▨ 연구논문

Operationalizing the Concept of Responsiveness In Management Tools

경영 도구에서의 '적절 대응' 개념 설정

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요 지

본 논문은 일반 인간사회에서의 '적절 대응' 개념을 살펴보고 이를 경영도구에서 설정하는 것에 관한 연구이다. 많은 경영도구들은 목적과 수단을 혼동함으로써 실패해 왔다. '적절 대응' 개념은 경영도구의 성공을 위해 필수적인 개념으로서 인간사회에서는 오래 전부터 성공의 기본 요건이 되어 온 것이다. 본 논문에서는 '적절 대응' 개념을 변수를 도입하여 정의하고, 관찰, 이해, 해석, 이행의 4단계로 구성되는 '적절 대응' 과정을 설정한다. '적절 대응' 개념을 실현하기 위해서 경영도구는 이러한 4단계의 과정을 이행할 수 있도록 일반 기능 측면에서의 능력, 사용자 인터페이스 측면에서의 능력, 적응성 측면에서의 능력을 보유해야 한다. 이러한 '적절 대응' 개념은 생산정보시스템에도 이용될 수 있을 것이다.

1. Introduction

We help managers most by providing management tools to support their decision making. Often these tools fail. Kurstedt [13] claims 70 percent of all management information systems fail and Martin [17] reports that "less than 5 percent of the money put into the nine software developments resulted in software which could be used as delivered or with minor changes" based on a Government Accounting Office study. I suspect this high failure rate of management tools is largely due to the lack of a total management system perspective. The success of management tools depends on the success of a management system the management tools support. Management tools are means to achieve all management system objectives. If the management system fails, the management tool fails whether it appears successful in itself. Often people are confused between their ends and means and tend to bend their needs(ends) to fit the tools(means) rather than vice versa. This forced fit causes the management system to fail in meeting system objectives. To rectify the confusion between ends and means, Kurstedt [13] has

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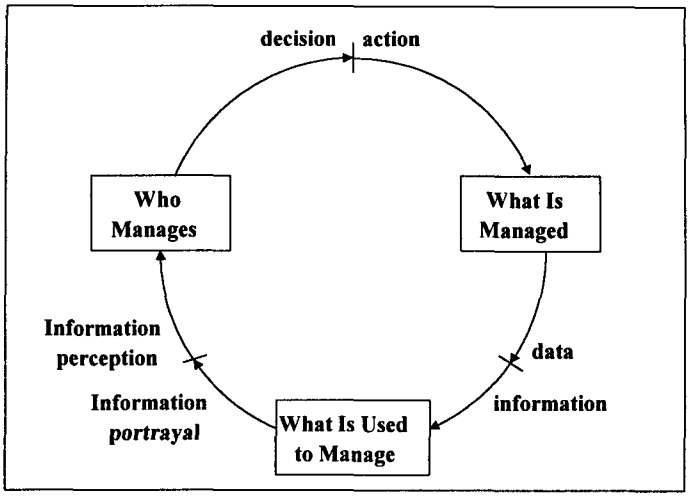

Figure 1. Management System Model

developed the Management System Model(MSM) shown in Figure 1.

The MSM represents a structured approach we need for understanding and applying management tools. The MSM provides a simple framework describing a management system, its components, and their relationships. The MSM consists of three essential components: 'who manages'(a manager), 'what is managed'(operation), and 'what is used to manage'(management tools). The 'who manages' component is anyone who uses information to make decisions resulting in actions affecting what is managed. The 'what is managed' component includes the tangible physical things the manager is responsible for. The 'what is used to manage' component comprises the tools with which we manage, such as organizational structures, information systems, plans, etc. Explicitly, the MSM separates means('what is used to manage') from ends ('what is managed'). A common source of management tool failure is the emphasis on 'what is used to manage' as the ends rather than the means. The MSM implies the focal point of managerial concern should be the physical things that constitute 'what is managed'.

We balance the three essential components by matching both sides of each interface between the components [13]. Kurstedt [13] argues lack of match in the MSM interfaces is another major source of management tool failure. Management tools must reflect 'what is managed' and must be acceptable (comfortable and useful) to 'who manages'. If our operation provides customer-oriented goods or services, a technical-function-oriented organizational structure will not work for us. If the manager is systematic and prefers definition and details, a colorful graphics package may not be appropriate.

The MSM highlights 'who manages', a component neglected in many management information system(MIS) research models. The MSM implicitly recognizes that different managers or a manager at a different time may ① need different kinds of information in different formats, ② perceive the same information differently, and ③ go through different decision making processes. The recognition of individual differences between managers implies management tools should reflect these individual differences to match the interface

between a manager and his or her management tools. To be more successful, management tools should respond to changes in 'who manages'. Usually conventional management tools have not reflected this changing nature of managers' needs. This is another source of management tool failure [13].

I'm also concerned with sharing management tools among different managers in terms of the converter of data, the information the tool produces, and the data the tool converts. We've experienced a low sharing rate of management tools [15]. I suspect one of the reasons is those management tools didn't have the ability to respond differently to different managers. In other words, they couldn't satisfy different needs of different managers. They might satisfy some of the managers they fit. For the rest of the managers, those management tools are useless. Therefore, if management tools could respond differently to different managers, those management tools will have higher sharing rates among managers.

In the context of success and sharing of management tools, we can imagine management tools responsive to the varying and evolving needs of the managers. Responsiveness is a valuable property human beings have shown with their intelligence for their success. Responsiveness characteristics mean the ability and willingness to listen and understand the needs of sponsors and to provide good and timely solutions to the problems of sponsors. Responsiveness is a key and requisite characteristic we need for our success.

In this regard, this paper considers successful management tools to be responsive to us: the user. Responsiveness implies intelligence. The rapid development of artificial intelligence(AI) supports our thoughts of intelligent management tools responsive to individual managers' needs. This research transfers the concept of responsiveness in the human world into management tools with AI technologies. This concept of responsiveness is readily applied to a manufacturing information system, which is to provide adequate, accurate and implicative information to its users.

2. The Concept of Responsiveness in Management Tools

2.1 Responsiveness in the Human World

Responsiveness is a valuable property human beings or groups of human beings have shown. We can think of lots of examples: responsive secretaries to their bosses [3], responsive nurses to their patients [18], responsive salespeople to their customers [8], responsive governments to their people [30], responsive schools to the parents of their students [10], responsive teachers to their students [27], etc. A responsive secretary observes the boss, anticipates what the boss needs, and implements it. Belker [3] exemplifies:

- The secretary scans an incoming letter to see what file needs to be pulled for the boss to process the matter with thoroughness, and attaches the file, putting the latest letter on top;
- The secretary looks at the boss's calendar, sees what meetings and appointments the boss has scheduled for the next week, and asks himself or herself what items the boss is likely to need for these appointments and what he or she can do to help the boss prepare for them.

The responsive secretary has the ability and willingness to listen and understand the boss's needs and provide appropriate and timely services. This implies three things:

① The responsive secretary matches his or her response to the boss's needs : provide appropriate and timely services.
② The responsive secretary goes through some process to match : listen, understand, interpret, and provide.
③ The responsive secretary has some abilities to perform the match : ability and willingness.

Many people talked about a computer system responsive to the user's needs [4, 6, 9, 21, 23,]. However, they didn't provide exact meaning of responsiveness and any prototype responsive system. Responsiveness implies a reasoning process occurring inside the human being. If we define the process and transfer it to computer systems, we can have computer systems responsive to the user's needs.

2.2 Conceptual Model of Matching

When we talk about responsiveness, we implicitly assume there are two components: one that is responsive such as a secretary, a nurse, a salesperson, a government, a school, and a teacher; and the other to which the one is responsive such as a boss, patients, customers, people, parents, and students, respectively. Responsiveness is a property of the server towards the receiver. Figure 2 represents a simple model describing the relationship between the server and the receiver.

In Figure 2, the receiver projects its state to the left side of the interface screen as needs and the server projects its state to the right side of the interface screen as responses. Here, the interface is not a physical one, but a conceptual one. The size and position of each projection depends on the states of the receiver and the server. Conceptually, the intersection of the projection areas defines the degree of match between the receiver and the server.

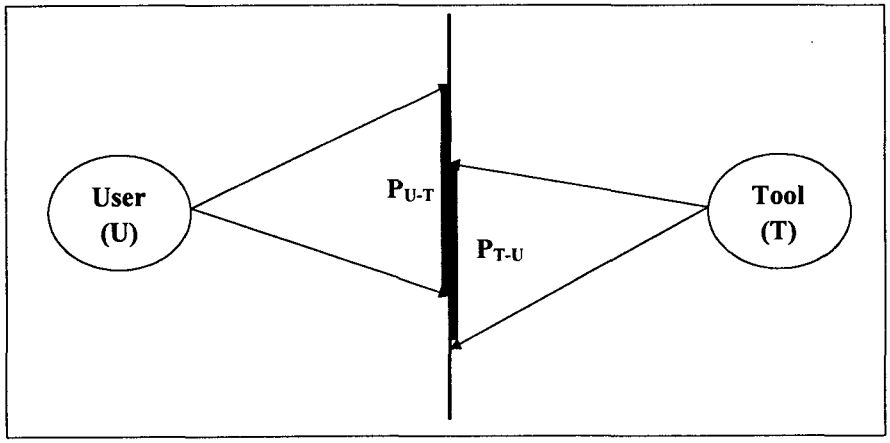

Figure 2. Conceptual Model of Matching

In the secretary example, the boss's characteristics, preferences, situation, etc define the boss's state. This state is projected to the interface screen as needs such that the boss ① wants to process recent letters first, ② needs to make some decisions, and ③ wants some information showing the trend of recent sales. On the other hand, the secretary's capabilities, resources, preparation, etc define the secretary's state. This state is projected to the interface screen as responses such that the secretary puts the latest letter on top and for the letter requiring it, attaches a line chart of the company's recent sales. In this case, a match occurs between the boss' needs and the secretary's response. If the secretary attached no information or attached a pie chart, a mismatch occurs because it doesn't satisfy the boss's needs.

Generally the manager has his or her characteristics, preferences, experiences, etc. The manager's characteristics determine the projection to one side of the screen. The management tool also has its design purpose, functionality, user interfaces, etc. The tool characteristics determine the projection to the other side of the screen. The central issue of this interface is information flow from the tool to the user. The flow of information through the interface is related to the size of the intersection area. No intersection area means no flow of information through the information portrayal/information perception interface in the MSM. That is, the tool is valueless if the manager doesn't use it or doesn't get help from it. The gap between projection areas may be defined by the unmatched areas and the difference between the two centroids. Perhaps we can project and affect the future usefulness of the tool by measuring and watching changes in the intersection area over time.

In the context of manufacturing information systems, the concept of responsiveness could be applied to all phases of manufacturing : planning, control and evaluation. In each phase, the responsiveness of a manufacturing information system would improve the manager's performance. For example, in an accidental situation which requires the manager's urgent response, the capability of the information system to provide the manager adequate information in an adequate format would be critical to the successful settlement of the situation.

2.3 Related Variables

Figure 2 implies a set of variables, in a broad sense, in terms of management tools.

U : This represents variables that define the status of the user. I categorize these variables into:

- ***User characteristics*** : attributes of a user considered relatively constant for a specific period of time. For example, age, gender, cognitive styles, skills, knowledge and beliefs, preferences, preunderstanding and background [11] physical attributes, etc.
- ***Problem characteristics*** : attributes of a problem the user is trying to solve and/or a task the user is trying to accomplish when using the system. For example, types of decision making tasks such as situation assessment, planning and commitment, and execution and monitoring [24]; structuredness [26], levels of managerial activity such as strategic planning, management control, and operational

control [2]; classes of the decision making situation such as familiar and frequent, familiar and infrequent, and unfamiliar and infrequent [24]; etc.

- ***Decision environment*** : attributes of the environment where the user is trying to solve a problem. For example, the degree to which subunits of an organization are organic or mechanistic, the degree to which decision-making is centralized or decentralized, environments of an organization [16], etc.
- ***User context*** : attributes of a user subject to change during the use of the system. For example, goals, plans, intentions [1, 12, 20], operative cognitions [11], misconceptions; etc.

These variables are not independent, but interrelated. As a whole, these variables define the state of the user.

T : This represents variables that define the state of the management tool. I categorize these variables into:

- ***System parameters*** : attributes of a system considered constant for a specific period of time. For example, problem solving methods or models [22], database management functions, interaction type, interaction style, interaction medium, etc.
- ***System variables*** : attributes of a system subject to change during the use of the system. For example, information content, information portrayal format, output frequency, level of help messages, etc.

The combination of these variables specifies a response of the system to the user.

P_{U-T} : This variable represents the projection of U and can be explained as the needs of the user. We can view needs in terms of decision support or interaction support. If the manager is making decisions on investments, he or she needs some information on investment alternatives and corresponding returns on investment. If the manager is a sensing person in terms of MBTI (Myers-Briggs Type Indicator) [19], he or she may need more detailed information. As such, P_{U-T} is multi-dimensional and is considered in terms of the user.

P_{T-U} : This variable represents the projection of T and can be explained as the responses of the management tool. It can be specific information, a help message, an error message, etc. This is also multi-dimensional and is considered in terms of the tool.

2.4 Dynamic View of the Model

Considering time and assume more than one receiver, the state of the receiver changes depending on when and whom the server is serving. The change of the state of the receiver causes its projection to change. The change in the projection again causes a mismatch in the interface. To put the mismatch into the perspective of the MSM, the state of the who manages component changes. We can think of two kinds of situations in which the individual user's projection area changes: ① different users are using the tool, and ② the same user is using the tool at different times. If the state of who manages changes,

the resulting projection to the interface screen changes correspondingly in size or location. If the tool's projection doesn't evolve as the user's projection area changes, the two projection areas may no longer be matched. Then we need another matching process: changing the state of the 'what is used to manage' component to match the changed projection of the 'who manages' component. Usually system designers do the change process, which limits the capability of the tool to respond to changes in the user's projection. If we transfer the role of the designer to the system, it will improve the system's capability to respond to the changes. Responsiveness, from a dynamic point of view, implies the system's automatic change in the system's projection P_{T-U}, by changing its state(T) to match the change in the user's projection(P_{U-T}) caused by the change in the user's state(U).

3. Responsiveness Process

In the previous section, I suggested that responsiveness, from the dynamic point view of the model, implies a process, which I call the responsiveness process. We can see responsiveness as a process. The responsive secretary listens, anticipates, and goes through some internal reasoning process, which the boss can't see. The only way the boss can see the process is through the result of the process matching in the interface.

The responsiveness process consists of four major iterative stages: observing, understanding, interpreting, and implementing. The first two stages are related to the receiver side of the interface screen shown in Figure 2 and the last two stages are related to the server side of the interface screen. In this section, I discuss each stage in more detail.

3.1 Observing

Responsiveness starts from observation. By becoming a better observer, the responsive secretary can draw conclusions that will enable him or her to anticipate certain actions [3]. The responsive secretary observes the boss and the surrounding environment. From the observation, the secretary gets data about the boss. Observation is gathering data about the receiver with all perception devices. The issue here is what to observe and how to observe. The secretary knows what is important to the boss and therefore knows what to observe about the boss. The secretary has observing devices such as eyes, ears, feeling, etc. and has observing management processes such as regular review of the boss' calendar.

In computer-based management tools, the primary way of observing is monitoring the user's interaction with the system. Monitored data can be used: in diagnosing and providing the user appropriate aid, in assessing user performance and user satisfaction, etc [21]. Other primitive forms of observing may be possible. For example, Starker & Bolt [28] use eye-tracking to monitor the user looking at a graphics screen in a gaze-responsive information display system. Computer vision and speech recognition will extend the meaning of observation in terms of both what to observe and how to observe in computer-based management tools.

3.2 Understanding

The second stage is understanding. Having observed data and prior knowledge about the receiver, the server reasons what the receiver really wants or needs. In this stage, the data about the user are transformed to information about the user. The responsive secretary reasons that the boss needs information showing the trend of recent sales after reviewing the incoming letters and remembering the boss preferred information about the matter in the letters. In computer-based management tools, user modeling effort fits this stage. In terms of the model in Figure 2, the ultimate goal of this stage is to figure out P_{U-T}. This implies a series of reasoning steps: from some variables in U to some other variables in U and then from those variables to P_{U-T}. For example, reasoning the goal of the user from the input of the user to the system and the context and then reasoning the needs of the user from the goal of the user and the characteristics of the user. Here all reasoning occurs in terms of the user(receiver).

3.3 Interpreting

The third stage is interpreting. The server reasons what they can do to satisfy the receiver's needs * the result of understanding. In this stage, a decision on what and how to respond is made based on information about the user. The responsive secretary determines to obtain a specific line chart showing the trend of recent sales. In computer-based management tools, this stage means the design of appropriate responses to the user's needs. In terms of the model in Figure 2, the goal of this stage is to change system variables to match P_{U-T}. Gargan et al [7] suggest an adaptable multi-modal response planner that dynamically designs the appropriate way to present information. Here all reasoning occurs in terms of the system (server).

3.4 Implementing

The fourth stage is implementing. The server provides the result of interpreting: a specific response. The responsive secretary prepares a line chart and attaches it to the letters. This stage implies capabilities of the server actually doing something, such as functionality and user interface capability. From the management perspective, if I say the first three stages correspond to information gathering and decision making, then this last stage corresponds to taking action. Without action, the decision is meaningless [5].

3.5 Cyclic Feature of Responsiveness Process

These four stages constitute the responsiveness process. After implementing the designed response, the server observes the receiver again to see the effects of its implementation. The responsiveness process is continuous and cyclic. This cyclic feature of responsiveness implies learning about the receiver. As the cycles go on, the server learns about the receiver and uses that knowledge in later reasonings. This learning aspect is vital for responsiveness.

4. Three Constructs of Responsiveness

The responsiveness process explained in the previous section requires certain capabilities of the server. I categorize these capabilities into three constructs of responsiveness in computer-based management tools as shown in Figure 2:

- ***Functionality*** : capability to provide what the user is trying to get or accomplish,
- ***User Interface Capability*** : capability to enable the user to interact well with the system, and
- ***Adaptivity*** : abilities to adapt itself or to be adapted to the user.

All three constructs, as a whole, define responsiveness of a system. However, this doesn't imply the software of a computer-based system can be split into disjoint parts according to the constructs. The three constructs simply define three different perspectives.

4.1 Functionality

When we deal with functionality, we are dealing with what can be done with a computer system in terms of the set of possible decision supports and the purposes for which the computer system is valuable for the user [11]. Functionality corresponds to functional skills of secretaries or nurses such as typing, filing, treating a patient, etc. For example, issues related to functionality include:

- What kind of information is available?
- What kind of statistical or mathematical packages (or functions) are supported?
- What kind of models are supported?
- How big is the memory?
- How fast is the processing?

Functionality is basic to be responsive. The responsive secretary is assumed to be able to do what they design to satisfy the boss' needs. In the early years of computers, the most important issue was functionality. Users were at the mercy of the system. But, as we have enough basic functionality because of the rapid development of computer technology, attention has shifted to the user. The user interface has become one of the hot issues for designing computer systems.

4.2 User Interface Capability

When we deal with user interface capability, we are dealing with how to make the user interact well with the system. Many people have suggested the importance of user interfaces. Powerful functionality by itself doesn't guarantee better performance of the user. User interface capability corresponds to communications or inter-personal skills of the responsive secretary or the responsive nurse. People have differentiated user interface from the application program. For example, issues related to user interface capability include:

- What kinds of input or output devices are available?
- What kinds of presentation formats are supported, such as graphics, charts, tables, etc.?
- What types of interaction are supported, such as commands, fill-in forms, menus, direct manipulation, windows, natural language processing, etc.?
- What kinds of metacommunication are supported, such as help messages, error messages, manuals, etc.?

The ability to understand and speak natural languages is included in user interface

capability. Many user interface techniques have been developed recently such as windows, pull-down menus, pointing devices, icons, etc. [25].

4.3 Adaptivity

Powerful functionality and user interface capability alone don't yet guarantee good performance of a system because users are different and evolve over time. Here comes the issue of adaptivity. Adaptivity corresponds to anticipation skills of the responsive secretary [3] and intellectual skills of the responsive nurse [18]. For example, issues related to adaptivity include:

- Can the user select one system mode among alternatives that fits him or her?
- Can the user customize the system ?
- Can the system adapt itself to the user ?

The adaptation perspective fits here. The main focus of adaptivity is to match the user. We can think of several levels of adaptivity:[2)]

- ***Custom-fit*** systems are designed to match the user and any change in the user impairs the match. Here the matching responsibility is up to the system designers.
- ***Flexible*** systems offer a series of fixed alternatives from which the user can choose. Here the matching responsibility is up to the system users.
- ***Adaptable*** systems adjust to the user when and as they are told. Here the matching responsibility is up to the system users.
- ***Adaptive*** systems adjust to the user without being told. Here the matching responsibility is up to the system itself. Adaptive systems
  - ▷ ***Self-adaptive*** systems adjust to the user without evaluating the expected outcome of the adjustment.
  - ▷ ***Self-regulating*** systems adjust to the user according to the evaluation of the expected outcome of the adjustment but without internalizing the learning.
  - ▷ ***Self-mediating*** systems adjust to the user with pre-evaluation of the various expected outcomes of their behavior.

Adaptivity is the key among the three constructs in this research and provides variables for the experiment evaluating a responsive system.

5. Conclusion and Implications for Manufacturing Information Systems

This paper presented the conceptual background of responsiveness in management tools. Based on the concept, Lee [14] built a prototype responsive system implementing the concept. This paper provides a way for a computer system to respond to needs varying among different users (individual difference) and evolving over time(evolution of the user). I expect responsive systems to provide more effective support to users and result in higher user satisfaction, higher user performance, and ultimately, higher success rates and more sharing of computer systems. To a limited degree, a laboratory experiment supports that

2) These terms are from Kurstedt [13] and Totterdell et al [28]. It is arguable that adaptivity includes the first three levels. The reason I put these in adaptivity is to focus on matching the user.

responsiveness in a computer system improves user performance and user satisfaction [14].

The concept of responsiveness could be readily applied to a manufacturing information system, which is to provide adequate, accurate and implicative information to its users - the managers, in such manufacturing phases as planning, control and evaluation. If the managers were all the same in terms of their preferences, the information system would not have to be responsive. But reality is far from this. Different managers have different preferences. If we have a responsive manufacturing informations system which responds adequately to different managers, we could expect greater success rate of the information system. However, considering the nature of manufacturing environment, we should be careful that there is a trade-off on the level of intelligence realized on the information system.

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