An Application of Hybrid Technology Acceptance Model to Object-Oriented Computing*

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Investing in new information technologies is a major decision for information officers in organizations. In particular, the object-orientation (OO) paradigm has been rapidly adopted and used in organizations and is becoming a hot issue for both academicians and practitioners of information technology. Despite the apparent importance of OO technology, relatively little is known about the adoption process and important factors that affect its adoption. The main purpose of this research is to analyze behavioral processes involved in OO technology acceptance and to evaluate the influence of the key factors on acceptance of OO technology. In particular, this research develops a new technology acceptance model, in which the idea of perceived behavioral control (PBC) based on theory of planned behavior (TPB) is incorporated into the original Technology Acceptance Model (TAM) framework and compares it with the original TAM.

Following the TAM, in the first model, all of the exogenous variables are hypothesized to affect the actual usage indirectly through the ease of use, usefulness, attitude, and intention. A new model is proposed by incorporating individual, managerial, and organizational characteristics into the original TAM model and by changing the positions of these variables in accordance with the theory of planned behavior. In this proposed model, except for the perceived usefulness and ease of use of OO technology, all the exogenous variables (the length of formal training, personal innovativeness, managerial support, number of professionals, accessibility to technology champion, and personal experience with previous technology) are hypothesized to affect both behavioral intention and actual usage of the OO technology paradigm. These relationships are in accordance with the role of PBC based on TPB. The usefulness and ease of use are hypothesized to affect the attitude toward OO technology, and then the attitude and usefulness are hypothesized to affect behavioral intention. The actual usage of OO technology is then affected by behavioral intention along with the perceived behavioral control variables. In the proposed research model, therefore, the usefulness and ease of use are shifted from endogenous variables to exogenous variables.

This research has replicated most of previous research's findings. The usefulness and the ease of use of object-oriented technology are found to influence the actual usage of this technology through attitude and behavioral intention. This study investigated the difference between the TAM and a proposed model. According to the results of goodness of fit indices, the proposed model is superior to TAM. The

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comparison of these two models through the goodness of fit indices demonstrates that the proposed model shows better model fit than TAM. These results are very encouraging in that the proposed model showed a potential role of perceived behavioral control for adoption of new technologies. With the concept of perceived behavioral control, this research found that it would be better to directly relate these exogenous variables to behavioral intention and actual usage rather than to relate these variables to usefulness and the ease of use.

With regard to the effects of research variables on technology adoption, individual experience, management support, and the length of training period were shown to critically influence the adoption of OO technology. The other variables such as the accessibility to technology champions and the number of IS professionals in the organization were not shown to significantly influence the adoption of OO technology.

Key words: Information Technology Acceptance, Object Orientation, Theory of Planned Behavior, Perceived Behavioral Control.

I. Introduction

Investing in new information technologies is a major decision for information officers in organizations. In particular, the object-orientation (OO) paradigm has been rapidly adopted and used in organizations and is becoming a hot issue for both academicians and practitioners of information technology. Despite the apparent importance of OO technology, relatively little is known about the adoption process and important factors that affect its adoption. With few exceptions (Detienne, 1995; Pennington et al., 1995; Jiang et al., 2000; Moon and Kim, 2001; Chau and Hu, 2002; Chen et al., 2002), the majority of studies about acceptance of IS technology has dealt with personal computing (Adams et al., 1992; Davis et al., 1989; Igbaria et al., 1995; Mathieson, 1991; Szajna, 1996; Taylor & Todd, 1995).

Previous studies have presented a variety of models for technology adoption (Zmud, 1984; Coleman, 1986; Kwon & Zmud, 1987; Davis, 1989; Venkatesh et al., 2003). Of these models, the technology acceptance model (TAM) is considered to be the most comprehensive one to explain the behavioral process of information technology acceptance.

Based on the theory of reasoned action (Fishbein & Ajzen, 1975), TAM has successfully explained the acceptance process of information technology (Davis, 1989). The theory of reasoned action (TRA) was developed under the assumption that a particular behavior is under the person's complete control (Fishbein & Ajzen, 1975). In an attempt to apply TRA to situations where the behavior is not totally under the person's control, Ajzen (1985) suggested the theory of planned behavior (TPB). In

real-world situations, it is extremely rare to find conditions where the behavior is completely under the person's control. Quite frequently, the organization itself plays a major role in initiating and launching new technologies. Considering these decision making situations in real-world organizations, TPB is considered more realistic in investigating acceptance process of a new technology, whereas TAM, which is developed based on TRA, reveals the same limitations as TRA.

Previous research on factors that affect technology adoption has shown that individual, managerial, organizational, and environmental characteristics as well as personal perception of technology are important (Rogers, 1983; Bayer & Melone, 1989; Alexander, 1989; Leonard-Barton, 1987; Gefen & Keil, 1998; Agarwal & Prasad, 1999; Venkatesh & Davis, 2000). Lee et al. (2002) applied TAM to the usage of Internet banking, and Kim (2000) investigated that TAM accommodates its causal relationships in case of object-oriented paradigm. Lee & Jang (2003) extended TAM2 through augmenting external variables. Chang et al. (2002) included perceived interactivity onto TAM, and Son (2001) tried to find the role of psychological factors in the processes of technological acceptance. In TAM, these variables are placed to indirectly affect acceptance of technology through other mediating variables. However, TPB allows these external variables to directly affect acceptance of technology through perceived behavioral control (PBC).

The main purpose of this research is to analyze behavioral processes involved in OO technology acceptance through investigating the relationship between individual, managerial, organizational and environmental factors, and the characteristics of technology. The other one is to evaluate the influence of the key factors on acceptance of OO technology. In particular, this research develops a new technology acceptance model, in which the idea of PBC of TPB (Ajzen, 1985; Ajzen & Madden, 1986) is incorporated into the original TAM framework.

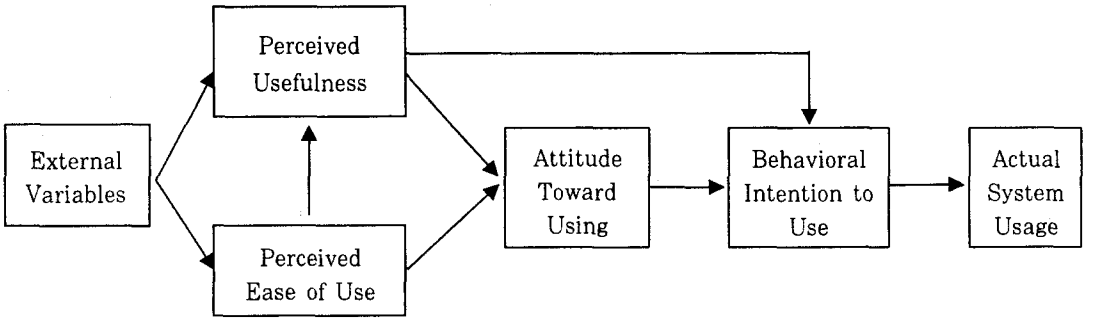
II. Theoretical Foundations

New technologies in IS are rapidly replacing old information technologies by providing more powerful tools for users. Not all of organization's attempts to launch a new technology are successful because successful implementation cannot be guaranteed unless organization members accept and effectively use it. Therefore, for the organization seeking to launch a new technology, it is essential to understand the acceptance process and to secure factors

that are essential to foster this process. With the rising importance of OO technology and organizations' endeavors to embrace this technology, the same demand is required. Nevertheless, research on OO technology has focused mainly on the technical and design aspects of OO (Detienne, 1995; Detienne & Rist, 1995; Pennington et al., 1995; Purao et al., 2002). Little research has been reported about the adoption process of OO technology.

Davis (1986) suggested a specific technology adoption model based on TRA and applied it to analyze computer usage behavior. In his model, every exogenous variable is assumed to precede two believes in a specific technology such as perceived usefulness and perceived ease of use. The perceived usefulness and ease of use are considered two predecessors affecting attitude toward a technology. The attitude toward a technology affects behavioral intention to use that technology and then the behavioral intention leads to actual usage of the technology. Several studies investigating determinants of the two believes have recently been conducted. Computer self-efficacy acts as a determinant of perceived ease of use, and objective usability does as a partial determinant (Venkatesh & Davis, 1996). Subjective norm, image, job relevance, and result demonstrability are empirically shown as determinants of perceived usefulness (Venkatesh & Davis, 2000). Although it provides a theoretical and practical meaning of the acceptance of computer technology, this model dealt exclusively with internal process of determining usage rather than with external factors affecting those internal processes (Davis, 1989). Furthermore, a critical review of this model concluded that significant factors such as human and social change processes are not included (Legris et al. 2003). 〈Figure 1〉 depicts the process of TAM.

〈Figure 1〉 The Technology Acceptance Model (TAM)



2.1 Theory of Planned Behavior

When Fishbein and Ajzen (1975) proposed TRA, they assumed that it works where the behavior is under the person's volitional control. Only when the behavior is under the person's total control, intention to perform a particular behavior is said to be a predictor of behavior. If the behavior is not completely under the person's control, it is assumed that the relationship between behavioral intention and actual usage will be attenuated (Ajzen, 1985). In an attempt to incorporate the behaviors over which people have incomplete volitional control, Ajzen (1985, 1991) and Ajzen & Madden (1986) proposed TPB. The essence of TPB is the concept of perceived behavioral control (PBC). Assuming that the performance of most behaviors depends on such non-motivational factors as requisite opportunities and resources, Ajzen (1985) thought that a person who has the required opportunities and resources (high perceived behavioral control) and intention to perform should succeed in performing the behavior.

Ajzen and Madden (1986) proposed two versions of TPB. In the first version, it was proposed that PBC emerges as a predictor of behavioral intentions. In the second version, it was proposed that PBC has both indirect and direct effects on actual behavior. According to Ajzen and Madden (1986), PBC has a direct effect on actual behavior when the person does not have complete control of the behavior.

Ajzen's (1985) argument about the role, components and placement of PBC provides a clue about external variables that were not adequately discussed in TAM. According to TPB, opportunities and resources available to the person are the components of PBC. The position of PBC enables the external variables to be placed ahead of behavioral intention and actual usage of technology. TPB differs from TRA because of its introduction of PBC. Most activities in the organization are not completely controlled by the person. Therefore, it would be more reasonable to reflect those situations in the model.

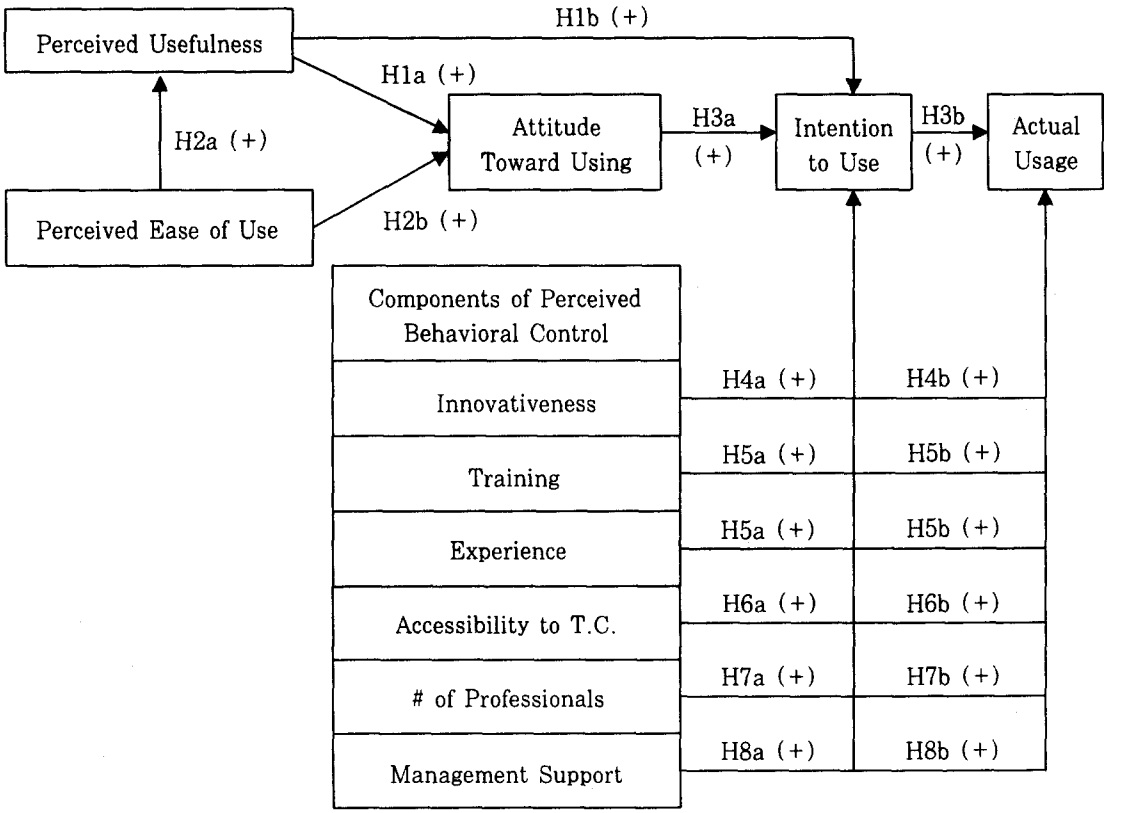
Although the placement of external variables in TAM is contradictory to that of external variables in TPB, and the situations to which TAM can be applied are more restricted, Igbaria et al. (1997) successfully found links between some of the exogenous variables and two endogenous variables (usefulness and ease of use). Venkatesh (1999) also challenged the basic assumption of complete mediation by TAM constructs. Following both the theoretical foundation of PBC and research findings of previous studies, this study proposes a new research model and compares the two models (TAM and the proposed model) to ascertain the correct placement and meaning

of exogenous variables in the acceptance process of OO technology.

III. The Proposed Model and Research Hypotheses

This research develops a new technology adoption model by incorporating the main concept of PBC of TPB into TAM. The difference between TAM and the new model is the placement of individual, managerial, and organizational variables. In the proposed model, the variables that were considered exogenous (preceding usefulness and the ease of use of technology) in the original model of TAM, are positioned to affect both the behavioral intention and actual behavior. 〈Figure 2〉 presents a schema of the newly developed model.

〈Figure 2〉 The Proposed Model for OO technology and research hypothesis



3.1 OO Technology Acceptance

Researchers have found that user satisfaction (Montazemi, 1988; Raymond, 1985; Yap et al., 1992) and system usage (Adams et al., 1992; Davis et al., 1989; Straub et al., 1995; Szajna, 1996) are two primary indicators of technology acceptance. Considering that managers are interested in the practical value of system usage (Straub et al., 1995), this study uses the level of actual usage of object-oriented programming as a measure of acceptance of object-oriented programming.

3.2 Perceived Usefulness, Ease of Use, Attitude Toward Using, and Behavioral Intention

Perceived usefulness was defined by Davis (1989: p320) as "the degree to which a person believes that using a particular system would enhance his or her job performance." Based on TRA, Davis et al. (1989) posited that perceived usefulness directly affects attitude toward using the technology and behavioral intention to use it. This study proposes the following hypotheses.

H1a: Perceived usefulness of object-oriented programming has a direct effect on attitude toward using the technology.

H1b: Perceived usefulness of object-oriented programming has a direct effect on behavioral intention of using the technology.

H1c: Perceived usefulness of object-oriented programming has an indirect effect on behavioral intention through attitude toward using the technology.

Davis (1989) defined perceived ease of use as "the degree to which a person believes that using a particular system would be free of effort (p. 320)." In TAM, perceived ease of use was posited to directly affect perceived usefulness and attitude. In addition to the direct effect on attitude, perceived ease of use was considered to have an indirect effect on attitude through perceived usefulness. Mathieson (1991) and Szajna (1996) showed that ease of use is a significant predictor of usefulness. Davis (1989), Davis et al. (1989), and Mathieson (1991) reported significant relationships between attitude and ease of use. Therefore, the following hypotheses are proposed.

H2a: Perceived ease of use of object-oriented programming has a direct effect on perceived usefulness of the technology.

H2b: Perceived ease of use of object-oriented programming has a direct effect on attitude toward using the technology.

H2c: Perceived ease of use of object-oriented programming has an indirect effect on attitude through perceived usefulness.

Building on the work of Igbaria (1993), attitudes toward using object-oriented programming refer to an individual's reaction to, evaluation of, and favorableness toward using the technology. In TRA, attitude was positioned to mediate the belief systems to behavioral intention of a particular behavior and behavioral intention was to mediate attitude to actual usage. Following TRA, in TAM, attitude toward using a technology was hypothesized to mediate the usefulness and ease of use to behavioral intention, which was then hypothesized to mediate attitude to actual usage of a technology. Though Davis et al. (1989) reported that attitude partially mediated the causal linkages between beliefs and behavioral intentions, and other researchers (Adams et al., 1992; Szajna, 1996) excluded attitude and behavioral intention in their research, these constructs are posited to play key roles in both TRA and TAM. Therefore, this study proposes the following hypotheses.

H3a: Attitude toward using object-oriented programming has a direct effect on behavioral intention of using the technology.

H3b: Behavioral intention of using object-oriented programming has a direct effect on actual usage of the technology.

3.3 Exogenous Variables of PBC

TPB posits a direct effect of exogenous variables on behavioral intention and actual usage through PBC, while TAM posits the direct effect of those variables on two belief constructs. PBC refers to individual's perceptions of "the presence or absence of requisite resources and opportunities" (Ajzen & Madden, 1986) provided by both individuals and organizations. This linkage was successfully proved by Mathieson (1991) and Thompson et al. (1991). Following the idea of PBC in TPB, this study investigates the process and effect of external variables on acceptance and usage of OO technology.

Individual characteristics. Zmud (1979) proposed a theoretical model to examine the effect of individual differences on the success of an information system. Since that study was published, individual characteristics have been reported to play a key role in MIS success. Leonard-Barton and Deschamps (1988) reported that factors connecting individuals and an organization are important than the general personality types or demographic factors. In particular,

these authors reported that personality difference (personal innovativeness) in the manners of facing change is a good predictor of successful technology implementation. When adopting a new technology, personality is expected to play an important role. A person with more innovative personality would be willing to try new things. Zmud (1984) found that innovativeness or receptivity toward change of an organization's members was an important determinant of innovation success. Following TPB's argument that individual factors affecting PBC have a direct relation with behavioral intention and actual usage, this study proposes the following hypotheses. Nevertheless, in an attempt to compare the two models, this study does not exclude the possibility of finding a relationship between the two belief constructs (perceived usefulness and ease of use) and personal innovativeness.

H4a: The more innovative a person is, the more likely he/she would intend to use object-oriented programming.

H4b: The more innovative a person is, the easier he/she would be to use object-oriented programming.

Gist (1987) reported that user training plays an important role in increasing user confidence in the ability to learn and use computers. This finding is meaningful in that it supports the idea of PBC of TPB. Ajzen (1985) referred to internal factors such as information, skills, and abilities as sources of deciding the level of PBC, in which training has been used as a way to increase individual skills and abilities of corresponding works. Raymond (1990) argued that computer training is a significant predictor of personal computing acceptance. It was also found that training had a positive impact on technology acceptance (Amoroso & Cheney, 1991; Igbaria et al., 1995). In addition, user experience of computer technology was also found to have a positive effect on system usage (Delone, 1988; Fuerst and Cheney, 1982; Igbaria et al., 1995). TPB and these prior research findings make it plausible that the length of training and experience directly affect behavioral intention of using object-oriented programming and actual usage of the technology. Therefore, this study proposes the following hypotheses.

H5a: The longer the training period about object-oriented programming, the more likely an individual would have intention to use the technology.

H5b: The longer the training period about object-oriented programming, the easier it would be for an individual to use the technology.

H5c: The more experience one has with

computer technology similar to object-oriented programming, the more likely he/she would have intention to use the technology.

H5d: The more experience one has with computer technology similar to object-oriented programming, the easier he/she would use the technology.

Organizational support. Former studies have recognized organizational support as one of the crucial factors affecting successful adoption of system (Fuerst and Cheney, 1982; Igbaria et al., 1995; Igbaria, 1993; Igbaria et al., 1997). This study identifies two broad areas of organizational support: (1) technical support, which includes getting access to technology champions inside the organization and the number of IS professionals in a working group; and (2) management support, which includes management encouragement and sufficient resource allocation. Igbaria et al. (1997) found that external computing support has a strong influence on personal computing acceptance; however, little research has been done with the effect on technology acceptance of internal technical support. Rothwell and Zegveld (1985) describe a product champion as a person who can contribute to an organization as a business innovator, technological gatekeeper, and problem solver. Likewise, technology champions in information systems must be information gatekeepers about new information technologies, problem solvers, and helpers. The IS professionals in a working group may affect other members' perceptions of using OO technology. Accordingly, this study proposes the following hypotheses.

H6a: The easier the accessibility to technology champions inside the organization, the more likely he/she is to have the intention to use object-oriented programming.

H6b: The easier the accessibility to technology champions inside the organization, the more likely he/she is to use object-oriented programming.

H7a: The greater the number of IS professionals in a working group, the more likely he/she is to have the intention to use object-oriented programming.

H7b: The greater the number of IS professionals in a working group, the more likely he/she is to use object-oriented programming.

The effect of management support on system usage has been widely researched and strongly proved (Igbaria, 1994; Igbaria et al., 1995; Igbaria et al., 1997; Kwon and Zmud, 1987). In particular, management

support is found to be associated with greater system usage and lack of management support is regarded as a major barrier to the utilization of computers (Fuerst and Cheney, 1982; Lucas, 1978). Reflecting the role and position of PBC in this research, this study proposes the following hypotheses.

H8a: The stronger the management support, the more likely he/she to have the intention to use object-oriented programming.

H8b: The stronger the management support, the more likely he/she to use object-oriented programming.

Ⅳ. Methodology

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 to solicit their members' participation in this survey. Subsequently, lists of DPMA directories were obtained with their permission. Eight hundred fifty-four questionnaires were sent to the members of nine chapters across four mid-western states. One hundred twenty-seven subjects responded to the questionnaires (the response rate = 14.9%). A reason why the response rate was relatively low may be that use of object orientation technology was still relatively new to the DPMA members at the time of the study. 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 study.

Eighty-eight 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 gender distribution was: males - 78 percent; females - 22 percent. 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 (See 〈Table 1〉).

4.2 Measures

The means, standard deviations, and the internal consistency estimates (Cronbach's alpha) about the research variables with more than one item are shown in 〈Table 2〉.

Research variables for this study are as follows:

〈Table 1〉 Descriptive statistics of respondents

Classification	Number (%)
Age	Mean = 43.4
Under 30	2 (1.8%)
31 - 40	39 (35.8%)
41 - 50	44 (40.4%)
51 - 60	23 (21.1%)
Over 61	1 (0.9%)
Gender	
Male	85 (78.0%)
Female	24 (22.0%)
Job Title	
Technical Staff	21 (19.3%)
Programmer/Analyst	10 (9.2%)
Supervisor	42 (38.5%)
Manager	12 (11.0%)
Director/Vice President	18 (16.5%)
Others	6 (5.5%)
Final Degree	
High School	6 (6.5%)
Special College/Bachelor	76 (69.7%)
Master	22 (20.2%)
Doctorate	5 (4.6%)
Major Area of Study	
Natural Sciences	6 (5.5%)
Applied Science	28 (25.7%)
Engineering	6 (5.5%)
Business Administration	44 (40.4%)
Social Sciences	14 (12.8%)
Unknown	11 (10.1%)
Years of Job Experience	Mean = 18.0
Under 10 Years	24 (22.0%)
11 - 20	46 (42.2%)
21 - 30	33 (30.3%)
Over 31 Years	6 (5.5%)
Management-Oriented Tasks	Mean = 35.3
Under 25%	48 (44.0%)
26 - 50	41 (37.6%)
51 - 75	10 (9.2%)
Over 76%	10 (9.2%)
Total	109

〈Table 2〉 Summary statistics and Cronbach's alpha for each scale with more than two items

Scale	Mean	SD	Alpha
Management support	12.10	3.14	.5629
Personal innovativeness	14.19	3.02	.8022
Usefulness for Programming	12.57	3.86	.9409
Ease of Use for Programming	12.70	3.12	.8514
Attitude for Programming	9.63	2.75	.9018
Intention for Programming	6.58	1.94	.9182
Actual Usage for Programming	3.81	2.36	.9413

(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. An exploratory factor analysis with these six items supported for a single factor. Four items out of six items were used for final data analysis which indicated maximum internal consistency estimate (Cronbach's alpha = .9409). 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, 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 programming." 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 = .8514). 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) Attitude: The attitude scale, developed by Davis (1989), was tested with three items. These items have 5-point Likert type format in which the one represents strong disagreement and the five represents strong agreement after being reworded for this research. An exploratory factor analysis showed that these three items are loaded on a single factor (one eigenvalue > 1.0). The internal consistency estimate mea-

sured by Cronbach's alpha is very high (= .9018).

(4) Intention: The intention scale, based on Mathieson (1991), was adjusted to measure users' perception about object-oriented programming. These two items have 5-point Likert type format. An exploratory factor analysis showed that these three items are loaded on a single factor (one eigenvalue > 1.0). The Cronbach's alpha is very high (= .9182).

(5) 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). Four items of these seven items were used for statistical analysis, which indicated maximum internal consistency estimate (Cronbach's alpha = .8022). Confirmatory factor analysis in which one factor was forced told that every single item was loaded on this single factor with significant t-value.

(6) Management support: Based on the research findings by Leonard-Barton & Deschamps (1988), the stronger management support is, the easier new technologies are adopted. The authors selected this scale as a good predictor for the adoption of the object-orientation paradigm. To measure the management support, the authors used four items with five-point Likert type format. One of the items used for this research is "Management support for the object-orientation paradigm is strong." An exploratory factor analysis supported a single factor (one eigenvalue > 1.0). Internal consistency estimate of this scale is fairly low (Cronbach's alpha = .5629).

(7) Accessibility to technology champions: Based on the research of Alexander (1989), the easier the accessibility to technology champions, the easier a person is likely to accept new technologies. The authors selected this

scale as a good predictor for the adoption of the object-orientation paradigm. This scale with five-point Likert type format, developed by Alexander (1989), was used to test how easily respondents can get access to and advice from technology experts in their organization.

(8) Amount of experience with structured methods, formal training period on the object-orientation paradigm, and number of professionals in a working group were also collected. One example of these scales is "How many total days of formal training have you received about using the object-orientation paradigm?" These predictor variables for the adoption of the object-orientation paradigm were selected: the shorter the experience of different technology and the longer the training period for the object-orientation technology and the more professionals in an organization, the easier people adopt the object orientation.

(9) Actual usage: Based on the scale developed by Davis (1989), the degree of actual usage of the object orientation was measured. One example of these scales is "How many times do you use the object-oriented programming?" Cronbach's alpha for this variable is 0.9413.

4.3 Data Analysis

A covariance matrix was used as an input to the LISREL 8 program (Joreskog & Sorbom, 1993) to analyze the structural model of this research. The estimation method used for the current research is maximum likelihood (ML). The covariance matrices are presented in 〈Table 3〉. Management support, usefulness, ease of use, attitude and intention were represented by the total scores on these scales.

Based on the Technology Acceptance Model (TAM), the original path model can be described as follows. The personal innovativeness, experience with the structured methods, management support, length of training period, accessibility to champions and the number of IS professionals in the organization are hypothesized to directly influence usefulness and the ease of use. The ease of use and usefulness are hypothesized to mediate the influence of all exogenous variables but to affect the attitude and behavioral intention directly. In particular, usefulness is hypothesized to mediate the influence of the ease of use on attitude and behavioral intention. Finally, behavioral intention is hypothesized to affect the actual usage. The proposition of this model, based on TAM, is that all of the exogenous variables are hypothesized to affect the actual usage indirectly through

〈Table 3〉 Covariance matrix

	usage	use.	ease.	atti.	int.	# pro.	train.	acce.	exp.	innov.	sup.
usage	1.77										
usefulness	1.75	14.95									
ease of use	1.62	9.13	10.16								
attitude	1.32	8.30	5.96	7.49							
behavioral intention	0.89	5.91	4.09	4.42	3.73						
# of professionals	-.24	-2.20	-1.90	-.70	-.69	3.21					
training	.90	.66	.96	.21	.20	.01	2.41				
accessibility to T.C.	.31	.58	.41	.67	.43	.27	.41	1.30			
experience	1.78	-5.92	-3.55	-3.81	-1.79	-.79	-1.48	.20	99.62		
innovativeness	1.10	.02	.05	.51	.29	-.41	.73	.06	3.93	9.31	
support	1.22	2.32	.65	1.19	.99	.35	.84	1.37	-1.68	.63	9.25

the ease of use, usefulness, attitude, and intention (see 〈Figure 1〉).

A new model, which can better explain the acceptance processes of the object-oriented programming, is proposed by incorporating individual, managerial, and organizational characteristics into the original TAM model and by changing the positions of these variables in accordance with the theory of planned behavior. In this proposed model, except for the perceived usefulness and ease of use of object-oriented programming, all the exogenous variables (the length of formal training, personal innovativeness, managerial support, number of professionals, accessibility to technology champion, and personal experience with previous technology) are hypothesized to affect both behavioral intention and actual usage of the object-oriented programming. These relationships are in accordance with the role of the perceived behavioral control (PBC) based on the theory of planned behavior. The usefulness and ease of use are hypothesized to affect the attitude toward object-oriented programming, and then the attitude and usefulness are hypothesized to affect behavioral intention. The actual usage of object-oriented programming is then affected by behavioral intention along with the perceived behavioral control variables. In the proposed research model, therefore, the usefulness and ease of use are shifted from endogenous variables to exogenous variables. 〈Figure 2〉 concisely shows the relationships among the research variables in the proposed model.

V. Results

An initial test of the proposed model and TAM model showed several paths with non-significant t-values. These paths were deleted one at a time and each time the model was re-estimated. The standardized path coefficients based on the initially proposed model are presented in 〈Table 4〉 and 〈Figure 3〉. The final model was obtained by deleting all paths with non-significant t-values as shown in 〈Figure 4〉.

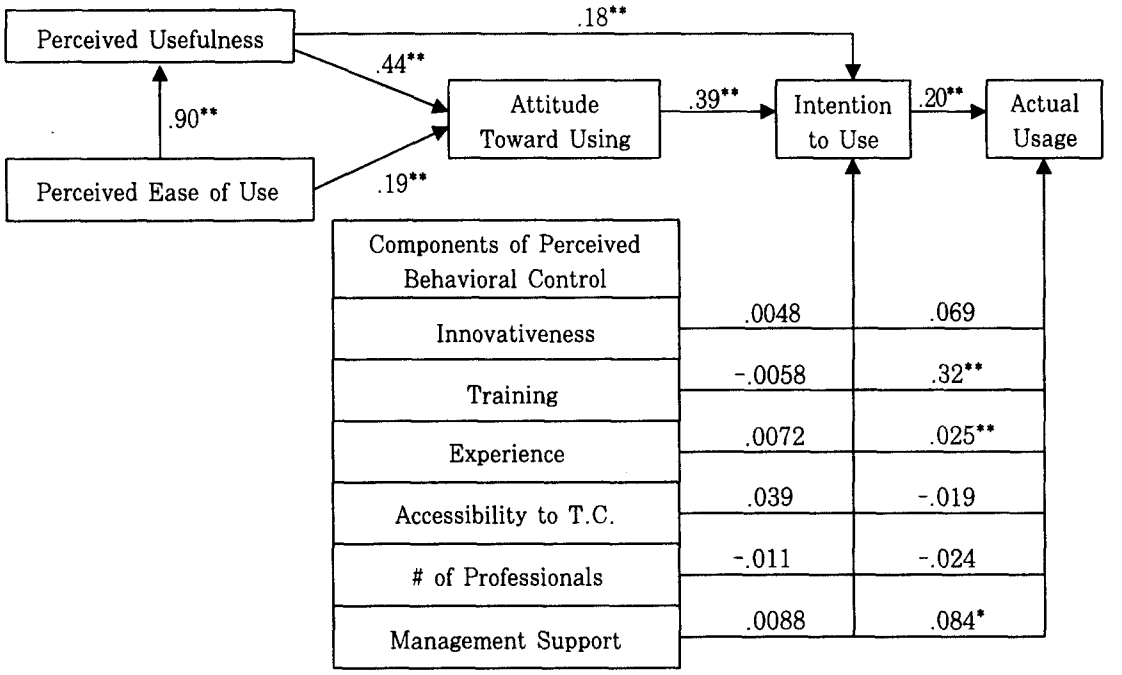
As expected, relationships of core variables of the original TAM model are strongly supported in the case of object-oriented programming acceptance. Perceived usefulness of object-oriented programming has a direct effect on attitude and direct and indirect effect on behavioral intention of using the technology (Path coefficients: H1a =.44, H1b =.18; Probabilities: <.01; Indirect

〈Table 4〉 Standardized path coefficients for the initially proposed model

Parameter	Standardized Path Coefficient
ease of use to usefulness	.90**
usefulness to attitude	.44**
ease of use to attitude	.19**
attitude to intention	.39**
usefulness to intention	.18**
training to intention	-.0058
innovativeness to intention	.0048
support to intention	.0088
# of professionals to intention	-.011
accessibility to T.C. to intention	.039
experience to intention	.0072
intention to usage	.20**
training to usage	.32**
innovativeness to usage	.069
support to usage	.084*
# of professionals to usage	-.024
accessibility to usage	-.019
experience to usage	.025**

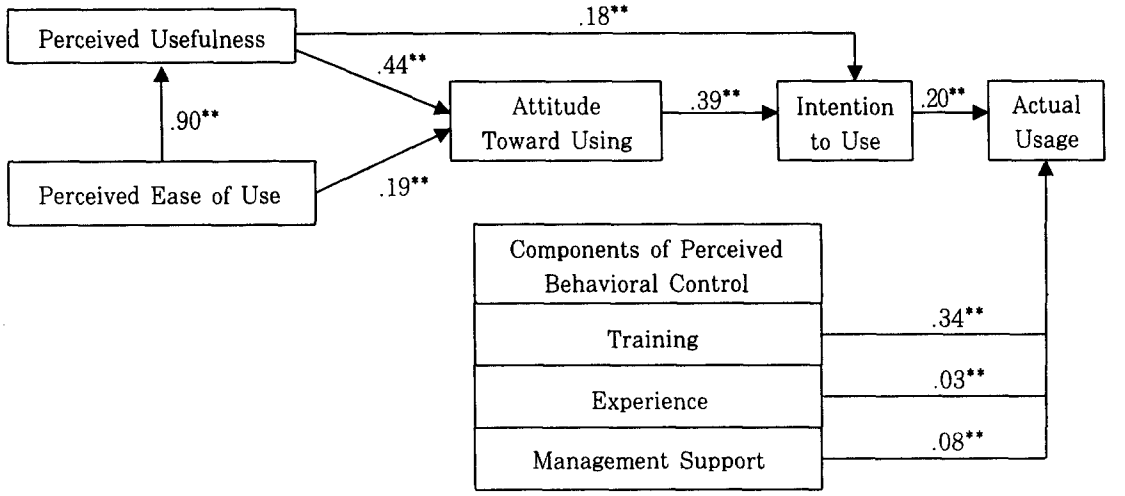
** < .01, * < .05

〈Figure 3〉 Standardized path coefficients for the initially proposed model



** < .01, * < .05

〈Figure 4〉 Standardized path coefficients for the final model



** < .01, * < .05

effect for H1c =.18)). The perceived ease of use of object-oriented programming has a direct effect on perceived usefulness of the technology and direct and indirect effect on attitude through perceived usefulness of object-oriented programming (Path coefficients: H2a =.90, H2b =.19 ; Probabilities: <.01; Indirect effect for H2c = .40). It is proved that attitude toward using object-oriented programming has a direct effect on behavioral intention and that behavioral intention of using object-oriented programming has a direct effect on actual usage of the technology (Path coefficients: H3a = .40, H3b = .21; Probabilities: <.01).

From 〈Figure 4〉, the perceived behavioral control variables such as training, experience with related technology, and management support are shown to influence actual usage directly without being mediated by other variables (Path coefficients: H5b = .34; H5d = .03; H8b = .08; Probabilities: <.01, <.05 (H8b)). Other perceived behavioral control variables such as the number of professionals and accessibility to technology champions do not significantly influence both behavioral intention and actual usage.

Contrary to expectations, the length of training period, experience, and managerial support do not have significant relationships with behavioral intention. The number of professionals, accessibility to technology champions, and personal innovativeness do not affect both behavioral intention and actual usage.

〈Table 5〉 shows that decomposition of the effects of exogenous variables on actual usage confirms the previous results. This table manifests that there are only direct effects on actual usage of behavioral intention, experience, length of training period, and management support, whereas the remaining variables have indirect effects on the actual usage.

The values of several goodness of fit indices for the original TAM and the proposed model are shown in 〈Table 6〉. Bentler and Bonnett (1980) suggested NFI (Normed Fit Index) that could be interpreted as an improvement in the fit of the hypothesized model over a baseline model. Because a better model-fit can always be obtained by adding parameters to the model, James, Mulaik, and Brett (1982) have proposed PNFI (Parsimonious Normed Fit Index) that gains the improvement in the model fit at the expense of degrees of freedom. In addition to these, the conventional chi-square statistic is reported for testing the goodness of fit of the models in this research. Except for the chi-square value, larger values are desirable for NFI and PNFI. In addition, a single sample cross-validation index (ECVI) is used (Browne & Cudeck, 1989).

As can be seen in 〈Table 6〉, compared to the original TAM model, the proposed model

〈Table 5〉 Decomposition of the effects using the final model

Direction	Effects		
On usefulness	Direct	Indirect	Total
of ease of use	.90		.90
On attitude			
of usefulness	.44		.44
of ease of use	.19	.40	.59
On Intention			
of attitude	.40		.40
of usefulness	.18	.18	.36
On Usage			
of intention	.21		.21
of innov			
of training	.34		.34
of experience	.03		.03
of support	.08		.08
of attitude		.08	.08
of usefulness		.08	.08
of ease of use		.02	.02

〈Table 6〉 Goodness of fit indices for the TAM and proposed models

Model	Chi-Square	df	Prob.	NFI	PNFI	ECVI
TAM model (model 1)	49.07	22	<.01	.87	.35	1.71
Trimmed TAM(model 2)	35.44	16	<.01	.90	.51	.91
Proposed model(model 3)	24.45	16	.08	.94	.27	1.58
Final model (model 4)	13.50	13	.41	.96	.45	.73

in this research is interpreted as having a better model fit. The proposed model (model 3) has significantly better fit than the original TAM model (model 1). The comparison between two trimmed models tells that the finally trimmed model (model 4) has significantly better fit than the TAM model (model 2). The model comparison index in 〈Table 7〉, based on the chi-square difference test between the proposed model and the original TAM model, confirms that the proposed model has significantly impro-

〈Table 7〉 Model comparisons with chi-square difference test

Comparisons	Chi-square	df
Model 1 to Model 3	24.62**	6
Model 2 to Model 4	21.94**	3

** < .01

ved over the original TAM model.

In conclusion, it is clearly evident that the proposed model presented in this paper is an improvement over the original TAM model not only in explaining the effects of exogenous variables on technology adoption but also in interpreting their relationships.

VI. Discussion and Conclusion

This research has replicated most of previous research's findings. In line with the findings by Davis (1989), usefulness and the ease of use of object-oriented programming are found to influence the actual usage of this technology through attitude and behavioral intention. While this research includes the concept of the planned behavior (Ajzen, 1991), the main idea of TAM is also confirmed.

This study investigated the difference between the TAM and a proposed model. According to the results of goodness of fit indices, the proposed model is superior to TAM. The main difference between these two models is the position of exogenous variables. In the proposed model, usefulness and the ease of use variables are shifted from endogenous variables as in TAM to exogenous variables. In addition, individual, managerial, and organizational variables, which are located ahead of usefulness and the ease of use in the original TAM, are shifted to precede behavioral intention and actual usage (see 〈Figure 2〉).

The comparison of these two models through the goodness of fit indices demonstrates that the proposed model shows better model fit than TAM. These results are very encouraging in that the proposed model showed a potential role of perceived behavioral control for adoption of new technologies. According to TAM, which does not include the concept of perceived behavioral control, every exogenous variable (individual, managerial, and organizational) is assumed to directly influence the usefulness and ease of use of a new technology. With the concept of perceived behavioral control, this research found that it would be better to directly relate these exogenous variables to behavioral intention and actual usage rather

than to relate these variables to usefulness and the ease of use. Though Venkatesh and Davis (2000) suggest the extended TAM by introducing the subjective norm concept into TAM, this research incorporates the concept of perceived behavioral control into the TAM in order to advance technology acceptance theory.

With regard to the effects of research variables on technology adoption, most of the results of this study are in line with those of the previous research. Individual experience (Hill et al., 1987), management support (Leonard-Barton & Deschamps, 1988), and the length of training period (Alexander, 1989) were shown to critically influence the adoption of OO technology. Contrary to the previous research, the other variables such as the accessibility to technology champions (Alexander, 1989) and the number of IS professionals in the organization (Zmud, 1984) were not shown to significantly influence the adoption of OO technology. These unexpected results might be derived from two possibilities. First, this study had a relatively small sample size, and it might have produced biased statistical results. Second, the multi-collinearity among the research variables might have caused this result.

Even though TAM has been widely used for studying the adoption process of new technologies, TAM seems to overemphasize the technology-related variables such as usefulness and the ease of use. This research attempted to overcome the limitations of TAM by incorporating the concept of perceived behavioral control.

The current research has some limitations. First, compared to the number of estimated parameters, the sample size is somewhat small. Bentler and Chou (1987) recommended that the ratio of the sample size to the number of free parameters be at least 10:1. In light of this criterion, this research could have produced some unstable estimation of parameters. For small sample sizes, ML (Maximum Likelihood) or GLS (Generalized Least Squares) estimates would be helpful, and the parameter estimates of this study might not be too much out of line. Second, some of the measurement items used for this study do not show univariate normal distribution measured by kurtosis and skewness criteria. This problem could have exaggerated the chi-square value and lowered SEs and parameter estimates. But in the sense that most items have an appropriate normal distribution, it could be said that this problem should not seriously affect this research. Third, the sample was collected from the mid-west area of the U.S., and the data might be a little out of date. This fact might limit the external validity of this research.

This study mainly focused on the role of

perceived behavioral control variables in relation to their affecting OO technology acceptance, which is theorized based on TPB. Important is the finding that these variables directly affect OO technology acceptance without being mediated by perceptual variables such as the perceived usefulness and the ease of use of the technology, which was proposed by the original TAM. However, the detailed mechanism is not revealed of how these PBC variables affect acceptance of OO technology. Future research is required to investigate this area and to provide a strong theoretical foundation for another robust technology acceptance model.

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객체지향 컴퓨팅에 하이브리드 기술수용모형의 적용*

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Abstract

기술수용모형(TAM: Technology Acceptance Model)은 정보기술과 관련된 수용행위를 설명하는데 광범위하게 사용되었다. 하지만 이전 다수 연구에서는 기술수용모형이 복잡한 정보기술의 수용 혹은 채택 과정을 효과적으로 설명하지 못하는 것으로 나타났다. 본 연구는 기술수용모형의 한계점을 지적하고, 계획된 행동이론(TPB: Theory of Planned Behavior)에 기반을 둔 지각된 행동통제(PBC: Perceived Behavioral Control)라는 개념을 기술수용모형에 결합한 새로운 연구모형을 제시한다. 본 연구는 기존의 기술수용모형과 새로운 모형을 객체지향 프로그래밍의 경우에 적용하여 두 모형을 비교한다.

본 연구의 결과는 계획된 행동이론의 개념을 도입함으로써 외생변수(External Variables)와 기술수용(Technology Acceptance)의 관련성을 명확하게 설명할 수 있었다. 전반적으로 볼 때 본 연구에서 개발된 모형이 객체지향 프로그래밍의 수용과정을 설명함에 있어서는 기술수용모형보다 더 나은 모형임을 실제로 증명하였다. 이 연구결과는 이전의 연구에서 지적된 바와 같이 기술수용모형이 복잡한 정보기술의 수용과정을 설명하는데 한계가 있다는 사실을 간접적으로 시사하고 있으며, 본 연구에서는 지각된 행동통제라는 개념을 도입한 새로운 연구모형(Hybrid Technology Acceptance Model)의 타당성을 입증하였다. 본 연구에서 사용된 독립변수 중에서 훈련기간, 조직차원의 지원, 그리고 개인의 경험이 객체지향 프로그래밍의 수용에 영향을 주는 것으로 나타났다.

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