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The Affecting Factors on the Adoption of Object-Oriented Computing : The Case of Programming Experience and Personal Innovativeness*

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I. Introduction

A new paradigm is a product of social changes. System developers have changed their viewpoints about processes and data in system development. Processes are emphasized in the structured methods. The structured methods, developed in the late 1960s and in the early 1970s, introduced standard methodologies by which a system could be divided into process-oriented modules. The process-oriented modules, mostly programmed in third-generation languages, could be kept flexible to accommodate frequent changes in system development processes. The information engineering approach emphasized data. Information engineering (Martin, 1990), which emerged in the late 1980s, assumed that (1) data lie at the center of modern data processing and that (2) data are stable but

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processes are not. The object-orientation paradigm, which emerged in the mid-1980s, focused not on processes or data alone but rather on objects that encompass processes and data. The concepts of encapsulation and inheritance are based upon hierarchical layouts of objects. Objects are data entities with which operations and processes are combined (encapsulation), and an object can inherit characteristics from single or multiple ancestors (inheritance). Inheritance is important because it enforces consistency on the definitions of related objects. Advocates of the object-orientation paradigm insist that these two concepts make it possible to reuse programming code and develop a reliable system (Booch, 1986; Burch, 1993; Garceau et al., 1993; Yourdon, 1989).

Object orientation is considered to be a revolutionary software engineering approach and it was anticipated it would replace traditional structured methods, but the deployment of object orientation in industry is slower than expected. Little empirical research has been conducted to examine factors that influence the successful implementation of object orientation. Recently, several empirical studies of object orientation show possible knowledge interference of procedural languages with object-oriented languages (Davies et. al., 1995; Detienne, 1995; Pennington et. al, 1995). The knowledge interference implies that object orientation is difficult to master if an individual is accustomed to the tradition of a different software engineering paradigm. The failures in many initial projects of object orientation in industry might be due to knowledge interference (Curtis, 1995). However, the external validity of these results remains questionable because the problem set was given to a small number of subjects in a simulated situation.

This paper empirically investigates the existence of the knowledge interference of the structured methods with object orientation in industry settings and the effect of personal innovativeness on adoption of object orientation. Personal innovativeness is chosen as one of the independent variables since personal innovativeness can play a role as a strong, counter-balancing factor against knowledge interference.

II. Research Design

Two key variables affecting technology adoption are chosen as dependent variables from the Technology Acceptance Model (TAM) (Davis et al., 1989) In the basic TAM, behavior intention to use a new technology depends mostly upon perceived usefulness and perceived ease of use of the new technology. A simple two-by-two quasi-experimental design is set forth. The length of experience in using the structured methods and the level of personal innovativeness toward technology (Leonard-Barton & Deschamps, 1988) are selected as the two independent variables.

The focus of this research design is on empirically testing the knowledge interference of the structured methods with object orientation, and investigating the effect of personal innovativeness on adoption of object orientation. Previous experience in using the structured methods and personal innovativeness toward technology may affect the perceived ease of use and usefulness in using object orientation. The length of experience in using the structured methods and the level of personal innovativeness toward technology are used to separate study subjects into two categories, such as high and low, according to median values for length of experience and personal innovativeness. Four cells are built on these two categorical variables: the level of using the structured methods and level of personal innovativeness. The values in each of the four cells represent the perceived ease of use and usefulness in using the object-oriented analysis and design (OOAD), and object-oriented programming (OOP).

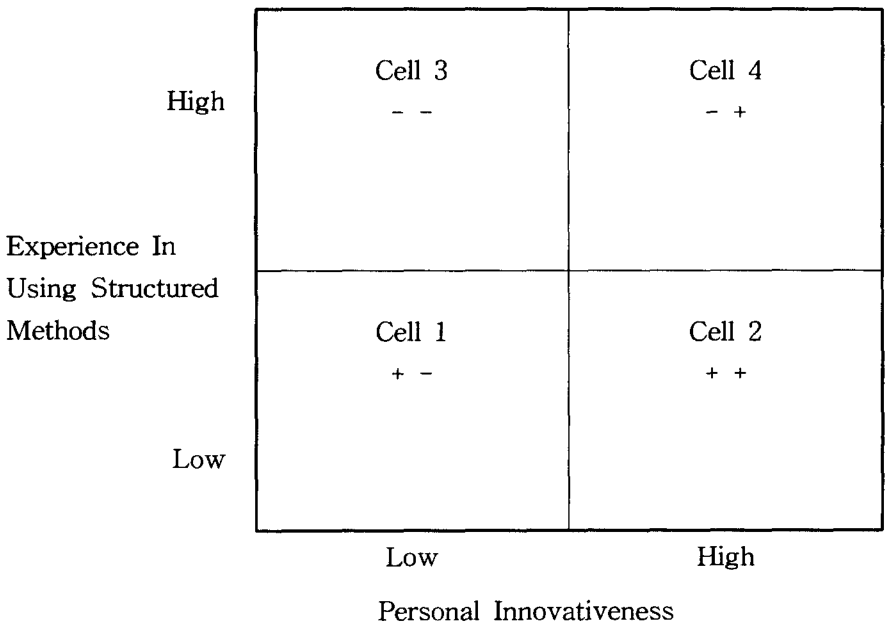
Cell 1: The subjects in this cell do not have much experience in using the structured methods and they do not tend to be open-minded toward new technologies. Because their previous experience in using the structured methods may not have much effect upon their use of the object orientation, but because they are conservative in using new technologies, their perceived ease of use and usefulness in using object orientation will be moderate compared with the perceptions about using object orientation found in the other cells.

Cell 2: The subjects in this cell do not have much experience in using the structured methods, and they tend to be open-minded toward new technologies. Their limited experience in using the structured methods will have minimal impact on their perceptions of using object orientation. Moreover, they are radical in using new technologies. Their perceived ease of use and usefulness in using object orientation will be highest among the four cells.

Cell 3: The subjects in this cell have much experience in using the structured methods, and they do not tend to be open-minded toward new technologies. Their experience in using the structured methods may strongly affect their perceptions of using object orientation, and they are conservative in using new technologies. Their perceived ease of use and usefulness in using object orientation will be lowest among the four cells.

<u>Cell 4</u>: The subjects in this cell have much experience in using the structured methods, and they tend to be open-minded toward new technologies. Even though their experience in using the structured methods may affect their use of object orientation, they are also radical in using new technologies. Their perceived ease of use and usefulness in using object orientation will be moderate among the four cells.

The relationship between individual characteristics and perceptions of ease of use and usefulness is shown in Figure 1.



++ : high perception of ease of use and usefulness
+- : moderate perception of ease of use and usefulness
-+ : moderate perception of ease of use and usefulness
-- : low perception of ease of use and usefulness

Figure 1: The Effects of Individual Characteristics on Perceptions

III. Data Collection and Analysis

Data were gathered from members of the Data Processing Management Association (DPMA). Nine DPMA chapters across four midwestern states participated in this survey. One hundred and nine subjects having experiences in using both the structured methods and object orientation responded to the structured questionnaires (response rate = 15 percent). This study includes variables about two types of the object-orientation technology: object-oriented system design & analysis (OOAD) and object-oriented programming (OOP). Research variables for this study are as follows:

(1) Usefulness: This scale was tested with six items developed by Davis (1989) which have five-point Likert type format after being reworded for this research. Using the object-oriented programming in my job would increase my productivity is one of the items. Six items were used for final data analysis which indicated maximum internal consistency estimate (Cronbach's alpha of OOAD= .951, that of OOP =.950). Confirmatory factor analysis in which one factor was forced showed that every single item was loaded on this factor with high significant t-value.

(2) Ease of Use: To measure the ease of use of object orientation paradigm for design & analysis and programming, the authors used six items developed by Mathieson (1991) which have five-point Likert type format. One example is I would find the object-orientation paradigm easy to use in the case of object-oriented analysis and design. An exploratory factor analysis indicated a single factor (one eigenvalue > 1.0). Four items of these six items were used for this research which supported maximum internal consistency estimate (Cronbach's alpha of OOAD = .868 and that of OOP = .901). Confirmatory factor analysis in which one factor was forced supported that every single item has a meaningful loading coefficient with very significant t-value.

(3) Personal innovativeness: Based on the former research (Leonard-Barton & Deschamps, 1988) about the effect of personality on the adoption of new technologies, the more innovative a person is, the easier he or she accepts new technologies. The authors selected this scale as a good predictor for the adoption of the object-orientation paradigm. The personal innovativeness scale developed by

Leonard-Barton & Deschamps (1988) consisted of seven items with five-point Likert type format. This scale has been widely used for deciding the extent to which people innovatively think of solutions and cope with problems related to their work. One example is I search for fresh ways of looking at problems using new technologies. An exploratory factor analysis supported a single factor (one eigenvalue >1.0). Three items of these seven items were used for statistical analysis, which indicated maximum internal consistency estimate (Cronbach's alpha = .729). Confirmatory factor analysis in which one factor was forced told that every single item was loaded on this single factor with significant t-value.

(4) Amount of experience with structured methods were measured by the number of months. The shorter the experience of different technology, the easier IS professionals adopt the object orientation.

The summary of the research variables are shown in Table 1. The period of experience in using the structured methods ranged from less than one month to three hundred months for structured analysis and design (SAD), and from less than one month to three hundred twelve months for structured programming (SP). The median values of these experience periods, were both one hundred twelve months. The median value of personal innovativeness (INV), which ranged from 1.00 to 5.00, was 3.00. Based on these median values, two-by-two factorial designs for OOAD and OOP can be set forth.

Research Variables	Previous Measure	Item Type (Number of Items)	Cronbach's α
Usefulness	Davis [1989], Moore & Benbasat [1991], Mathieson [1991]	5-point Likert Scale (6 Items)	OOAD: 0.951 OOP : 0.950
Ease of Use	Davis [1989], Moore & Benbasat [1991], Mathieson [1991]	5-point Likert Scale (4 Items)	OOAD: 0.868 OOP : 0.901
Personal Innovativeness	Leonard-Barton & Deschamps [1988]	5-point Likert Scale (3 Items)	0.729
Amount of Experience	Hill et al. [1987]	Metric (Number of Months)	-

Table 1: The Operationalization of Research Variables

Ⅳ. Findings

The mean of ease of use (EOU), mean of usefulness (USE), and number of subjects for OOAD are shown in Figure 2. A MANOVA for EOU and USE of using OOAD showed only the main effect of SAD with $\alpha=0.10$: the effect of SAD (F=2.863, Sig. of F=0.062), the effect of INV (F=1.508, Sig. of F=0.227), and the effect of both (F=1.344, Sig. of F=0.266). When the Roy-Bargmans stepdown F-test was applied, only USE was selected as a salient dependent variable under the effect of SAD (F=5.331, $p<0.05$).

The mean of ease of use (EOU), mean of usefulness (USE), and number of subjects for OOP are shown in Figure 3. A MANOVA for EOU and USE of using OOP also showed only the main effect of SP with $\alpha=0.05$: the effect of SP (F=12.726, $p<0.001$), the effect of INV (F=0.451, Sig. of F=0.638), and the effect of both (F=0.573, Sig. of F=0.565). When the Roy-Bargmans step-down F-test was applied, both EOU and USE were selected as salient dependent variables under the effect of SP.

To summarize the findings, previous experience using the structured methods was the only significant factor in the adoption of both OOAD and OOP. The results confirmed the existence of the much-hypothesized knowledge interference of the structured methods with object orientation: the low experience group had higher adoption scores than did the high experience group. Neither personal innovativeness nor the interaction of personal innovativeness and previous experience significantly affected the adoption of objected orientation. The summary of findings is shown in Table 2.

Experience In Using Structured Analysis and Desing(SAD)	Low	High
High	Cell 3 EOU : 3.019 USE : 3.080 (27)	Cell 4 EOU : 3.152 USE : 2.795 (22)
Low	Cell 1 EOU : 3.295 USE : 3.273 (22)	Cell 2 EOU : 3.447 USE : 3.440 (25)

Personal Innovativeness Toward Technologies(INV)

( ) : the number of subjects

Figure 2: Perceptions of Using OOAD

Experience In Using Structured Programming(SP)	Low	High
High	Cell 3 EOU : 2.875 USE : 2.861 (24)	Cell 4 EOU : 2.854 USE : 2.681 (24)
Low	Cell 1 EOU : 3.393 USE : 3.500 (25)	Cell 2 EOU : 3.692 USE : 3.682 (22)

Personal Innovativeness toward Technologies (INV)

( ): the number of subjects

Figure 3: Perceptions of Using OOP

Category	Effects (Main and Interaction)	F Value
OOAD	SAD	2.863*
	INV	1.508
	SAD X INV	1.344
OOP	SP	12.726**
	INV	0.451
	SP X INV	0.573

* : $p < 0.1$ ** : $p < 0.05$ *** : $p < 0.01$

Table 2: Summary of Findings

V. Discussion and Conclusions

Contrary to our expectations, the level of personal innovativeness had little influence on the adoption of object orientation in both EOU and USE dimensions. There are several possible reasons why the results did not support the contribution of personal innovativeness to the adoption of object orientation. First, a general pro-innovation attitude may not be an accurate indicator of innovative behavior since general attitudes often have been poor predictors of behavior in a specific setting (Leonard-Barton and Deschamps, 1988). Second, Individuals rarely have complete autonomy regarding the adoption and use of object orientation since a workplace innovation like object orientation is heavily affected by managerial influences (Fichman, 1992; Leonard-Barton and Deschamps, 1988). Policies for software engineering technologies are determined at the organizational level and management can encourage or discourage adoption explicitly by expressing preferences and mandates. Individuals are generally forced to adopt a specific software engineering technology. For this reason, the personal innovativeness or willingness to change may not play a significant role in the adoption of object orientation.

The evidence that the prior experience of using the structured methods adversely affects the adoption of object orientation raises a serious challenge to the successful implementation of object orientation. A vast majority of software engineers in the field are using the structured methods. Hence, how to overcome the knowledge interference of structured methods with object orientation may be a key factor for smooth adoption of object orientation. Why do individuals with extensive experience in structured methods have difficulties in adapting to object orientation? The primary reason seems to be the compatibility problem (Fichman and Kemerer, 1993). Object orientation is a new paradigm for systems development. It demands a new set of skills in analysis, design, and programming that replace, rather than add on to, the skills in the structured methods. Experienced software engineers in structured methods are expected to have greater difficulties in absorbing a new paradigm, object orientation, than are novices in structured methods who have little compatibility problem.

VI. Limitations and Future Study

Several limitations are imposed on this research. First, a research design depends on a cross-sectional survey of respondents through structured questionnaires, and longitudinal survey may be more informative in the area of this study. Second, the research involved only two factors among many factors influencing the adoption of object orientation in organizations, and the knowledge interference of structured methods with object orientation was shown indirectly by the perception of ease of use. Third, while the subjects are chosen to ensure variety, the participating subjects are confined to the mid-west area of the US. Nationwide data may increase external validity of this study.

In the future study, the knowledge interference effects may be analyzed in order to guide IS professionals who have been experienced in both structured methods and object orientation. Several recommendations for the future study can be suggested. First, we suggest employing different training methods for IS professionals: (1) one method for persons having much experience in using the structured methods and (2) another method for persons having little experience in using the structured methods. Since experienced programmers tend to organize their logic along the lines of functional relations between components (Davies et al., 1995), their way of thinking basically differs from that of object orientation. Many contrasting examples may help experienced structured programmers to better understand object orientation. Also, highlighting frequent pitfalls, such as the tendency to retain an obvious input-process-output structure by having visible input and output objects (Pennington et al., 1995), may be a valuable lesson for experienced structured programmers. For inexperienced programmers of structured methods, standard training materials without contrasting examples might be better. They will prevent inadvertently introducing the knowledge interference effect.

Second, the culture and values of systems development groups need to be changed to promote shared learning. The real productivity gain of the object orientation paradigm comes from reuse of objects. To maximize the effect of reuse, developers must trust objects developed by others (Fichman and Kemerer, 1993). The culture of shared learning will enhance cooperation and communication necessary to accomplish effective reuse and accelerate the learning curve. Sharing of knowledge in programming and design will serve as a vehicle for experienced structured developers to swiftly escape the problem of knowledge interference.

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<초 록>

객체지향 컴퓨팅 채택에 미치는 영향요인 : 프로그래밍 경험과 개인혁신성의 경우

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소프트웨어 기술의 생명주기가 점점 짧아지고 복잡해짐에 따라 그 기술을 이해하기가 힘들어 진다. 객체지향 기술채택을 더욱 잘 이해하는 것이 이 논문의 연구동기이다. 객체지향 기술이 전통적인 소프트웨어 프로세스 기술에 대한 새로운 패러다임이기 때문에 프로세스 중심의 구조지향 기술과 같은 기존의 소프트웨어 엔지니어링의 경험에 영향을 받을 수 있다.

본 연구의 목적은 이전의 구조지향 기술의 경험과 기술변화에 대한 개인적인 인식이 미국 기업체에서 객체지향 기술채택에 어떻게 영향을 미치는지를 실제로 조사하는데 있다. 2 X 2 유사 실험계획법이 사용되었다. 구조지향 방법을 사용한 경험과 새로운 기술에 대한 개인적 혁신정도(Personal Innovativeness)가 독립변수로, 객체지향 방법에 대한 사용편이성(Ease of Use)과 유용성(Usefulness)이 종속변수로 선정되었다. 데이터는 구조지향 방법과 객체지향 방법을 모두 사용한 경험이 있는 자료처리 및 관리협회(DPMA: Data Processing and Management Association)에 소속된 정보시스템 전문가로부터 수집되었다.

연구결과는 구조지향 방법을 사용한 경험은 객체지향 방법의 사용편이성과 유용성에 영향을 주지만 개인적 혁신성은 영향을 주지 않는 것으로 나타났다. 과거의 구조지향 방법을 많이 사용하면 할수록 객체지향 방법의 사용편이성 값이 낮게 나타나기 때문에 이전 문헌에서 제시된 구조지향 방법의 객체지향 방법에 대한 지식간섭(Knowledge Interference) 현상이 있음을 실증적으로 보여주었다. 마지막에는 본 연구의 한계점과 향후 연구에서 지식간섭을 줄일 수 있는 방안을 제시하였다.