10.28	94.66
knowledge-sharing on group level(C_3)	10.50*	10.81*	10.38	98.79

α = 10.46

| C_i \ C_j	C_1	C_2	C_3	CI
tolerance for error(C_1)	3.39	3.96*	3.97*	33.45
accountability(C_2)	3.26	3.20	3.50	29.38
inquiring atmosphere(C_3)	3.50	3.74*	3.42	31.85

α = 3.55

> threshold value α
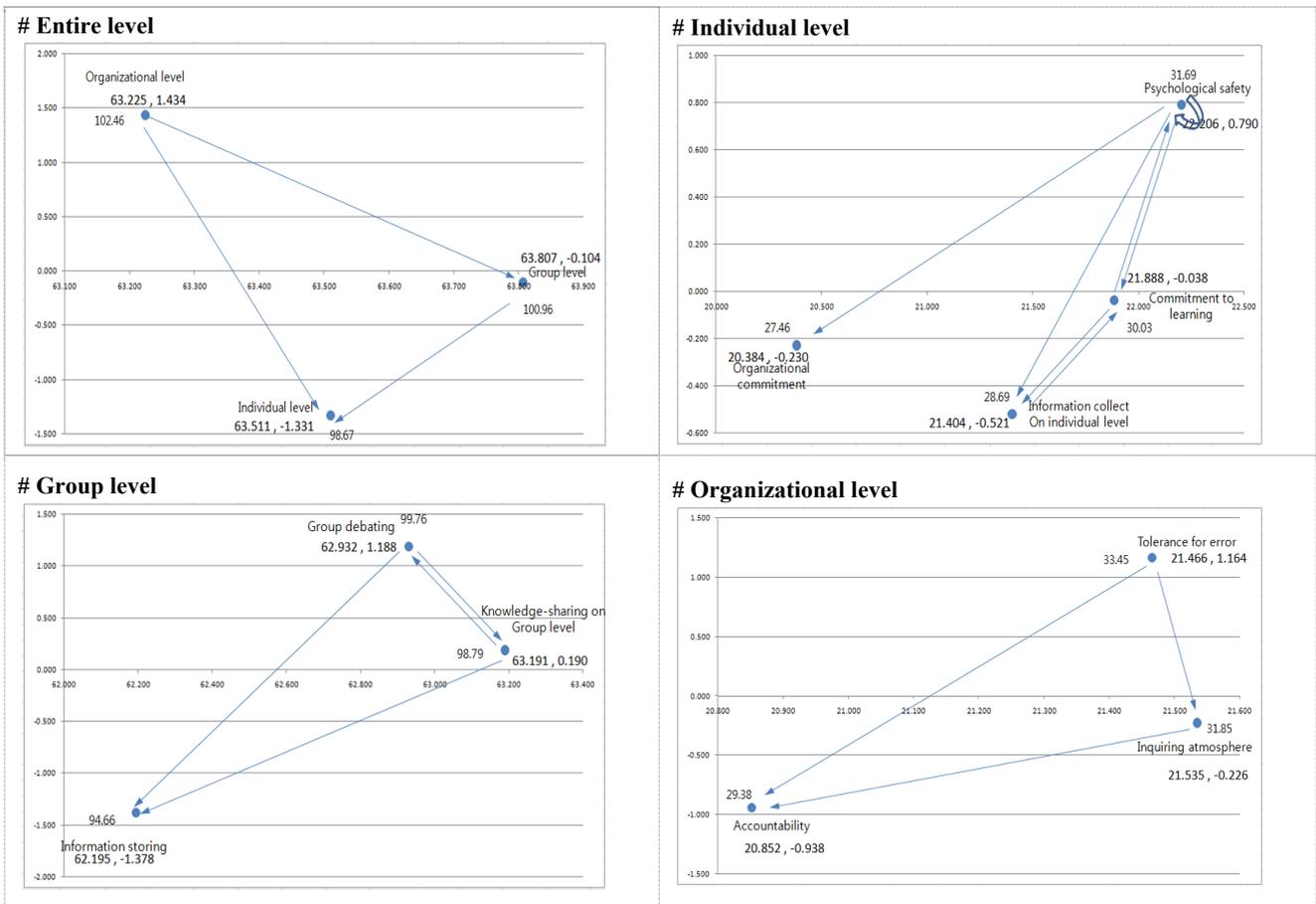
Fig. 6. Causal map(researcher)

6.4 Administrator

The entire level $(r_i - c_j)$ values on the vertical axis of the "organizational level" and "group level" are high and connected to each other, which means that they play a major role in affecting the "individual level" factor to facilitate organizational learning.

The $(r_i - c_j)$ and $(r_i + c_j)$ values of the "psychological safety" factor at the individual level are the highest. Therefore, this factor could play a central role to emerge and facilitate organizational learning at individual level. This is also supported by the result of CI and the feedback loop, providing the value in establishing an order of priority, and affecting the influence of other factors on organizational learning.

The $(r_i - c_j)$ value on the vertical axis of "group debating" and "knowledge-sharing at group level" are high and connected to each other. Moreover, the "information storing" factor has a negative value on vertical axis.

The $(r_i - c_j)$ and $(r_i + c_j)$ values and CI value of "tolerance for error" are the highest, which means that this factor strongly connects with others and has a powerful influence on facilitating organizational learning. Additionally, two factors, "accountability" and "inquiring atmosphere" are connected with each other, and can be considered as effect(*i.e.*, being affected by others).

This result and diagrams serve as a strategic map to help decision makers understand the overall relations through graphic representations. To simplify the relations between factors and provide decision makers with a clear understanding of which relations are more important, values over threshold value alpha need to be emphasized [35].

This study conducted a survey to find the factors that facilitate the organizational learning mechanism by applying the DEMATEL method. It suggested 10 criteria on three levels: individual, group, and organizational level. Unlike the traditional DEMATEL method, this study applied the composite importance concept to evaluate the importance of factors. That is, by applying DEMATEL with composite importance, the importance of the 10 criteria could be determined and the relationship among them evaluated.

Consequently, we found that the psychological factor at organizational and group levels could serve as key values to facilitate public organizations' learning. As such, these organizations should concentrate on the psychological and organizational climate to be innovative and creative in order to facilitate the organizational learning mechanism. Therefore, in order to enhance organizational learning, the public organization(*e.g.*, the Ministry of Education of the Republic of Korea) should allocate more resources, effort, and time in this direction.

Table 5. Total relation matrix(administrator)

L_i \ L_j	L_1	L_2	L_3	CI
Individual level(L_1)	5.84	5.90	5.77	53.08
Group level(L_2)	6.81*	6.21	6.41*	58.97
Organizational level(L_3)	6.79*	6.52*	6.06	58.86

α = 6.26

C_i \ C_j	C_1	C_2	C_3	C_4	CI
physical safety(C_1)	4.84*	4.91*	5.10*	4.97*	52.06
organizational commitment(C_2)	4.69	4.29	4.69	4.56	47.77
commitment to learning(C_3)	4.97*	4.78*	4.72	4.84*	50.85
information collect on individual level(C_4)	4.86*	4.67	4.85*	4.49	49.44

α = 4.76

C_i \ C_j	C_1	C_2	C_3	CI
Group debating(C_1)	9.67	10.32*	10.21*	87.78
Information storing(C_2)	9.41	9.40	9.60	82.77
knowledge-sharing on group level(C_3)	9.92*	10.24*	9.78	87.18

α = 9.84

| C_i \ C_j	C_1	C_2	C_3	CI
tolerance for error(C_1)	4.21	4.69*	4.81*	36.13
accountability(C_2)	4.16	4.00	4.41*	33.25
Inquiring atmosphere(C_3)	4.25	4.39*	4.18	34.17

α = 4.35

> threshold value α
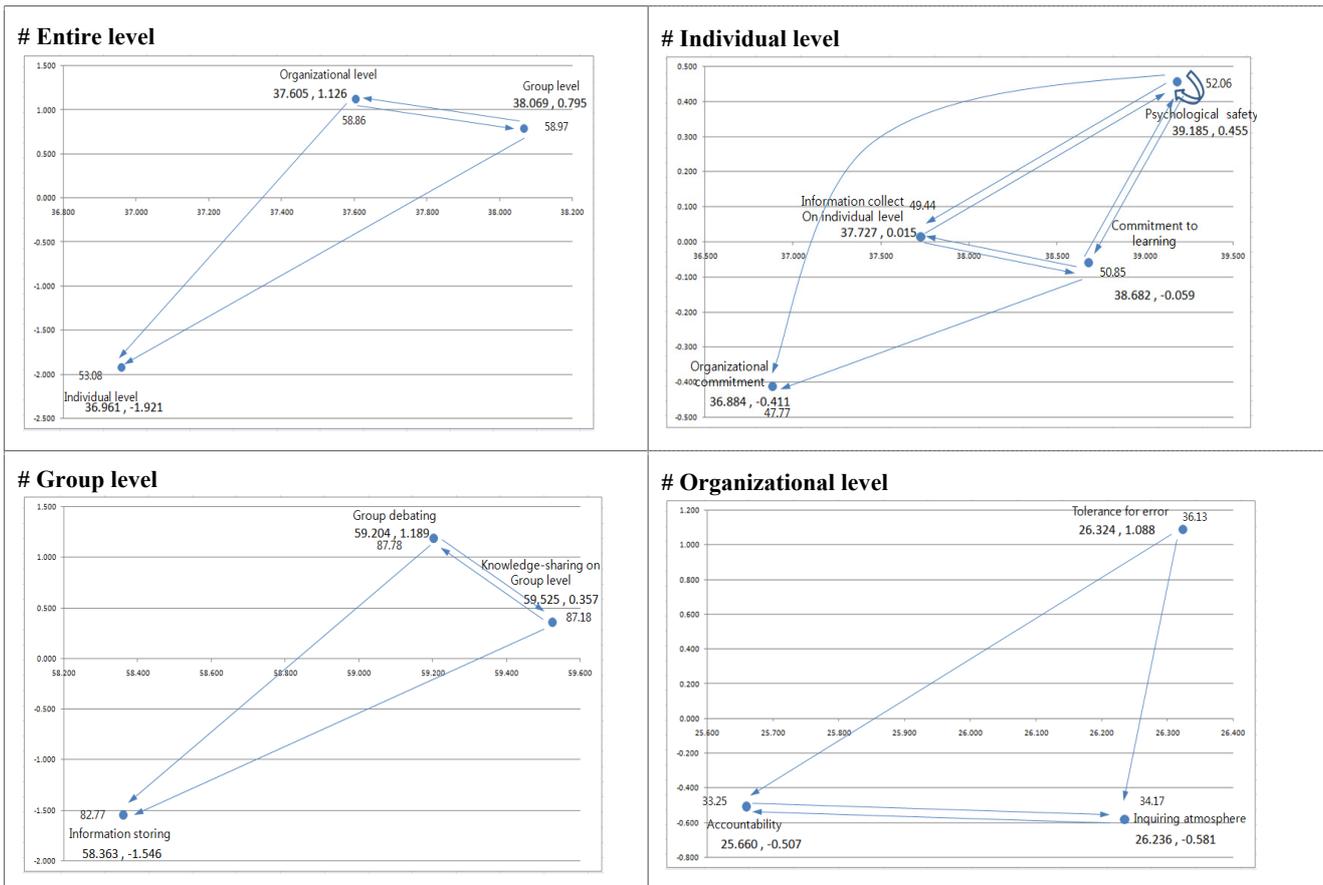
Fig. 7. Causal map(administrator)

Table 6. Core factors that facilitate organizational learning

	male officer				female officer			
	EL	**IL**	**GL**	**OL**	**EL**	**IL**	**GL**	**OL**
importance factor	group level	psychological safety	group debating	tolerance for error	group level	information collect	group debating	tolerance for error
core mediator	group level	psychological safety	knowledge sharing	tolerance for error	group level	psychological safety	group debating	inquiring atmosphere

	researcher				administrator			
	EL	**IL**	**GL**	**OL**	**EL**	**IL**	**GL**	**OL**
importance factor	organizational level	psychological safety	group debating	tolerance for error	organizational level	psychological safety	group debating	tolerance for error
core mediator	group level	psychological safety	knowledge sharing	inquiring atmosphere	group level	psychological safety	knowledge sharing	inquiring atmosphere

7. DISCUSSION

Since the capacity of organizational learning as a valuable intangible asset would enable people to analyze the complex problem faced with organizations as well as to find practical solutions for their problems encountered, its importance has been emphasized in today's business environment mainly concerned with the competitive advantage.

However, the capacity is complicatedly interwoven within organizational systems. It means that these contradictions positively block the intervention of organizational development and performance within organizational working process. Therefore, the organizations and their members should consider improving their dynamic performance to deal with these problems. The smart organization would like to effectively cope with a wide range of issues in management faced with complex environment.

Conducting systemized and scientific studying for organizational learning are required to effectively manage the members holding the determined willingness to learn as a intangible asset and complex concepts composed of various factors such as psychological factors, group dynamics and organizational facets. Although numerous researchers have studied organizational learning for a long time, a clear definition seems to be elusive because each organization has its own learning style and environments faced which are contingent on a range of factors. So, before looking into about strategies to solve the problems, it might be useful to find the factors that facilitate the organizational learning mechanism thoroughly.

For this, we have applied the methodology reflecting the relations between each factors emerged in three levels of learning as arithmetic logic. Combining the traditional DEMATEL method and composite importance could serve as a critical linchpin in understanding the relation, for the factors that facilitating organizational learning mechanism and knowledge creation within organizational systems. Therefore, this study would offer a possible means to comprehend the process of change in individual and shared thought and action,

affected by in the organizational learning. Also, the suggested results of the study have practical implications for the enhancement of organizational learning performance in the Ministry of Education and some directions taken into account for further research in this area.

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Sun Hyung Park

He received the B.S., M.S in Education at Dongguk University, Korea in 1987, 1990 respectively and also received Ph.D. in Educational Administration from University of Tasmania, Australia in 1998. He is Dean, College of Lifelong Education and Professor, Department of Education at Dongguk University. He is mainly concerned with dealing with some issues regarding knowledge management in education and organizational creativity.

Il Soo Kim

He received the M.S in Educational Leadership & Policy at Florida State University in 2010. He is currently working at the Office of the President Republic of Korea as an Assistant Secretary of Education to the President. His research interests focus on Developing Inter-Korean Social Integration, the New Direction of Unification Education and Multicultural Education/Intercultural Education in Korea.
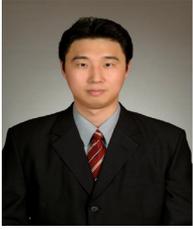
Seong Bum Lim
He received his M.S. in Public Administration at Yonsei University, Korea. He also received Ph.D. in Public policy from Kyunghee University in 2011. He is currently a research professor, Department of Public administration at Dankook University. His research interests focus on developing university education satisfaction index, strategic decision making support system and structural equation modeling.