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Affecting Factors on the Technology Adoption of Object Orientation*

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I. Introduction

Is an object-orientation paradigm a silver or magic bullet in the software development process? (Brooks, 1987; Burch, 1993) The object-orientation paradigm has been a hot issue for several years. Advocates for the object-orientation paradigm insist that the paradigm can increase flexibility, productivity, and reliability through code reuse (Booch, 1986; Burch, 1993; Garceau et al., 1993)

Because adoption of new information technology is critical for organizations to survive in a competitive environment, it is important to investigate the influencing factors of technology adoption. The need to better understand the adoption of a

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particular information technology by organizations provides the motivation for this research.

One central research question is addressed: What are the factors that significantly influence the adoption of object orientation? A questionnaire measuring related variables is adapted and developed. The answers to this questionnaire are used to study the effects of the identified independent variables on the dependent variables. The questionnaire is administered to junior/senior programmers or system analysts/designers with actual programming experience.

The contributions of this research can be described as follows. The factors affecting the adoption of object orientation are suggested and empirically tested. These results will suggest to IS professionals some guidelines about how they respond to adoption of object orientation in organizations.

II. Literature Review

Lots of studies on technical issues of object orientation have been reported, but empirical studies of object orientation have rarely been shown (Davies et al., 1995; Detienne et al., 1995; Pennington et al., 1995). However, this approach focuses on the cognitive process rather than on managerial aspects, and the number of subjects in those experiments is very limited. Industrial perceptions about object orientation should be carefully evaluated so that an accurate picture of object orientation can be available to IS professionals in organizations. The related literature affecting factors of software process technologies and empirical studies of software process technologies will be carefully reviewed.

2.1 Affecting Factors of Technology Adoption

Bayler and Melone (1989) define the diffusion of innovation as a process by which knowledge of an innovation spreads throughout a population. Rogers (1983) says that technology diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system.

Rogers (1983) insists that his classical diffusion theory is composed of four factors: (1) innovation, (2) communication, (3) time, and (4) social system. Innovation is an idea, practice, or object that can be considered as new by an individual or other unit of adoption. One remarkable thing is that adoption of technology depends on the perception of a potential user rather than on the actual worth of the innovation

(Kling, 1980; Leonard-Barton, 1985). The characteristics of innovation include the following items: the relative advantage of the innovation over alternative or non-adoptive technology; the compatibility of the innovation with the existing idea; the perceived complexity of the innovation; the triability of the innovation; and the observation of the innovation (Rogers, 1983; Bayer et al., 1989). Communication is the process by which people create and share information in order to reach a mutual understanding. Communication can be enhanced when the source of the communication and the target of the communication are similar with each other. The communication channel is a particular media by which a new idea or information can be exchanged (Rogers, 1983). Time is an important element in the diffusion of process. Many researchers define the stages of diffusion process differently. The relative speed with which the innovation is adopted has been shown empirically to follow an S-shaped curve due to the amount of information transfer, uncertainty reduction, economic advantage, and learning effects (Bayer et al., 1989). Social system is defined as a set of interrelated units that are engaged in joint problem solving to accomplish a common goal (Rogers, 1983).

Many researchers differently explain factors affecting technology adoption. These classified factors will be carefully selected for the adoption study of object orientation. Alexander (1989) classifies the factors affecting the implementation of large database systems into four classes: (1) environmental characteristics-vendor involvement and training; (2) innovation characteristics-perceived compatibility, complexity, and relative advantage; (3) organization characteristics-organizational structure, management support, and information systems planning; and (4) manager characteristics-champions and technology awareness. Leonard-Barton (1987) clusters potentially influential factors into three groups: (1) characteristics of the innovation; (2) organizational influences on user acceptance; and (3) personal characteristics of the potential users. Bayer and Melone (1989) explain that the diffusion prediction is based on characteristics of the technology, networks used to communicate information about the technology, characteristics of the adopters of the technology, and the degree of similarity between change agents and potential adopters.

Boyton, Zmud, and Jacobs (1994) contend that the use of information technology depends on managerial knowledge of information technology and the effectiveness of information-technology management. Zmud (1982) states that the diffusion of modern software practices is affected by the characteristics of the organization. Wynekoop (1991) states that the implementation of CASE is affected by seven factors: (1) perceived complexity, (2) perceived relative advantage, (3) optimistic relative advantage expectations, (4) optimistic complexity expectations, (5)

communication amount, (6) perceived management commitment, and (7) months of use. Cooper and Zmud (1990) argue that the implementation of information technology is influenced by technology compatibility and task compatibility. Tornatzky and Klein (1982) analyze seventy five articles that are related to innovation, and find that three innovation characteristics consistently influence the innovation adoption: (1) compatibility, (2) relative advantage, and (3) complexity. Grover and Goslar (1993) argue that diffusion of telecommunication technology is influenced by three elements: (1) environmental uncertainty; (2) organizational factors-size, centralization, and formalization; and (3) information system factors. Ball, Dambolena, and Hennessey (1987) examine the relationship between the adoption of database management systems and the characteristics of organizations and information sources.

Zmud (1983) investigates the effects of ten information channels on the adoption of Modern Software Practices (MSP) in software development groups. Nilakanta and Scamell (1990) examine how information sources and communication channels facilitate the diffusion of data base design tools and techniques. They argue that the technical support function influences technology adoption at the organizational level rather than at the individual level. Eveland and Tornatzky (1990) enumerate five factors of technology adoption: (1) the nature of technology itself, (2) user characteristics, (3) characteristics of deployers, (4) boundaries within and between deployers and users, and (5) characteristics of communication and transaction mechanisms. Zmud (1984) investigates the effects of complexity of project environment, innovation recognition, and management attitude on adoption of Modern Software Practices (MSP). Brancheau (1987) states that adoption of spreadsheet software is affected by adopters characteristics, types of communication channels, and communication sources.

2.2 Empirical Studies of Adoption of Software Process Technologies

Software process technologies are a means by which an application software is produced. The structured methods, information engineering, and object orientation are the major concepts, and the other technologies represent tools that support these major concepts. The supporting tools include the third generation languages (3GLs), fourth generation languages (4GLs), relational database management systems (RDMS), computer-aided software engineering (CASE), object-oriented database management systems (OODBS), and integrated programming support environments (IPSEs). The previous empirical studies are reviewed according to three major concepts of software process technologies.

Structured Methods: Leonard-Barton (1987), Zmud (1982, 1983, 1984), and Mahmood (1987) study adoption of structured methods in organizations. Leonard-Barton (1987) analyzes adoption behavior of structured systems analysis (SSA) by individual system developers. He surveys 145 programmers, system analysts, and supervisors in three organizations, and finds that supervisors, influential peers, and clients strongly influence adoption of the structured methods. Zmud (1982, 1983, 1984) surveys 49 software development managers to analyze adoption of modern software practices. Zmud (1982) examines the relationship between organizational and innovational characteristics. Zmud (1983) confirms that organizational characteristics, such as size, professionalism, and context, mediate the relationship between information channels and adoption of modern software practices. Zmud (1984) finds that group receptivity toward change and managerial support influence adoption of modern software practices. Mahmood (1987) compares the system development life cycle (SDLC) with prototyping methods in terms of project management, project characteristics, impact on decision making, and user and designer satisfaction. He finds that selecting design methods should depend on project, environment, and decision characteristics, and that no one method is totally preferred. Computer-Aided Software Engineering (CASE): Wynekoop (1991) suggests a CASE implementation model in which the level of use and acceptance of CASE are affected by personal perception, expectation, and communication amount. She finds that accurate information is needed during the implementation process, and that unrealistically optimistic expectation is reversely related to adoption of CASE. Finlay and Mitchell (1994) investigate one company's experience with the introduction of CASE, and find that productivity and quality gains from CASE.

Relational Database Management System (RDMS): Ball et al. (1987) investigate the relationships between the acquisition of large database management systems and the characteristics of organizations and their personnel. They find that most RDMS decisions are made through group process, and that large, technically-oriented organizations tend to adopt database management systems at an early stage of acquisition. Alexander (1989) explores the implementation of database machines, and finds that the existence of champions and perceived management support are highly related to the implementation of database machines.

Object Orientation: Empirical studies of object orientation trace back to the early 1990s. Most research can be classified as either cognitive-level or explorative studies. The studies cover a wide variety of topics: the relationship between the level of experience using object-oriented programming and problem type (Detienne et al., 1995); a comparison of solutions produced by different systems development

methodologies (Boehm-Davis, 1992); different cognitive processes of novice and expert programmers (Davies et al., 1995; Weiser et al., 1983); the effectiveness of communication among team members using object orientation (Herbsleb et al., 1995); the role of domain knowledge in the object-oriented design (Pennington et al., 1995). A few researchers have learned valuable lessons from participating in projects using object orientation (Burkle et al., 1995; Capper et al., 1994).

Detienne (1995) investigates the design strategies of object orientation for both procedural and declarative problems and demonstrates the difficulties that procedural programmers have in switching to the object-orientation paradigm. Boehm-Davis and Ross (1992) examine three approaches to decomposition (data-structure based, function based, and object based methods) that can lead to differences in the final solutions of three different types of problems. They find that the data-structure and object based methods have advantages in consistency, completeness, complexity, and design time.

Davies et al. (1995) find that while novice programmers think of programs in terms of objects and their relations, experienced programmers think of programs in terms of components and their functional relations. Pennington (1987) shows that programmers represent their programs in different ways depending on the task they are performing. Weiser and Shertz (1983) insist that novice programmers organize their thinking in terms of application domains, whereas expert programmers build up their logical thinking in terms of algorithmic structures.

Herbsleb et al. (1995) find that teams using object orientation use their communication skills more effectively than teams using traditional methods. Their findings, including more walk-throughs and integration, are matched with seamless development (Henderson-Sellers, 1992) in object orientation. Pennington et al. (1990) insist that domain knowledge can play a critical role in the object-oriented design phase. They also discuss two difficulties in learning the object-oriented design: (1) providing principles for training; and (2) answering several questions of knowledge transfer and interference in skill acquisition. Burkle et al. (1995) apply object orientation successfully to an ongoing project which has failed using traditional procedural design methods. They consider the system development as a learning and communication process, and show how their methods facilitate both mapping between the application domain and software solution, and communication among team members. Capper et al. (1994) demonstrate the increase of software quality in terms of low defect rates, low level of design changes through early user interface, and close users involvement.

III. Research Hypotheses

Based on the previous studies, the affecting factors are categorized into the three major groups: (1) individual factors-personal innovativeness and amount of experience in using structured methods; (2) managerial factors-management support and training; (3) organizational/environmental factors-number of IS professionals, technology champions, and hardware and software environment. The seven research variables are also selected in the viewpoints of the knowledge barrier between the structured methods and object orientation, and the early adoption stage of object orientation. The knowledge barrier between structured methods and object orientation will be affected by the personal innovativeness and the amount of experience in using structured methods, and this may influence the adoption of object orientation in organizations. At early adoption stage of object orientation, training, management support, and hardware/software environment will critically affect the adoption of object orientation. The number of IS professionals and the existence of technology champions may afford more valuable information in using object orientation.

3.1 Individual Factors

Zmud (1982) proposes a theoretical model to examine the effect of individual differences on the success of information system. Since this study was published, individual characteristics have been reported to play a key role in a MIS success. When adopting a new technology, personality is expected to play an important role. The more a person has an innovative personality, the more he or she would be willing to try new things. Zmud (1984) finds that innovativeness or receptivity toward change of an organizations members is an important determinant of innovative success.

The experience in using a similar computer technology is also found to have a positive effect on system usage (Delone 1988; Igbaria et al. 1995). However, object orientation needs a different way of thinking compared with structured methods. The more experience a person has in using structured methods, the less he or she tends to be comfortable in using object orientation (Curtis, 1995; Davies et al., 1995). The possible knowledge barrier of structured methods on object orientation can be empirically tested.

3.2 Managerial Factors

Gist (1987) reports that user training plays an important role in increasing

user confidence in their ability to learn and use computers. Raymond (1990) argues that computer training is a significant predictor of personal computing acceptance. It is also found that training has a positive impact on technology acceptance (Amoroso et al. 1991; Igbaria et al. 1995).

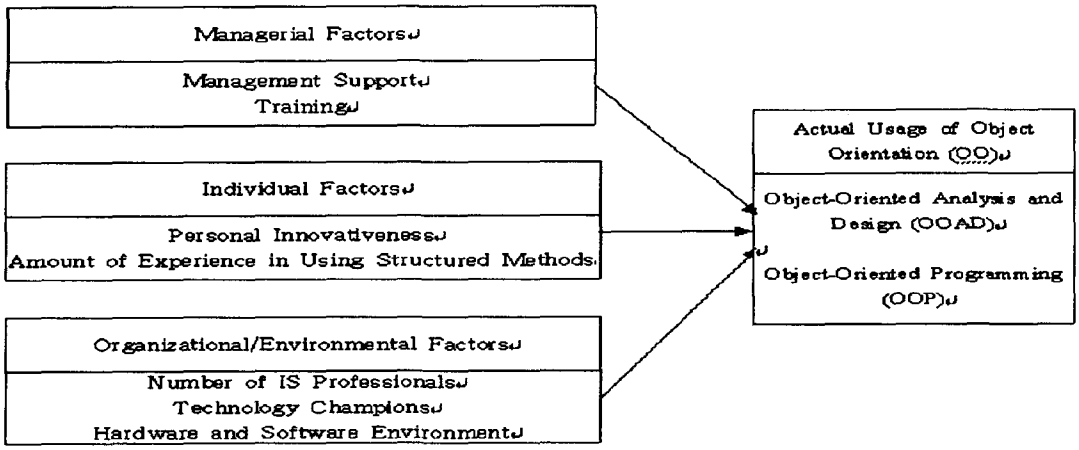
Former studies have recognized management support as one of the crucial factors to affect successful technology adoption (Fuerst and Cheney, 1982). The management support includes managerial encouragement and sufficient resource allocation.

3.3 Organizational/Environmental Factors

The IS professionals in a working group may affect other job incumbents perceptions of using OO(Object Orientation) technology because the technology is at the initial stage of adoption in many organizations. Technology champions in organizations should be an information gatekeeper, problem solver, and helper, and the existence of accessible technology champions will affect the adoption of object orientation. Finally, the hardware and software environments for using object orientation may also affect the usage of object orientation in organizations.

3.4 Conceptual Model and Research Hypotheses

Simple regression models are presented to analyze the effects of the seven independent variables in the individual, managerial, and organizational/environmental factors upon the dependent variable-the actual usage of object orientation. Simple regressions will test the direct relationships between the independent and dependent variables. A conceptual research model is presented in <Figure 1>.



<Figure 1> A Conceptual Research Model

The seven independent variables are depicted in Figure 1, and the relationships between the seven independent variables and one dependent variable lead to seven hypotheses.

H1: The more a person is open to new technologies, the more he or she uses object orientation.

H2: The more a person has used the structured methods, the less he or she uses object orientation.

H3: The more a person perceives management support in using object orientation, the less he or she uses object orientation.

H4: More opportunities for training in using object orientation result in the higher usage of object orientation.

H5: Easier access to technology champions in organizations results in the higher usage of object orientation.

H6: The number of IS professionals in an organization is positively related to the usage of object orientation.

H7: The necessary hardware and software environments for using object orientation are positively related to the usage of object orientation.

IV. Data Analysis and Results

4.1 Data Collection

Data were gathered from information technology professionals of the Data Processing Management Association (DPMA) in four mid-western states of the U.S. Before the final questionnaires were distributed, phone calls were made to local presidents of DPMA in order to ask for the support of members participation in this survey. Subsequently, lists of DPMA directories were obtained with their permission. Eight hundred fifty-four questionnaires were sent to nine chapters across four mid-western states. One hundred twenty-seven subjects responded to the questionnaires (the response rate = 14.9%). The response rate was relatively

low because using object orientation was still relatively new to the DPMA members. After deleting respondents who did not answer questions completely, 109 subjects who had experience in using both the structured methods and object orientation were included in the overall statistical analysis.

88 cases were included in the final statistical analysis due to the listwise deletion of missing values. The average age of the subjects was 43.4 years. The percent of males was 78 and that of females was 22. Most subjects had the job title of supervisor (42%), while remaining subjects titles were distributed among technical and managerial jobs. The average job experience was 18 years, a relatively high level of IS experience.

4.2 Operationalization

The research variables can be classified into one dependent variable (actual usage) and seven independent variables (personal innovativeness, amount of experience in using structured methods, management support, training, technology champions, number of IS professionals, and hardware and software environment). <Table 1> summarizes the operationalization of these research variables.

Classification	Variable	Previous Measure	Description
Dependent Variable	Actual Usage	Davis (1989), Davis et al.(1989), Hill et al. (1987)	Likert Scale: the current and actual usage of object-oriented analysis and design, and object-oriented programming
Independent Variables	Personal Innovativeness	Leonard-Barton & Deschamps(1988)	Likert Scale: the level of openness toward new technologies
	Amount of Experience in Using Structured Methods	Hill et al. (1987)	Number of Years: the experience length in using conventional structured method
	Management Support	Leonard-Barton & Deschamps(1988)	Likert Scale: the perceptions on management support including reward, understanding, and general support of object orientation in organizations
	Training	Alexander (1989), Dolan & Tziner (1988), Leonard-Barton (1987)	Days of Formal Training in a Year: the up-to-date days of formal training
	Technology Champions	Alexander (1989)	Likert Scale: the level of easiness to consult with designated technology champions in an organization
	Number of Professionals	Zmud (1984)	The mean value of IS professionals in a working group and an organization
	Hardware and Software Environment		Likert Scale: the hardware/software environment supporting object orientation

<Table 1> The Operationalization List of the Research Variables

4.3 Factor Analysis

Factor analysis is conducted according to the independent variables with more than two items. Four factors can be generated on the basis of the above independent variables. Final results will be summarized in <Table 2>.

Rotated Factor Matrix

	Factor 1	Factor 2	Factor 3	Factor 4
INV1	.99580	.02891	-.07389	-.03291
INV2	.61503	.00826	-.08433	.25921
INV3	.59762	.21382	.14876	.07414
SPT1	.06111	.93998	.05662	.03954
SPT2	-.06748	.50419	.01190	.27886
SPT3	.05547	.33872	.17223	-.02440
SPT4	.09830	.25606	.02322	.06930
GSIZE	-.12165	-.01436	.88322	-.09915
OSIZE	.10575	.29839	.62326	.01446
HARD	.19444	.05189	-.04148	.80151
SOFT	.05193	.16803	-.03801	.63902

Factor Transformation Matrix

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	.99626	.02993	-.07446	-.03191
Factor 2	-.01019	.97139	.19818	.13048
Factor 3	.06161	-.13935	.92145	-.35737
Factor 4	.05966	-.18997	.32573	.92426

<Table 2> Factor Analysis with VARIMAX for Independent Variables

4.4 Reliability Test

Each variables reliability is verified by conducting a reliability test based on the results of the factor analyses. Variables with more than two items are analyzed. Cronbach alpha values are listed in <Table 3>.

Type	Variable	Number Items	Alpha Value
Independent Variables	Personal Innovativeness	3	0.7298
	Perceived Management Support	4	0.5631
	Number IS Professional	2	0.6513
	Environment for OO	2	0.7188
Dependent Variables For OOAD and OOP	Actual Usage for OOAD	2	0.9269
	Actual Usage for OOP	2	0.9161

<Table 3> Reliability Test of Each Variable with More than Two Items

4.5 Correlation Analysis

The variables in this study are explained as follows. Most variables were adapted from previous researchers. For the independent variables, there were three highly-correlated groups: ENV and INV; ACCESS and SUPPORT; and ENV and TRAIN ($p < 0.01$). However, this high correlation may be expected in the social science studies.

4.6 Tests of Hypotheses

Seven hypotheses based on one research question were suggested. An explicit research question and seven hypotheses were shown and tested. One research question asks what factors significantly influence the adoption of object orientation. <Table 4> shows the final regression tests.

Hypotheses	Relationship	Significant T Value
H1	INV and AUSAGE1	0.0013**
	INV and AUSAGE2	0.0062**
H2	SAD and AUSAGE1	0.6532
	SP and AUSAGE2	0.1937
H3	SUPPORT and AUSAGE1	0.0012**
	SUPPORT and AUSAGE2	0.0083**
H4	TRAIN and AUSAGE1	0.0000***
	TRAIN and AUSAGE2	0.0000***
H5	ACCESS and AUSAGE1	0.0076**
	ACCESS and AUSAGE2	0.0539
H6	SIZE and AUSAGE1	0.9799
	SIZE and AUSAGE2	0.7243
H7	ENV and AUSAGE1	0.0001***
	ENV and AUSAGE2	0.0001***

* (α=0.05); ** (α=0.01); *** (α=0.001)
AUSAGE1: Actual Usage of OOAD
AUSAGE2: Actual Usage of OOP
INV: Personal Innovativeness toward New Technology

SAD: Amount of Experience in Using Structured Design and Analysis
SP: Amount of Experience in Using Structured Programming
SUPPORT: Perceived Management Support
TRAIN: Cumulative Day of Formal Training
ACCESS: Accessibility to Technology Champions
SIZE: Mean Number of IS Professionals in a Working Group and an Organization
ENV: Hardware and Software Environment for OO

<Table 4> The Results of Simple Regressions

V. Discussion

Final answers to one research question can be obtained from the data analysis. The factors affecting the object-oriented analysis and design are similar to those affecting object-oriented programming except for the factor of technology champions. Among these factors, training and hardware/software environment profoundly influence the adoption of object orientation with =0.001. This outcome can be explained because object orientation is at the early adoption stage in organizations. Personal openness to new technologies and managerial support also affect the adoption of object orientation with =0.01. Technology champions partially affect the adoption of object orientation (See <Table 4>). <Table 5> indicates the final results of seven hypotheses.

Hypotheses	Results
H1: The more a person is open to new technologies, the more he or she uses object orientation.	Supported
H2: The more a person has used the structured methods, the less he or she uses object orientation.	Not Supported
H3: The more a person perceives management support in using object orientation, the more he or she uses object orientation.	Supported
H4: More opportunities for training in using object orientation result in the higher usage of object orientation.	Supported
H5: Easier access to technology champions in organizations results in higher usage of object orientation.	Partially Supported
H6: The number of IS professional in an organization is positively related to the usage of object orientation.	Not Supported
H7: The necessary hardware and software environments for using object orientation are positively related to the usage of object orientation.	Supported

<Table 5> Summary of Finding

This research has implications for technology adoption, MIS researcher, and IS practitioners. First, as the adoption stages in their unified model are suggested (Kwon et al., 1987), affecting factors vary according to the adoption stages. For example, personal innovativeness, training, and software/hardware environment are most important to the early adoption of object orientation. Because object orientation is not widely used in organizations, personal openness to new technologies, training, and new investment for object orientation are critical to the adoption of this new paradigm. Second, factors affecting object orientation support the previous findings in the areas of technology adoption. Third, this research indicates that managerial support, training, environment for object orientation, and personal innovativeness are important during the early adoption stage of object orientation. This result has some implications for IS practitioners. Investment for object orientation, and personal characteristics are required for the successful adoption of object orientation.

This study makes several contributions to both information technology adoption and information systems research areas. Factors affecting the adoption of object orientation were defined from previous studies and empirically tested. The results suggested how IS practitioners respond to adoption of object orientation in organizations.

Several limitations are imposed on this research. First, a research design depends on a cross-sectional survey of respondents through structured questionnaires (Cook et al., 1979). Longitudinal survey may be more informative in the area of this study. Second, 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. Third, even though the measure items show high internal consistency, further improvement of the measures is required. This study has raised more questions than it has answered. This study showed training was very important to the adoption of object orientation, but a detailed description of training methods was not suggested. Further studies may concentrate on how to train IS professionals by using organizational learning.

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<초록>

객체지향 기술채택에 미치는 영향 요인

김 인 재

본 연구는 객체지향 기술채택에 영향을 미치는 요인을 조사했다. 한가지의 중요한 연구 의문을 제시했다: 무엇이 객체지향 기술의 채택에 중요하게 영향을 미치는가? 본 연구는 객체지향 기술의 실제 사용정도에 영향을 주는 독립변수를 연구했다. 그 독립변수는 다음과 같은 세 가지 범주로 분류된다: (1) 개인적 요인: 구조지향 방법론을 사용한 경험, 새로운 기술에 대한 개방 정도; (2) 관리적 요인: 경영층의 지원 정도, 훈련; (3) 조직적/환경 요인: 부서와 조직에 있는 정보시스템 전문가의 수, 기술 챔피언에 대한 접근 용이성, 객체지향 기술을 지원하는 소프트웨어 및 하드웨어 환경.

설문지를 이용하여 위에서 언급된 독립변수들이 하나의 독립변수, 즉 객체지향 기술의 실제 사용정도에 미치는 영향을 조사하였다. 그 구조화된 설문지가 미국에 있는 DPMA(Data Processing Management Association)에 소속된 정보시스템 전문가에게 돌려졌다.

본 연구는 기존의 연구 결과와 일치하는 중요한 내용을 보여 주었다. 새로운 기술에 대한 개인의 개방성, 경영층의 지원정도, 훈련, 그리고 하드웨어 및 소프트웨어 환경은 객체지향 기술의 사용과 밀접한 관련이 있었다. 본 연구는 또 조직에서의 객체지향 기술의 초기 채택을 이해하는 실증적인 근거를 제시하였다.