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# Effects of Representation Forms on Analysts' Identification of Systems Development Problems
## - An Empirical Study -

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Despite repeated exhortation about the importance of social and human dimensions of systems development, socio-organizational issues continue to be neglected and ignored in the current information systems practice. A review of the human information processing literature suggests that the reasons for this continuing lack of attention to social issues may be found in the limitations of human cognition and information processing capacities. Bostrom and Heinen (1978) and Kumar and Bjorn-Anderson (1990) also suggest that the inadequate attention to social problems and issues by the analyst could originate from the analysts limited problem perception. This research explores how the representation forms of information systems (IS) methodology used in understanding and modeling the problem situation affect such systems development problem perception.

Typically, a system development methodology prescribes the use of system models (i.e., system representations) to understand, analyze, evaluate, and design the information system. Given the size and complexity of information systems, and the abstraction and simplification underlying the modeling process, system representations usually depict only a limited set of aspects of the system. Thus, a methodology whose representations are limited to technical aspects will tend to limit the analyst's perspective to a technical one only (Kumar & Welke, 1990). Following the same line of argument, in contrast, it is the conjecture of this study that a methodology which specifies both social and technical aspects of IS development will help the analyst develop a more comprehensive view of the IS problem domain.

Based on the above concept, a theoretical model was first developed which explained the systems analysts cognitive process. Drawing on this model, a research model was developed hypothesizing the impacts of representation forms on problem identification. The model was tested using a laboratory experiment with 70 individual subjects. A special computer software was developed with a hypermedia authoring tool to conduct the experiments in order to avoid experimenter biases and to maintain consistency in administrating repeated experiments. The program, designed to replace the experimenter, consisted of functions such as presenting the subjects with problem material, asking the subjects questions, and saving the typed answers of the subjects.

The results indicate that representation forms strongly influence problem identification. It was found that the use of the socio-technical representation form led to the findings of more social problems than the use of technical representation form. The results imply significant effects of representation forms on problem findings and also suggest that the use of adequate representation forms may help overcome dysfunctional effects of our limited information processing capacity.

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# Ⅰ. Introduction

Ever since the introduction of the first business computer system in the early 1950s, information systems (IS) failures and their antecedent causes have continued to be reported in the literature [Alter & Ginzberg, 1978; Ewusi-Mensah & Przasnyski, 1991; Lucas, 1975, 1981; Lyytinen & Hirschheim, 1987; Poulymenakou & Holmes, 1996; Ropponen & Lyytinen, 1997]. Mowshowitz [1976] stated that many, if not most, information systems are failures in one sense or another. Gladden's survey in 1982 indicated that 75% of all systems development undertaken is either never completed or never used if completed.

As the reasons of such IS failures, a number of researchers suggest that lack of attention to socio-organizational issues may often be the cause of these IS disasters [Bostrom & Heinen, 1977; Hirschheim & Klein, 1989; Keen, 1981]. They suggest that these failures could be due to the adverse socio-organizational consequence of the IS because the introduction of an information system often causes changes in job descriptions, authority and power of the users, and quality of users' working life. Furthermore, many recent IS studies have identified the following social and behavioral issues as antecedents to IS failure: user resistance [Frantz & Robey, 1984; Markus, 1983], implementation problems [Lucas, 1975, 1981], lack of user involvement [Doll, 1985; Frantz & Robey, 1986; Ives & Olson, 1984], negative user attitudes and inadequate expectations [Ginzberg, 1981], and conflicts between diverse stakeholders [Markus, 1983].

In the current practice, overly technical, rational, and economic issues are still dominant, and they easily overwhelm the consideration of social, political, and behavioral issues [Hirschheim, 1985]. Critical behavioral impacts of the information systems on the organization and its users have often been overlooked during IS development. Thus, the major motivation of this research is the investigation for the reasons for this inadequate attention to social and organizational issues during the typical development process.

The lack of attention to critical socio-organizational problems seems to be promoted by the use of inadequate IS methodologies which lead one's attention to mainly technical problems while blinds out social aspects, particularly when considering that most systems developers currently use only technical methodologies or representation forms such as data flow diagrams (DFDs) or entity-relationship (E-R) diagrams. Thus, the purpose of this research is to examine how the additional use of a social representation form with a technical one influences the analysts' attention to social problems, compared to the use of a technical representation form only. Specifically, this research investigates the relationship between the types of representation forms and the types of problems identified by the analyst who used the specific representation forms during the systems development process.

The remainder of the article is organized as follows. The next section presents a review of the literature which provides a conceptual basis to this study. Based on the conceptual theory, a research model and the hypotheses are established, and problem identification are operationalized. Next, the experiment processes are outlined, and the results of statistical analysis and the implications of these results are described.

# Ⅱ. Conceptual Backgrounds

## 2.1 Representation Forms of IS Methodologies

The methodology is defined a "recommended series of steps and procedures to be followed in the course of developing an information system" [Avison & Fitzgerald, 1988, p. 262]. However, beyond directing the steps and procedures of IS development processes, an information systems methodology also guides the analyst's philosophy of IS development and his view of the organization, its members, and the functions of the IS within the organization [Checkland, 1981]. Thus, an IS development methodology employed by an individual analyst in systems development can influence an analyst's view of social and technical issues [Kumar & Bjorn-Anderson, 1990; Lyytinen, 1987; Welke, 1980]. A system development methodology focuses the analyst's attention on specific aspects of the system to be modeled. Because focused information search will more lead to mental model maintenance in which new information fits into the existing mental models and confirms them, rather than lead to a new mental model building (means to develop a new mental model besides the existing ones) in which mental models themselves are changed to accommodate new information [Vandenbosch & Higgins, 1996], the use (drawing) of a particular representation form will greatly affect the system analysts information finding or acquisition results. Furthermore, by focusing on these aspects, the methodology implicitly takes away attention from other aspects.

Typically, a system development methodology prescribes the use of system models (i.e., system representations) to understand, analyze, evaluate, and design the information system. Given the size and complexity of information systems, and the abstraction and simplification underlying the modeling process, system representations usually depict only a limited set of aspects of the system. Thus, a methodology whose representations are limited to technical aspects will tend to limit the analyst's perspective to technical ones only [Kumar & Welke, 1990]. Following the same line of argument, it is our conjecture that a methodology which specifies both social and technical aspects of IS development will help the analyst develop a more comprehensive view of the IS problem domain. This argument is further supported by Burns and Vicente [1996] who found that perceived relevance and perceived importance of the information being sought govern information search behavior.

In this regard, the purpose of this research is to examine how different types of system representation forms influence the way IS development inquiry is conducted. Two types of representation forms which have different IS problem aspects are identified and will be compared: technical and socio-technical. The first representation form models technical aspects of the system, while the second representation form consists of both a technical and a social representation and explicitly represents technical as well as socio/organizational issues and problems.

## 2.2 Conceptual Underpinnings: Representation Forms and Cognitive Biases

The concept of judgmental biases, developed by Hogarth [1980], suggests that representation forms that analysts currently use may affect problem identification. He developed a conceptual model of human judgment that is based upon problem-solving phases similar to those in Simon's [1960] model of decision making. The model includes three phases: information acquisition, information processing, and output. The information acquisition phase is similar to the Simons intelligence phase, information processing corresponds to design, and the output phase coincides with the choice stage. This concept suggests that analysts' information acquisition can be hindered or facilitated depending on the salience of the problems in the representation.

First, representation forms may facilitate problem identification. Hogarth [1980] suggests that if particular cues explicitly exist in the representation form, then problems associated with these cues will be more easily identified. When the systems analyst is given a "complete" representation where relevant problem aspects are clearly shown, he or she is more likely to recognize and identify such problem aspects since the representation explicitly indicates their existence.

On the other hand, representation forms may hinder ones problem identification. Representations which fail to represent all the relevant problems are called "incomplete" representations [Smith, 1989]. Smith [1989] found that such incomplete representations could rather hinder problem identification. Several empirical studies in cognitive psychology suggest that problem aspects that are excluded in the representation are no longer salient and therefore are not considered in the subsequent cognitive processes [Fischhoff, Slovic, & Lichtenstein, 1978; Smith, 1989; Taylor & Fiske, 1978]. To better explain the effect of representation forms on the humans information acquisition process, we present related biases as follows. The biases related to the representation form are availability bias and data representation bias. Data representation bias is further classified into data type and logical data display biases.

### 2.2.1 Availability Bias

Hogarth's availability bias, defined as the "chance availability of particular cues in the immediate environment" [Hogarth, 1980; p.166] can be related to problem identification. This bias suggests that representations used in IS development may both facilitate and hinder problem identification.

In the information systems development process, it can be inferred from this bias that the simple presence of a representation may greatly facilitate the analyst's perception of socio-organizational problems if the representation directly describes socio-behavioral relations and thereby provides clues and cues. On the other hand, the lack of such hints in the presentation may result in the analyst failing to perceive or identify the problems since they are not available nor salient in the present representation. Data presentation bias explains such a limited role of representation forms.

### 2.2.2 Data Presentation Bias

Two types of data presentation biases can

<Table 1> Biases in the Information Acquisition Phase (Hogarth, 1980; pp. 166-167)

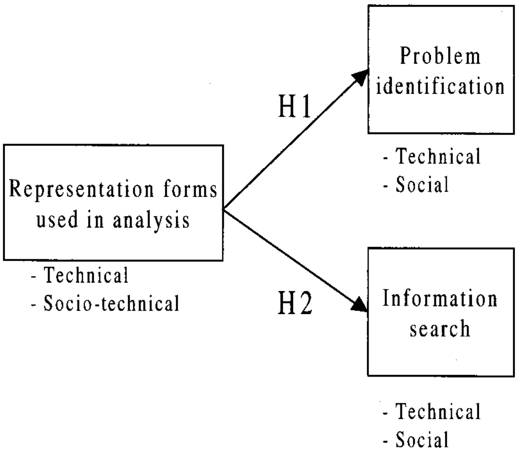
| Bias | Description | Example |
|---|---|---|
| Availability | • Chance 'availability' of particular 'cues' in the immediate environment affects judgment. | • Problem solving can be hindered/facilitated by cues perceived by chance in a particular setting (hints set up cognitive 'direction'). |
| Data presentation | • Logical data displays.<br>• Mixture of types of information, e.g., qualitative and quantitative. | • Apparently complete 'logical' data displays can blind people to critical omissions.<br>• Concentration on quantitative data, exclusion of qualitative, or vice-versa. |

also influence information gathering and problem identification. "Logical data display" bias can be a source of problem finding and identification failures caused by the representation forms. In a given representation, when the sources of problems are displayed in a way that they seem logical and complete although they actually are not, people are less likely to identify the problem aspects absent in the given representation, even though the missing problems may be very important. For example, the structured requirement specification document [DeMarco, 1979] provides seemingly complete representations as far as the technical problems of IS development are concerned. Since the DFD logically seems to represent IS development problems in a complete manner, people may tend to ignore other kinds of problems such as organizational issues while working with the structured analysis document.

The second one is "data type" bias. When both qualitative and quantitative information are mixed together, people may pay more attention to quantitative information than to qualitative information. Concentration on quantitative information can cause exclusion or disregard of qualitative information, or vice versa. Therefore, if the analyst concentrates on the quantitative aspects of IS development (e.g., technical aspects such as functional efficiency and consistency), he or she may not pay attention to qualitative aspects of IS development such as ,social or organizational aspects. <Table 1> summarizes these two types of biases described above.

## Ⅲ. Research Model and Hypotheses

The research model shown in <Figure 1> first suggests that problem identification can be influenced by the representation forms used by the analysts in understanding and describing the problem situation. Many decision theorists indicate the effect of representation forms on the problem solving process [Hogarth, 1980; Smith, 1989]. Representation forms influence the process of identifying problems because cognitive processes can be largely directed by "what we currently see." In accordance with his comprehensive explanation of judgmental biases, Hogarth [1980] suggested that the representation forms could both hinder and facilitate



<Figure 1> The Research Model

problem identification depending on their characteristics. Thus, we establish the following hypothesis relating to problem identification.

H1 : The use of a socio-technical representation form may lead to greater identification of social problems than the use of a technical representation form.

In addition, representation forms used by the analyst may guide his or her further information search. Additional information is usually sought in order to confirm the initially held views or opinions by the analyst. This search for additional information may also be influenced by the adopted representation forms. The representation form may influence his or her search for additional information by guiding further information investigation. In this regard, the following hypothesis is suggested.

H2 : The use of a socio-technical representation form may lead to greater search for social problems than the use of a technical representation form.

# Ⅳ. Research Design and Experimental Procedures

## 4.1 Development of the Experimental Tools

### 4.1.1 Experimental Case

An experimental case was developed which illustrated how a sales management information system (SMIS) was implemented in a wholesale company of chemical products. The Chemical U.S.A. case was designed to include both technical and social issues arising during the implementation of a computer-based information system.

Careful attention was devoted to the development of the case because the case was the key in describing the problem situation. First, the industry and the type of the application were selected based on the criterion that the case should be easy for subjects in the experi- ment to understand. The SMIS in the wholesale company met this criterion because the sales function is easily understood by most students who roled as subjects in this study.

Second, it was desirable that an equal number of technical and social problems be included in the case. An unbalanced case with a fewer problems in one problem aspect but a preponderance of issues in other problem aspect may not be adequate to test problem identification. If the case had a large number of salient social problems, but had only a few or trivial technical problems, then all subjects, irrespective of representation forms used, would mainly identify social problems.

In order to avoid this problem, after the initial development of the case was completed, the characteristics of problems in the case were discussed with two experts in the MIS field, and the case was rewritten based on this discussion. The next validation of the case and its problem aspects was performed by six senior MIS and computer science undergraduate students at a major state university in the U.S.A. They were asked to identify all the critical problems in the case and to classify each individual problem as either technical or social. They were also asked to rate critical nature of each problem using a five-point Likert scale. The result of these pre-tests with early versions of the case indicated that social problems were less identifiable and were rated less critical while most technical problems were easily identified and were rated more salient. As a result, less salient social problems were modified and additional problems with social aspects were added to develop a balanced case situation. After this modification, two MIS experts met again to discuss the balance in the problem aspects and suggested a few more changes. After these changes, they evaluated the final version of the case as reasonably balanced in both technical and social aspects. The final version of the SMIS case used in the experiment is attached in Appendix A.

#### 4.1.2 Information Module Set (Additional information)

In the experiment, once the subjects had reviewed the case materials, drew the required representation forms, and identified the initial set of problems, they were presented a set of modules as additional information. The subjects could see at first titles of the fourteen information modules only. They could read contents if they selected a particular information module to read. The total number of modules they could select was five. The subjects were allowed to select five modules only which they were interested in to clarify further the problem situation of the SMIS case. The subjects were asked to select most interesting or useful modules one by one from this module set and then they read the detailed contents.

To provide additional information, fourteen information modules which further described the SMIS problems were prepared. These modules provided information for the search for additional information. A caution was also made in the design and validation of these information modules. The title of each module should adequately expressed the contents of the module because the subjects selected the module by examining only its title. Each of these modules expanded upon the individual problems described in the experimental case. There were prepared seven technical and seven social modules respectively.

#### 4.1.3 Software Used in the Experiment

If the nature of the experiment requires the experimenter to have frequent interactions with the subjects during the experiment, the experimenter's effect [Barber, 1976; Rosenthal, 1966] might impose a serious threat to the construct validity of the research. This effect suggests that the experimenter by his very presence could influence the responses of the subject. In order to avoid these biases, and to develop consistency in administrating repeated experiments, a special hypertext software was developed to replace the researcher in conducting the experiment. The software was designed to drive the experiment to the end, thus making interactions between the experimenter and the subjects unnecessary. It consisted of such functions as showing the subjects how to draw the representation forms, to ask the subjects questions, and to save the typed answers of the subjects. All the subjects' actions, including typed answers, tasks completed, and task completion time were recorded by the software.

A popular educational authoring tool was used to develop this experiment driving software. After developing the initial version of the software, it was tested a number of times to ensure that it would work as expected. First, an MIS expert intensively reviewed the software. He revised instructions which were not clear and suggested critical improvements. Next, usability-laboratory testing was conducted with an MIS doctoral student. He was asked to keep notes about any ambiguous instructions, inadequate animation, and terminology that was not understandable, and to record any difficulties he experienced during the test. Based on the test results, the software was modified again to remove the problems identified.

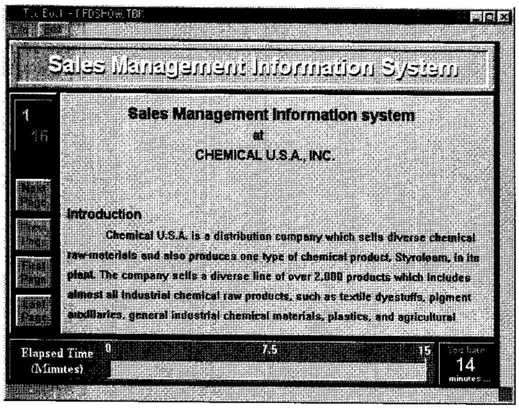
The subjects completed the experiment only by interacting with this software. The subjects received instructions from the software and followed those instructions to complete the experiment. During the course of the experiment, the subjects had no interaction with the experimenter.

## 4.2 Experimental Procedures

The experimental software provided subjects necessary instructions and the subjects followed those instructions to complete the experiment. As the first step in the experiment, the program provided the subjects with the SMIS case. The case information was presented in a sequence of 16 computer screens. Subjects were asked to take notes while they read the case because they would not be allowed to go back and review the case when they performed tasks associated with the case. After the subjects read the case, they were asked to draw a DFD representation, or both a DFD and a rich picture of the system. Next, the subjects were informed that the implementation of SMIS in Chemical U.S.A. was having difficulties. The subjects were asked to assume the role of a systems consultant and to identify and to rank-order the five most critical problems. Next, they were asked to select the five interesting additional information, which seemed relevant or useful in further exploring or confirming their previously identifying problems, from the fourteen information modules. Upon the completion of the experiment, the subjects were debriefed about the true purpose of the experiment.

### 4.2.1 Case Reading

As the first step in the experiment, the software provided the subject with the SMIS case to read. This case was designed to embody an ill-structured IS implementation situation. As described earlier, it was designed to include both technical and social issues during the development and implementation of a sales management information system. The case information was presented in a sequence of sixteen computer screens. Subjects were asked to take notes while they read the case because they would not be allowed to go back and review




<Figure 2> The First Screen of the SMIS Case

the case when they performed tasks associated with the case.

Comprehension tests using several MIS undergraduate students indicated that most students could find all the problems described in the case when they were allowed to spend as long as they wanted in reading the case. Therefore, a 15 minute time limit was imposed by the software to complete reading the case. This time limit was established through pre-tests by identifying the time needed by most subjects in reading the case. The time pressure would presumably have the subjects focus on the problem aspects they perceived to be most important while ignoring or filtering out details considered less important (Cantor & Mischell, 1977; Walsh 1988). Finally, the use of a time limit also increased the realism of the situation as systems analysts usually have limited time and a deadline for collecting requirements information in the real world. <Figure 2> shows the first computer screen of the case from which the subject read the SMIS case situation. The screen was provided by the experimental software developed specially for this experiment.

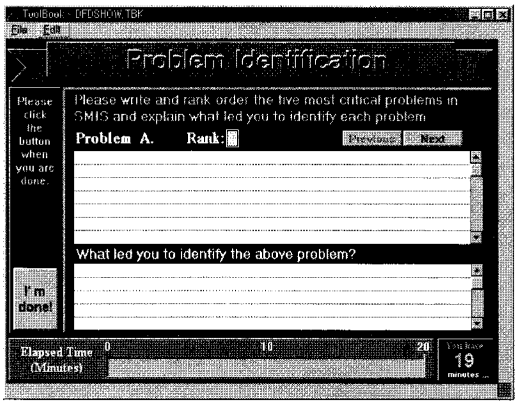
After the subjects read the case, they performed the next three tasks in the following sequence:

### 4.2.2 Drawing the Representation Form

First, the subjects were asked to draw the required system representation forms. This task acted as the treatment for the representation form variable (the independent variable). The treatment group employing a technical representation form only was asked to draw a data flow diagram. The socio-technical representation form treatment group was asked to draw both a DFD and a rich picture. The drawing sequence for the DFD and the rich picture in the socio-technical group was randomly assigned by the software. Fifteen and thirty minute time limits were imposed on the completion of technical and sociotechnical representation forms respectively to prevent anyone from spending too much time on this task.

### 4.2.3 Problem Identification

Next, the subject was informed that the implementation of SMIS in Chemical U.S.A. was having difficulties. The subject was asked




<Figure 3> The Answer Screen for Problem Identification of the Experiment

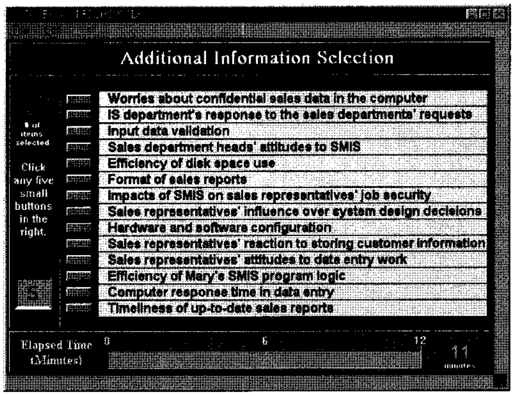
to assume the role of an invited systems consultant from a big accounting firm, and to identify and rank-order the five most critical problems from the case. The subjects were also asked to explain their rationale for each problem in an open-ended form. They typed their answers to the answer screen shown in <Figure 3> which was provided by the experimental software.

#### 4.2.4 Search for Additional Information (additionally obtained information by selecting information modules)

Once the subjects had completed the required representation forms, they could collect additional information from a set of 14 information modules. Each information module was developed and written to expand upon each of the problems in the Chemical U.S.A. case. Seven modules were developed from the technical problems in the case, and the other seven modules were developed from the social problems described in the case. The average length of each module was 2.5 screen lengths.

The procedure by which each subject selected the modules was as follows. First, titles of the fourteen information modules were presented to the subjects as illustrated in <Figure 4>. The sequence of presentation of the titles was randomized by the software for each subject. The subjects could select each module by clicking on its title.

Use of the information modules simulated the requirements acquisition process in the real systems development situation where the systems analysts had interviews with users in order to pursue or confirm their initial hypotheses and inference of the development project.




<Figure 4> Titles of the Information Modules

Therefore, selection of a specific information module was expected to be affected by the subjects' initial appraisals of the situation. The additional information obtained through the module selection was supposed to influence their problem refinement.

The number of modules a subject could select was limited to five. This restriction was given to simulate the real world situation where the systems analyst usually has a limited time and budget for requirements acquisition.

### 4.3 Research Variables

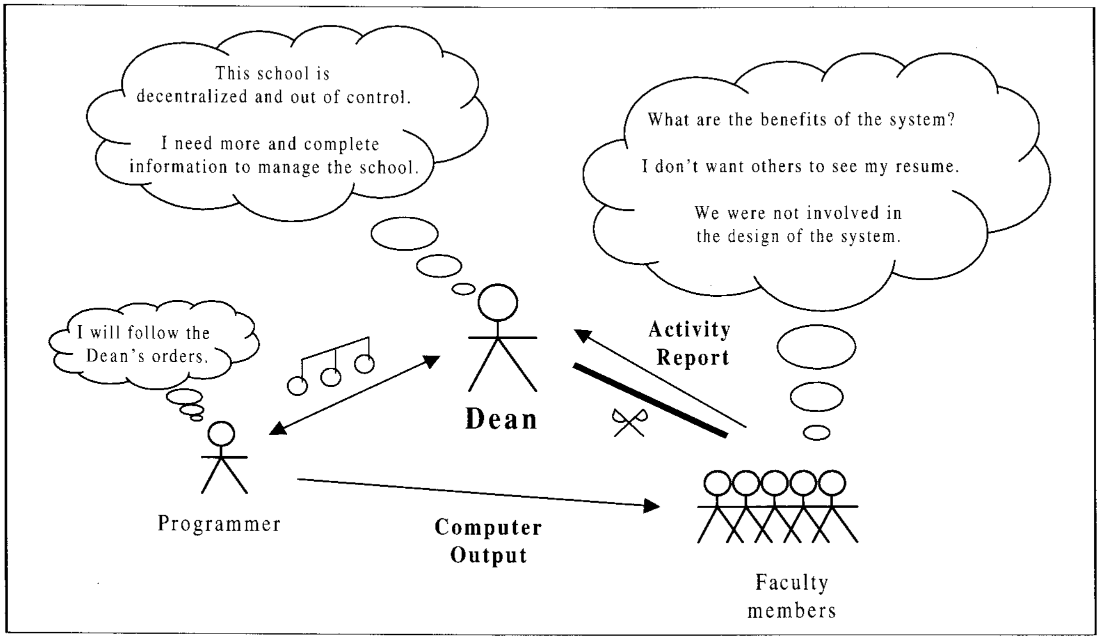
#### 4.3.1 Independent Variable: Representation Forms

The two representation forms used in this study are technical and socio-technical representation forms. The technical representation forms are used to describe data and processing problems in IS development such as data flows, processes, activities, entities, and attributes. Their main purpose is to provide tools and methods for developing technically valid systems. DFDs, data dictionaries, E-R diagrams, and petri-nets are typical examples of technical representation forms. In this research, DFDs, which are a part of the structured analysis and structured design (SA/SD) methodology, were used as technical representation form. The choice of DFDs was influenced by the wide use of DFDs in professional practice. The subjects assigned to technical representation form were asked to draw DFDs after they read the Chemical U.S.A. case.

The socio-technical representation, on the other hand, consist of both technical and social representations. They are a deliberate combination of technical and social representations and are used together to describe both technical and social aspects. The subjects who were selected as socio-technical representation were asked to draw both a DFD and a rich picture when they completed to read the Chemical U.S.A. case.

An example of social representations is the "rich picture" devised by Checkland [1981]. Starting from the systems thinking, he thought that the fuzzy, ill-structured or soft problem situations are common in organizations. According to him, in many situations, this fuzzy situation originate due to the human activity system which are unpredictable and complex. He argues that it is relatively easy to model data and processes, but hard to model the human activity system where people may have different and conflicting objectives, perceptions and attitudes. Rich pictures help the systems analyst model and find out problems and their origins of the fuzzy human activity system.

An example of a rich picture is shown in <Figure 5>. This rich picture describes a situation where the in-house development of a faculty activity system(FAS) has eventually failed due to the conflicts between the faculty members and the dean of a major business




<Figure 5> A Rich Picture describing the FAS Development Situation

school in the U.S.A. [Davis, et al., 1992]. It also shows diverse stakeholders of the faculty activity system (the dean, faculty members and the programmer) and their relationships each other. Although the faculty members indicated several technical problems of the system such as data inaccuracy, the real reasons that they refused the system were that they did not want others to see their resumes and they thought that the dean would more control them through the use of the system.

The rich picture represents the behavioral, organizational, and political aspects of the system development situation [Avision & Fitzgerald, 1988]. The picture shows both subjective and objective perceptions of the problem situation in diagrammatic and pictorial form thereby people involved and their relations are shown. Elements of this rich picture will include the clients of the system, the people taking part in, the task being performed, the environment, and the owner of the system. Through the use of a pictorial form, a rich picture shows the people involved, problem areas, power and authority relationships, etc. The perceived relative importance of people and things by the systems analyst is reflected by the size of the symbols. The think bubble represent the concern or worriers of the major characters. Arrows indicates the relationship between people. Cross-swords reflect conflict while musical notes represent harmony [Wood-Harper, Antill, & Avison, 1985]. It also represents social and organizational issues such as conflicts between organizational actors and functions, the absence of communication lines, and sources of conflicts and harmony.

A set of DFDs and rich pictures together is an example of socio-technical representations (i.e., the subject in the socio-technical representation form level was asked to draw both DFDs and rich pictures together) and is adopted as the socio-technical representation form in this study.

### 4.3.2 Dependent Variables

#### (1) Problem Identification

In previous research, problem identification was usually measured as the number of problems identified corresponding to the respective problem aspect [Dearborn & Simon, 1958; Walsh, 1988]. The simple counts of, for instance, marketing, accounting, and financial problems were employed as the dependent variable to represent problem identification. However, problem identification is usually accompanied by the importance of the respective problems identified. Because all the problems are not likely to be of the same level of importance, the use of a simple count for each problem aspect may not be adequate to represent an individual's problem identification. Thus, in addition to the number of problems identified, the importance attached to each problem identified should also be considered in defining problem identification.

Problem identification is thus defined as "the perceived importance of problems identified." For instance, if the systems analyst finds a large number of social problems and recognizes them as important, then we can conclude that his or her identification score on the social problem aspect is high.

The subject was asked to identify and rank order the five most important problems he or she perceived in the problem situation. The perceived importance of the problem was derived from its rank (1 through 5) assigned by the subject.

The rank for each problem was assigned by the subject as the perceived importance. Because the subject was asked to identify only five problems, the ranks ranged from the first most important to the fifth most important. Both the count of the types of problem aspects (social or technical) and their ranks were considered in calculating the problem identification score. To consider the rank-orders of the problems identified, a weight was assigned to each problem based on its rank. The weight 5 was assigned to the most important problem and 4 was given to the second most important problem, and so on. The least important problem was given the weight of one. The problem identification score for each problem aspect was obtained by summing up these importance weights for that problem aspect. Thus, the problem identification score for the technical problem aspect was decided by summing up the importance weights for technical problems, and the problem identification score for the social problem aspect was obtained by adding up the importance weights of social problems identified. Thus, both technical and social problem identification scores could range from zero to 15. If the analysts identified all the technical problems, for instance, the problem identification score for the technical problem aspect was 15. On the other hand, if they identified all the social problems, the problem identification score for the technical problem aspect would be zero while the score for the social problem aspect was 15. Using the two technical and social scores, we developed the problem identification score to assess the problem identification as a single measure. The problem identification score was obtained by subtracting the technical problem identification score from the social problem identification score. This score could range from -15 to 15. A positive score indicated that the analysts identified more social problems than technical problems.

#### (2) Search for Additional Information

In addition to the experimental case, the subject was allowed to collect additional information from a set of information modules. As suggested by Smith [1989], the additional information search using information modules was supposed to refine the initial appraisal of the problem situation, and influence the final problem assessment.

We operationalized the "search for additional information" as the number of the modules selected for the particular problem aspect, either technical or social. A set of fourteen information modules was used to provide the subjects with further additional information about the SMIS development and implementation situation which was initially described in the experimental case. Each information module consisted of two parts: a title and the detailed description. The fourteen titles were shown first. The subjects selected five modules after they examined these titles. Each time they selected a specific module, then they were provided with the detailed description of the module. The fourteen modules were designed to consist of seven technical modules and seven social modules. The subject was asked to select only the five modules which he or she considered the most relevant in assessing the case.

The score for the variable search for additional information was calculated by using the following method. The score was decided by subtracting the number of the technical modules from the number of the social modules selected. Thus, the score could range from -5 to 5. If the subject selected all the social modules, the score was five and if the subject selected all technical modules, the score was -5. A positive score indicated that the subject selected more social modules than technical modules, while a negative score implied that the subject selected more technical modules than social modules.

## V. Experimental Results

This section summarizes the statistics and test results obtained in the experiments. Tests for the hypotheses require one-tailed tests of differences between the averages (means) of the outcome variables of two populations.

### 5.1 Subjects

Seventy subjects participated as volunteers in the experiment. The subjects were all undergraduate students of the major universities in the U.S.A. who were taking systems development related courses. <Table 1> summarizes the demographic profiles of participants collected from the experiment.

Forty-six of the participants were male and twenty-four were female students. The average age was 23 and they had 1.3 average years of work experience. It is important to note that the subjects in the current study were required to have certain qualifications. First, they should have sufficient knowledge about the system development process to understand the situation proposed in the experiment. Second, their knowledge or experience about the representation forms should be similar because variations of the knowledge may hamper the true effects of representation forms.

### 5.2 Hypothesis 1: Effects of the Representation Forms on Problem Identification

Two representation forms whose effects were examined in this research are purely technical and socio-technical representation forms. It was hypothesized that, in general, the use of a socio-technical representation form would result in the identification of more social problems than the use of a purely technical representation form.

The averages and standard deviations of the initial problem identification between the analysts with a purely technical and with a socio-technical representation form are presented in <Table 2>. The analyst with a purely technical representation form scored -3.40 while the analyst with a socio-technical representation form scored

<Table 1> Profiles of Subjects

| Category | | Number | Percent |
|---|---|---|---|
| Sex | *Male* | 46 | 66% |
| | *Female* | 24 | 34% |
| Age | Mean : 23 | | |
| Work experience | Mean : 1.3 years | | |

<Table 2> Means and Standard Deviations of Problem Identification(Technical versus socio-technical representation forms)

| Representation forms | N | Mean | Standard deviation | Minimum score | Maximum score |
|---|---|---|---|---|---|
| Technical | 35 | -3.40 | 6.95 | -15 | 15 |
| Socio-technical | 35 | 5.94 | 7.02 | -9 | 15 |

<Table 3> Mann-Whitney U-test Results on Problem Identification(Technical versus socio-technical representation forms)

| Representation Forms | Number of observations | Sum of scores | Mean scores |
|---|---|---|---|
| Technical | 35 | 843.0 | 24.09 |
| Socio-technical | 35 | 1642.0 | 46.91 |
| | Z score | 4.6999 | |
| | PROB > Z | < 0.0001* | |

* Indicates a significance at the 1% significance level

5.94 in the problem identification. This large mean difference indicates that the two groups may not be equal in the identification of problems .

The result of a statistical test is summarized in <Table 3>. A non-parametric Mann-Whitney U-test was used to test mean differences of the initial problem identification between the purely technical and socio-technical representation form groups because the two groups of the analysts were compared and the initial problem identification outcomes in the two representation form treatments were found to be not normally distributed. If the values of the dependent variables for the two populations were found to be normally distributed, a one-tail t-test should have been used to test the differences between the two populations. Otherwise, a non-parametric Mann-Whitney U-test was used to test the differences when the outcome variables were found not to be normally disibuted. When the sample size is large, Z score is used as the test statistic in the Mann-Whitney U-test because the sampling distribution of the U-statistic becomes approximately normal with a large sample size. The Z score is 4.6999 and the p-value is less than 0.0001. This small p-value less than 0.0001 indicates that the analysts with a sociotechnical representation form identified more social problems than the analysts with a purely technical representation form. Therefore, hypothesis 1 is strongly supported by the results.

## 5.3 Hypothesis 2: Effects of the Representation Forms on Search for Additional Information

It was hypothesized that the use of a socio-technical representation form (i.e., when the systems analyst drew both a technical representation form(DFD) and a social representation form(rich picture) would result in the examination of more social problems than the use of a purely technical representation form (i.e., when the systems analyst drew only a purely technical representation form such as DFDs). <Table 4> shows the means and standard deviations for the variable search for additional information for both types of representation forms used. The analyst with a purely technical representation form scored -0.09 while the analyst with a socio-technical representation form scored 0.37 in the search for additional information. Therefore, the analyst with a socio-technical representation form scored 0.46 higher than the analysts with a technical representation form. This result indicates that although the systems analyst who used a socio-technical representation was more interested in social problems than the analyst who used a technical representation form, the difference between two groups was trivial. This difference was examined using a Mann-Whitney U-test and the test result is summarized in <Table 5>.

The Z score 0.7867 provides a p-value 0.2157. This result implies that the difference between the use of technical and socio-technical representation forms in search for additional information was not significant. Thus, hypothesis 2 is not supported from the experimental data.

## Ⅵ. Discussion and Conclusions

The results reported indicate that the representation forms used by the analyst had a very strong influence on the types of problems identified. They show that the scores for problem identification are determined largely by the representation forms drawn by the analyst. The analyst using a socio-technical representation form identified significantly more social problems than the analyst who used only a technical representation form. Thus, clear evidence was found for the hypothesis that the use of a socio-technical representation form results in the identification of a greater number of social problems than the use of a technical representation form.

When the results are examined in detail, two additional observations become evident. First, the analyst using a socio-technical representation forms not only identified more social problems than the analyst using only a technical representation form within his own analysis

<Table 4> Means and Standard Deviations of Search for Additional Information(Technical versus socio-technical representation forms)

| Representation forms | Mean | Standard deviation | Minimum score | Minimum score |
|---|---|---|---|---|
| Technical | -0.09 | 2.29 | -3 | 5 |
| Socio-technical | 0.37 | 2.41 | -3 | 5 |

<Table 5> Mann-Whitney Test Results on Search for Additional Information(Technical versus socio-technical representation forms)

| Representation Number of forms | Sum of scores | Mean scores | |
|---|---|---|---|
| Technical | 35 | 1177.0 | 33.63 |
| Socio-technical | 35 | 1308.0 | 37.37 |
| | Z score | 0.7867 | |
| | PROB > Z | 0.2157 | |

work, but also he identified more social problems than technical problems. For example, during the problem identification, the analyst using a socio-technical representation form had problem identification score of 10.4 for social problems while he scored only 4.5 for technical problems. This result is remarkable in light of the fact that great care was taken in the experimental set-up to include an equal number of technical and social problems. These problems also were rated as having similar salience and importance by the panel of experts. Moreover, the socio-technical representation form used by the analyst consisted of both technical representations (DFDs) and social representations (rich pictures). Thus, it was expected that these analysts would identify an equal number of social and technical problems, but this expectation was not confirmed by the data.

However, a closer examination of the two representation forms provided a possible explanation for the phenomenon. As compared to DFDs, rich pictures seem to have a more explicit orientation towards problems and issues encountered in the task environment. Thus, they are more likely to make problems salient thereby increasing problem awareness and recognition. DFDs, on the other hand, provide a problem neutral representation and require that the analyst by himself apply diagnostics to unearth problems. Thus, the problem-orientation nature of the rich picture representation form could have resulted in identification of a greater number of social problems.

Additionally, the novelty of learning and using social representations such as rich picture may have made social problems more salient for the analyst. In any case, this result makes a strong case for the using "richer" problem-oriented social representation forms such as rich picture, especially in the early stage of analysis where the identification of a relatively complete set of problems may be critical for the success of the development project.

The second observation deals with dysfunctional effects of using a technical representation form only. The analyst using a technical representation form largely ignored social problems. It almost seems as if a technical representation, by focusing the analysts attention on to the limited set of technical aspects and problems, crowd out the awareness of social issues. This phenomenon is consistent with the previously reported dysfunctional effects of "incomplete problem representations" on problem identification behavior [Smith, 1989]. Studies in decision making [Fischhoff et al., 1978; Hogarth, 1980; Smith, 1989; Taylor & Fiske, 1978] report that when decision makers use incomplete representations, problem elements not included in the representation lack salience, are under attended, and are consequently dropped from consideration. As information systems are considered to be socio-technical artifacts, which have both social and technical aspects, a technical representation of the system will be an incomplete representation with corresponding disadvantages.

Most of the currently popular information systems development methodologies (e.g., structured analysis and design, Information Engineering, object-oriented analysis and design, Method/I, SSADM, etc.) do not include any social representations of the system being analyzed. Thus, there is a real danger that the analysts who are required to use these methodologies will tend to ignore social issues and problems during systems analysis. Moreover, as generations of systems analysts are trained in and repeatedly use these "incomplete" methodologies, they will tend to learn information search and problem identification behaviors which focus primarily on technical problems.

In this study it was shown that the types of representation forms did not have any significant effect on the type of additional information searched for by the analyst. The analyst who used a socio-technical representation form did select more additional social information in his search for additional information than the analyst who used a technical representation form. However, the difference was not statistically significant. The result, however, exhibits an interesting anomaly. Although statistically not significant, because the result is not consistent with the expectation about the influence of representation forms. An examination of the post-interview and debriefing notes for these subjects provided some explanation of this behavior. It appeared that these individuals who used the technical representation felt that they already understood most of the important technical issues in the case and given the opportunity to search for additional information, wanted to explore some other interesting issues, i.e., social problems and issues. Given that these results were statistically not significant, further research is needed, in the real field in particular, to either confirm this phenomenon or to explain it away as an anomaly.

## Appendix A : CHEMICAL U.S.A., INC. CASE

### (1) Introduction

Chemical U.S.A. is a distribution company which sells diverse chemical raw-materials and also produces one type of chemical product, Styrofoam, in its plant. The company sells a diverse line of over 2,000 products which includes almost all industrial chemical raw products, such as textile dyestuffs, pigment auxiliaries, general industrial chemical materials, plastics, and agricultural chemicals. The company has exclusive dealerships for two leading international chemical companies, IChem in the U.S., and Rendolf in Germany. These two companies supply most of Chemical U.S.A.'s products.

The company has 34 sales persons in the Sales Division and over 50 employees in the Styrofoam plant. The Sales Division is located in the downtown section of a large Southwestern city, while the plant is in the suburbs.

### (2) Organization of the Company

The company has three independent operating divisions: the Finance/Management division, the Marketing division, and the Styrofoam Plant. The Finance/Management division includes the departments of Finance, Personnel, General Management, and Management Information Systems (MIS). The Marketing division consists of five departments: Textile, Pigment Auxiliaries, General Chemicals, Plastics, and Agricultural Chemicals. The Styrofoam Plant division oversees the production of Styrofoam in its plant.

The sales departments have been organized by product groups. For instance, the Textile department sells textile-related chemicals such as dyestuffs. Since the products each department sells are usually separate from each other, the business of each department is independent from the other departments; thus, the customers are rarely shared by different departments.

Department heads in each department have broad authority and considerable latitude over the sales made by their departments. As a result, many decisions are usually made without obtaining approval from top executives. Chemical U.S.A. is run on an informal basis. Everyone is called by his or her first name, and there are few internal memos, letters, or other formal documents. Very little is written down in terms of policies and procedures. Most of the business is conducted orally in discussions between the sales department head and the responsible sales representative.

Customers of Chemical U.S.A. are usually chemical plants which produce chemical end products using raw materials purchased from Chemical U.S.A. or other suppliers. In each department, every sales person has his or her own customers. Because these customers are not usually shared among sales representatives, except for a few of the very large companies, information about these customers which might be useful to sales activities are not usually kept by the assigned sales representatives only.

### (3) Chemical U.S.A.'s Business

Sales representatives at Chemical U.S.A. are required to have a wide knowledge about the company's products and the relevant chemical processes. Thus, all sales persons have degrees in areas such as textile or chemical engineering. Most sales items are used to produce chemical end products at the customer's plant. If problems with these products occur, sales persons visit the customer's plant to solve them. Thus, long-term know-how and experience at and knowledge about the customer's plant sites are essential for good sales. Because this technical expertise and information are very valuable to individual sales representatives, they usually do not share such information with other sales representatives.

#### (4) Sales Management Information System (SMIS)

In June 1992, the sales director, who had worked for 30 years at Chemical U.S.A., retired. After a two month search, a new sales director joined the company. The new director, Mr. Jones, had more than 20 years sales experience in the chemical industry and had previously been employed by a major U.S. chemical company.

In early 1993, Mr. Jones suggested that the company develop a new computer system to support sales activities: a sales management information system (SMIS). This system was designed to track sales activities by providing periodic sales reports, sales analysis reports, and specific information about the customers and competitor companies. This new computer-based information system also provides top management with specific and detailed information about customers, in order to aid them in the decision-making process regarding the company's future business strategy. In the past, top management had asked the sales department head or sales representatives for this information and had consulted with them whenever necessary. It took six months for the task force team of the MIS department to design and install the new sales management information system. The SMIS system runs on an IBM PC or other PC clones with at least 640K of RAM. Paradox, a DOS-based database software, was used to develop the system. It requires less efforts to make the same function than other programming languages like C, COBOL, or Pascal; however, it needs more computer resources due to the overhead of Paradox itself .

#### (5) Subsystems of SMIS

The SMIS consists of the following four subsystems.

1. *Competitor information:* Chemical U.S.A. keeps track of ten other major chemical product distributors to maintain its competitive power and market share in the industry. The information includes competitors' sales amounts, good-selling products, major customers, etc.
2. Customer information: Detailed, sometimes private, information regarding the purchasing personnel in customer companies are stored in the databases. Examples of customer information include birthdays, hobbies, authority for purchasing decisions, family information, and any other relevant customer information.
3. Sales statistics: Sales clerks enter daily sales data when a copy of an invoice is delivered to the department. Sales reports are prepared from these input data.
4. Customer visit information: Sales representatives enter the results of their visits to customer sites. They input such information as reason for visit, discussions held with customers, and sales achieved.

*Competitor and customer information* was originally entered when the databases were created and are updated whenever necessary. *Sales statistics data* are entered every day when a copy of invoices arrives from the shipping department. Sales representatives key in *customer visit information* when they return from a customer visit.

### (6) Operations of SMIS

Each department stores these data in its individual PCs which run as stand-alone units. Every Friday, an IS staff person manually collects each department's data in SMIS on floppy diskettes and inputs them into the PC in the IS department in order to create a corporate SMIS database. Then, he prints the periodic (weekly and monthly) sales reports using the corporate database. It takes more than four hours to create a new central corporate database and print the periodic sales reports completely.

These sales reports are sent to the sales director and the corresponding department heads. The department head makes these reports available to the sales representatives. Because the sales report is single-spaced, the sales representatives sometimes made a mistake in matching the company name and the amount sold to the company. Also the total quantity sold and the total amount sold are not easily distinguished as they are closely located in the report, and there is no dollar signs in front of the sales amount.

When the system was proposed, each sales department head was concerned about the security of confidential sales data because the data would be stored in the PC which was easily accessible. Therefore, each PC was designed to operate as a stand-alone unit without being connected to a local area network. The PCs have been physically locked when the sales persons leave the office.

SMIS was originally initiated by the new sales director. Being new to the company, he needed a computer system to collect all the departments' sales information quickly in order to easily get a grasp of the sales division. One objective of SMIS was to centrally collect and store detailed information about the customers gathered by the sales representatives themselves. Therefore, after SMIS was used, the sales director could obtain the sales related information directly from the sales representatives. In the past, the sales department head usually filtered out its contents and then reported it to the sales director.

As the individual sales department PCs were standalone PCs, they did not have access to the centralized customer and product databases. These databases only existed in the IS department's PC with a large (1 giga byte) hard disk. As a result, when the sales clerks in individual departments entered the sales data, the input data was not verified right away. The data verification and validation was performed once per week when the data were collected and entered into the centralized database. Another reason for not validating the data at the time of data entry was that the sales clerks used PC-AT machines and thus, additional time for validation would have further slowed the data entry process.

The influence of sales representatives over system design was kept a minimum in the SMIS development process. Mr. Jones did not usually ask the sales representatives for their opinions. Most of the design decisions were made by Mr. Jones and Mary, a junior programmer in the IS department. Mary graduated from college a year ago as an MIS major. Mary developed most of the SMIS programs. The SMIS is a complex system that integrates four subsystems and thus required good programming skills to make the program logic efficient.

Sales representatives regarded storing their customer information and customer visit reports into the computer as making their sales know-how public and revealed to everyone in the company. Previously, this information remained in the sales representatives' private files. Sales representatives also thought that by sharing this information they would lose the control of their private information which might affect their job security.

The sales department sometimes was dissatisfied with the IS department because the sales department's requests for new programs or updates of the existing programs were not usually done immediately by the IS department. Although sales representatives spend time entering customer information and customer visit results into the system, the sales representatives usually did not review or inquire the information which they themselves input because they already knew the content stored in the computer.

Mary designed the data bases of SMIS and decided their data structures. The discussion content in the customer visit data base occupied 1200 bytes of disk space. Occasionally, a few sales representatives brought two pages of discussion content, which is more than 2000 bytes long. However, most sales persons used only 500 to 600 bytes on average to store their discussion content.

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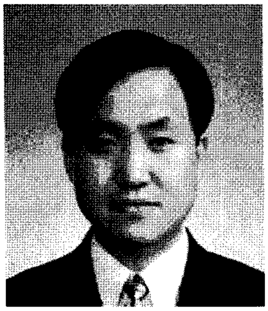
## ◆ 저자소개 ◆



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서울대학교에서 산업공학으로 학사(1982), 미국 Georgia State University에서 경영정보학으로 박사(1994) 학위를 받았다. 쌍용정보통신과 BASF Korea Ltd.에서 시스템 개발 업무를 담당하였으며 Clark Atlanta University에서 연구원으로 재직하였다. 주요관심분야는 시스템 분석 및 설계, 전자상거래 비즈니스 모델 개발, 정보시스템 평가 등이다. 현재 영남대학교 경영학부에서 조교수로 재직하고 있다.