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A Structural Equation Model for ICT Usage in Higher Education

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ABSTRACT

This study focuses on Information and Communication Technologies (ICT) usage, which is the indicator of diffusion. A model composed of the variables which can explain ICT usage in Turkish higher education is established and tested within the study. The two dimensions of ICT usage are considered: instructional and managerial. The data collected from 814 faculty members in Turkey were used to test the model by using LISREL 8.72; it explained 61% of the faculties ICT use, with a good model fit. The model supposes that the perceived attributes of ICT and ICT facilities in the universities predict the ICT use. The faculty members make use of ICT most as a means of communication and for searching for information about the course through the Internet; and the least, for publishing their lecture notes and the announcements concerning the course-assignments, projects-on WWW.

Keywords

Diffusion of innovation, adoption, Higher education, ICT usage, Perceived attributes

With the ongoing development of ICT and the diversification of the fields it affects, various theoretical studies have been carried out in order to ensure better understanding concerning its diffusion, adoption, acceptance, and usage (Davis, 1989; Taylor & Todd, 1995; Venkatesh & Davis, 2000; Rogers, 2003; Venkatesh, Morris, Davis, and Davis, 2003; Yi, Jakson, Park, and Probst, 2006).

In this study, the concept ICT "usage" is preferred since it is believed that usage is an indicator of adoption, acceptance as well as diffusion. In his Diffusion of Innovation (DoI) theory Rogers (2003) mentions that the rate of adoption is partially influenced by perceived attributes named as innovation characteristics which are relative advantage, compatibility, trialability, complexity, and observability. The relative advantage, compatibility, trialability, observability of an innovation, as perceived by members of a social system, are positively related to its rate of adoption; on the other hand the complexity of an innovation, as perceived by members of a social system, is negatively related to its rate of adoption.

The theory is used to explain the diffusion of innovation in numerous fields such as medicine, agriculture, and information technologies. Rogers (2003, p. 223) stated that, "The first research on attributes of innovation and their rate of adoption was conducted with farmers, but studies of teachers and school administrators suggested that similar attributes predict the rate of adoption for educational innovation." Bussey, Dormody, and VanLeeuwen (2000) stated that the strongest predictor of the level of adoption of technology education was the perception of the teacher of the attributes of technology education. The researchers also concluded that Rogers' theory of perceived attributes can be a valuable tool for instructional developers working to increase the utilization of their products.

There is a consensus on the idea that the prediction power of certain innovation characteristics is different from the prediction power of other innovation characteristics; while, there is a disagreement about innovation characteristics. For instance, Aşkar, Usluel, and Mumcu (2006) stated that complexity or ease of use was found to be a common perceived innovation characteristic for teaching delivery, preparation, and managerial tasks in schools; observability is a perceived attribute in teaching delivery in some specific tasks performed during the class period whereas relative advantage and compatibility are for teaching preparation tasks. Yi et al. (2006) reported that the conclusion of

subsequent studies put evidence that relative advantage, complexity, result demonstrability, and image are among the most important factors in predicting users' intentions to make use of technology. In a study on the use of the Internet as an instructional tool carried out in Brasil (Martins, Steil, and Todesco, 2004) it is found out that two most significant predictors are trialability and observability. Mumcu (2004) highlighted in her research that there is a positive relationship between relative advantage, compatibility, and visibility with the use of ICT in vocational and technical schools. Surry and Gustafson (1994) concluded that compatibility, complexity, and relative advantage can be important considerations when introducing an innovation into instructional settings.

A study focused on perceived innovation characteristics and the differences in prediction powers concludes that it may be related to the innovation itself, the usage of innovation, and culture. In an intercultural study carried out in three countries, Japan, Switzerland, and the United States, making use of Technology Acceptance Model, the results indicate that TAM holds for both the U.S. and Switzerland, but not for Japan, suggesting that the model may not predict technology use across all cultures (Straub, Keil, and Brenner, 1997).

Hence, the aim of this study is to study the dimensions of the ICT usage of faculty members in Turkey by perceived attributes and ICT facilities.

Literature Review

Li (2004) carried out a study on faculty perceptions about attributes and barriers effecting the diffusion of Web-based distance education (WBDE) at China Agricultural University (CAU), in which he concluded that CAU faculty tended to agree with the existence of the five attributes of WBDE (relative advantage, compatibility, complexity, trialability, and observability). Professional area, gender, age, the level of education, and academic rank had no significant influence on the five perceived attributes. Teaching experience had no significant influence on the five perceived attributes, except compatibility. Distance education experience had no significant influence on the five perceived attributes, except compatibility and observability. The faculty members' stage in the innovation-decision process, did have a significant impact on faculty perception about compatibility, complexity, trialability, observability of WBDE, and WBDE program credibility as a perceived barrier. Relative advantage, compatibility, complexity, and trialability were correlated with at least one of the ten barriers. Observability was not related to any of the barriers. In their study based on Technology Acceptance Model, Yi et al. (2006) concluded that user perception of result demonstrability was a significant determinant of both perceived usefulness and perceived ease of use, indicating that when an innovation generates job relevant results that are readily discernible, perceptions of usefulness, and ease of use are considerably affected.

Bennett and Bennett (2003), who studied the impacts of perceived characteristics of instructional technology on faculty members' willingness to integrate it in their teaching, found out that the most important factor which impedes the use of technology in higher education is not the lack of technological facilities or financial funds, but faculty members' reluctance and their disbelief in the use of technology.

Medlin (2001) studied different variables and identified the factors which are likely to affect teachers' decisions on making use of electronic technologies throughout the teaching process and found out that the personal motivation is an important factor which forces faculty members to improve their teaching methods and contribute to the learning of students by technological means.

Ma, Andersson, and Streith (2005) obtained that : (1) the student teachers' perceived usefulness of computer technology had a direct significant effect on their intention to use it; (2) the student teachers' perceived ease of use had only an indirect significant effect on intention to use; however, (3) the student teachers' subjective norm, that is the possible influence of external expectations did not have any direct or indirect significant effect on their intention to use computer technology.

Although potential user perceptions are defined in various studies as significant variables to explain ICT usage, ICT usage depends first on whether there are enough ICT facilities. The research studies focusing on the barriers to use ICT reveal that the insufficiency or lack of ICT facilities appears as significant barriers (Beggs, 2000; Bussey et al., 2000; Lee, 2000; Braak, 2001; Butler & Sellbom, 2002; Mumcu & Usluel, 2004; Usluel & Seferoğlu, 2004).

Higher Education in Turkey

Formal education in Turkey includes preschool education, basic education, secondary education, and higher education. The Ministry of National Education is responsible for all educational services in the country excluding higher education. The Council of Higher Education is the planning, coordinating and policy making body for higher education (YÖK, 2005a).

In 1981, the Turkish higher education system entered a process of restructuring, and the institutions functioning within the scope of higher education were assembled under the framework of the Higher Education Council (YÖK, 2005b). Today, the Higher Education Council, whose functions as an autonomous organization within the framework of duties and authorities granted by the relevant articles of the Constitution, affiliates a total of 77 universities: 53 state universities and 24 private universities (YÖK, 2005b). Each university consists of faculties and four-year schools, offering bachelor's level program, and two years vocational schools offering pre-bachelor's (associate's) level program of a strictly vocational nature. Graduate-level programs consist of masters and doctoral program, coordinated by institutes for graduate studies.

Admission to higher education is centralized and based on nationwide examinations administered by the Student Selection and Placement Center every year. The center was established in 1974 and is affiliated with the Council of Higher Education. Each year approximately one and half million students take Student Selection and Placement Center Exam and approximately one third of these students is placed into a higher education program.

The increases in the number of university students and in the number of students who wish to study in a university brings up the need use of opportunities provided by ICT facilities in the universities. It is believed that ICT plays a significant role though it is not the only factor, in coping with the increasing demand for universities.

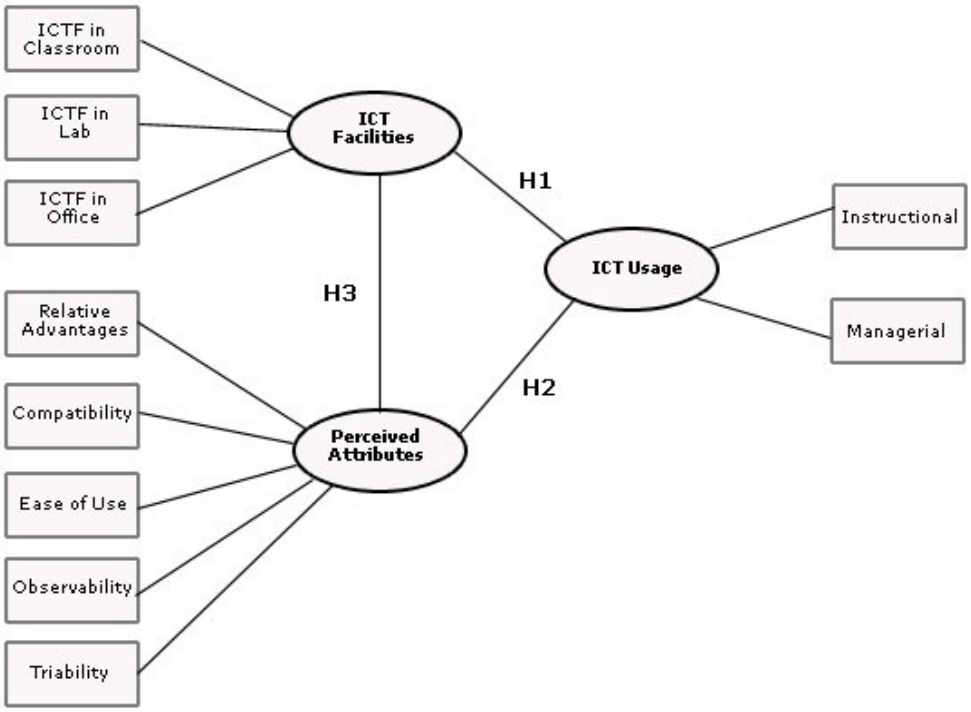

Figure 1. Proposed structure model for the ICT usage

Research Model and Hypotheses

In this study, a research model which is based on the DoI explains the ICT usage for higher education. It consists of ICT facilities (ICTF) and five perceived attributes: relative advantage, compatibility, ease of use, observability, and trialability. Several previous studies have shown that there are various external factors that influence the adoption of

innovation (Davis, 1989; Venkatesh & Davis, 2000; Venkatesh et al. 2003). In this study we expect ICTF to be an external factor affecting the usage of ICT for higher education.

The research model is shown in Figure 1.

The following three hypotheses are proposed:

H1. ICT facilities have a positive effect on the ICT usage

H2. Perceived attributes have a positive effect on the ICT usage

H3. ICT facilities have a positive effect on the perceived attributes

Research Method

Survey research was used in this study. The research group consist of faculties who answered the online questionnaire.

Research Group / Subjects

834 faculty members working in 22 universities overall Turkey. As mentioned, there is a total of 77 universities, 53 state and 24 private universities in Turkey, and according to the data of 2003-2004 academic year 77,065 faculty members are working in these universities (YÖK 2005c). It can be concluded that the research group represents the population in terms of gender and titles, considering the percentages in the population illustrated in Table 1.

Table 1. Profile of the subjects

		Research Group		Population in Turkey	
		frequency	**%**	**frequency**	**%**
Gender	Female	320	38.4	29653	+38.4
	Male	514	61.6	47412	61.5
Age	20-25	36	4.3		
	26-30	159	19.1		
	31-35	190	22.8		
	36-40	176	21.1		
	41-45	125	15.0		
	46-50	65	7.8		
	51-55	39	4.7		
	56-60	33	4.0		
	61-65	9	1.1		
	65+	2	0.2		
Title	Prof. Dr.	109	13.1	10.688	13.9
	Assoc. Prof. Dr.	76	9.1	5.121	6.6
	Assist. Prof. Dr.	187	22.4	13.266	17.2
	Instructor	223	26.7	19.564	25.4
	Assistant	239	28.6	28.426	36.9

Among the faculty members in the research group 38.4% (320 people) are female, and 61.6% (514 people) are male. Majority of the respondents are in 26-45 age group. The most populated one is 31-35 age group with 190 respondents (22.8%). Then come 36-40 age group (21.1%) and 26-30 age group (19.1%). The least represented one is 65+ age group with 2 respondents.

The distribution of respondents by their title is as follows: Research Assistant (28.6%), Instructor (26.7%), Assistant Prof. Dr. (22.4%), Associate Prof. Dr. (9.1%), and Prof. Dr. (13.1%).

Instruments

A questionnaire and a scale were administered to faculty members in this research. The questionnaire is composed of 8 questions concerning the demographic features of faculty members, 2 questions concerning the duration of using ICT, a 5-item question concerning ICT facilities, a 3-item question concerning the accessibility of ICT and a 10-item question concerning the purposes of using ICT.

"Perceived Attributes of ICT Scale" for faculty members was developed. While preparing the items of the scale, the instrument which was developed by Moore and Benbasat (1991) was considered. The scale is composed of 10 items anchored with notations: 9-10=almost always true, 1-2=almost never true was used to design the scale. Cronbach's α was used for reliability estimates. The findings were, 0.93 for the relative advantage, 0.86 for compatibility, 0.92 for complexity/ease of use, 0.74 for observability, 0.81 for trialability.

The items, the means, the standard deviations and Cronbach's α values are summarized and listed in Table 2. For the factorial validity, confirmatory factor analysis was utilized. The result was shown in Appendix 1 with the covariance matrix.

Table2. Summary of descriptive statistics of items in the scale

	Mean	SD	α
Relative Advantage			**0.93**
• ICT usage ensures that I carry out my task more rapidly	9.06	1.775	
• ICT usage facilitates the fulfillment of my tasks	9.12	1.693	
Compatibility			**0.86**
• ICT usage is appropriate for my profession in all aspects	8.45	2.031	
• ICT usage is appropriate for my working style	8.56	1.977	
Complexity/ease of use			**0.92**
• It is easy for me to learn to use ICT	8.22	2.079	
• It is easy for me to carry out my tasks by using ICT	8.13	2.038	
Observability			**0.74**
• I see what my colleagues do by using ICT	7.80	2.219	
• I observe easily that others in the department use ICT	7.13	2.498	
Trialability			**0.81**
• I can have access to and try ICT and other relevant applications	7.87	2.082	
• I had the opportunity to try out how I can make use of ICT in my profession	8.39	2.067	

Data Collection

The instrument was online and replied by the respondents via the Internet (http://www.bity.hacettepe.edu.tr). An electronic mail message which explains the aims of the research and contains the link to the online instruments was sent to the respondents.

Analysis and Results

The ICT facilities, the faculty members' usage of ICT and their purposes for using ICT are provided by percentages and frequencies. The means related to perceived attributes of ICT range from 7.13 to 9.12. A structural equation modeling technique was used to test the model. The LISREL 8.72 program was employed. The covariance matrix and standard deviations of the variables in the model were given in Appendix 1.

Faculty Members and ICT Facilities

The majority of faculty members in the study group have a computer and access to the Internet in their offices in the department. The availability of computer is 63.5% and the Internet is 55.9% in laboratories whereas it is 38.7% for computer and 28.2% for the Internet in classrooms. The projector is mostly available in seminar-meeting room (65.5%) and in classrooms (55.8%).

Table 3. ICT Facilities

	Computer		Internet connection		Projector	
	frequency	**%**	**frequency**	**%**	**frequency**	**%**
In classrooms	323	38.7	235	28.2	465	55.8
In laboratory	530	63.5	466	55.9	310	37.2
In seminar-meeting room	494	59.2	370	44.4	546	65.5
In administration	600	71.9	596	71.5	260	31.2
In offices	702	84.2	684	82.0	69	8.3

Majority of the respondents have personal access to computer and the Internet. 89.1% of the respondents have their own computers at home and 70.6% of them have Internet connection. It is identified that the percentage of faculty members who have their own computers and access to the Internet is quite high (82.5% for computer, 81.2% for the Internet) and that the remaining 17.5% of faculty members state that they easily have access to computer and the Internet in the department though they do not have their own computers.

Table 4. Access to ICT Facilities

	Computer		Internet connection	
	frequency	**%**	**frequency**	**%**
I have my own at home	743	89.1	589	70.6
I have in the department for my personal use	688	82.5	677	81.2
I have easy access in the department though I do not have my own	146	17.5	146	17.5

Furthermore, it can be concluded that almost all computers used by faculty members have Internet connection.

Faculty Members and ICT Usage

The longest duration of using ICT stated by the respondents are 8-11 years (33.1%) and 4-7 years (30.1%). The lowest percentage for the duration of ICT usage is 0.8% which is composed of the respondents who have been using ICT for no more than 1 year. As for the usage of ICT in the courses, the majority is composed of the respondents who have been using them for 1-3 years (35.7%) and 4-7 years (33.5%). Seventy nine respondents (9.5%) state that they do not make use of ICT in their courses. The lowest percentage for using ICT in the courses belongs to the respondents who have been using them less than 1 year (4.4%) and is followed by the ones who have been using them for 11 years and more than 11 years (6.5%). It is found out that almost 70% of faculty members have been using ICT in their courses for 1-7 years.

Table 5. ICT Usage of Faculty Members

	How many years have you been using ICT?		How any years have you been using ICT in your courses?	
	frequency	**%**	**frequency**	**%**
I do not use	-	-	79	9.5
Less than 1 year	7	0.8	37	4.4
1-3 years	57	6.8	298	35.7
4-7 years	251	30.1	279	33.5
8-11 years	276	33.1	87	10.4
11+ years	243	29.13	54	6.5
Total	**834**	**100**	**834**	**100**

Moreover, 32.1% of the faculty members in the study group have their personal website/page and %15.1 of them have a website/page devoted to their courses.

For What Purposes Do Faculty Members Use ICT?

The responses of faculty members in the study group to the 10 items, asked to ascertain the purposes why they use ICT, disclose that faculty members make use of ICT. The faculty members make use of ICT most, as a means of communication (97.5%), as searching for information about the course (96.5%), and for preparing their lecture notes (91.6%).

This situation can be explained, on one hand, by the willingness of faculty members; and on the other hand, by the opportunity to access applications suitable for their course requirements on the Internet with the introduction of open code applications in universities such as Massachusetts Institute of Technology. It can be claimed that the prevalence of such applications will contribute to the globalization of course contents.

Furthermore the faculty members make use of ICT least, for publishing their lecture notes and the announcements concerning the course on WWW (54.4%). On the other hand the low percentage (40.8%) of using ICT in laboratories and workshops and for making an experiment may derive from the fact that the study fields of all faculty members do not require laboratory, workshop or experiments.

Table 6. Faculty Members' Purposes of ICT Usage

I use ICT for		**frequency**	**%**
Instructional	Searching information on the Internet about the course	805	96.5
	Preparing the course and lecture notes	764	91.6
	Making presentations in the course	530	63.5
	Making use of ready-made software packages about the subject matter	502	60.2
	Carrying out studies in laboratories or workshops, and making experiments	340	40.8
Managerial	Publishing the lecture notes and the announcements (assignments, projects, etc.) concerning the course on WWW	454	54.4
	Preparing exam questions	647	77.6
	Statistical analysis of exam results	523	62.7
	Official correspondence	694	83.2
	As a means of communication	813	97.5

Almost half of faculty members do not publish their lecture notes and the announcements concerning the course on WWW (54.4%) may result from their insufficiency in using web tools. In fact, a study carried out by Usluel and Seferoğlu (2004) reveals that faculty members use computers for "searching on the Internet" and as "a means of communication," for example for word processing, e-mail communication, and searching through the Internet resources and that they are not interested in databases, web publishing, and desktop publishing. However, it is important to use web tools effectively. That is why, universities should have policies which regulate the use of ICT for the diffusion of information and these policies should focus on both developing the skills of faculty members and providing technical and educational support.

Analysis of the Structural Model

A structural equation modeling technique was used to test the model. The LISREL 8.72 program was employed for this purpose. The model testing results are shown in Figure 1. It was found that ICT facilities and perceived attributes have direct impacts on the ICT usage of faculty members.

The observed variables used to predict the latent variables in structural equation modeling were obtained by processing the data in the instrument.

A separate score was obtained for each place by considering computers, the Internet connection, and projectors. The items in the scale were used to obtain the scores of the following variables: “Relative Advantages”, “Compatibility”, “Ease of Use”, and “Observability."

The variables “instructional” and “managerial”, which predict the latent variable “ICT usage”, were calculated using the relevant items as a result of the factor analysis carried out on the items, in the data collection tool, which tend to explain the purposes of faculty members for using ICT.

7 fit indexes which are commonly used in the literature (x^2/d.f, GFI, AGFI, NNFI, CFI, RMSR, RMSEA) were employed to test model fit. The best fit was acquired when trialability was dropped from the model. As the values in Table 3 reveal, the fit indexes of the model are included in the values which are acknowledged in the literature. The commonly used measures of model fit, based on results from an analysis of the structural model, are summarized in table 7. In practice, Chi-square / degrees of freedom less than 3, GFI, NNFI, CFI greater than 0.9, an AGFI greater than 0.8, RMSR less than 0.1, and RMSEA less than 0.06 or 0.08 are considered indicators of good fit. As seen in table 7, all goodness-of-fit statistics are in the acceptable ranges except for Chi-square/ degree of freedom which is close enough (3.56) to the recommended value of 3.00.

Table 7. Summary statistics of model fit

Fit Index	Recommended Value	Observed Value
Chi-square/ degrees of freedom	≤3.00	3.56
GFI	≥0.90	0.98
AGFI	≥0.80	0.96
NNFI	≥0.90	0.96
CFI	≥0.90	0.97
RMSR	≤0.10	0.07
RMSEA	≤0.06 or ≤0.08	0.05
GFI = goodness-of-fit index; AGFI = adjusted goodness-of-fit index; NNFI = non-normed fit index; CFI = comparative fit index; RMSR = root mean square residual; RMSEA = root mean square error of approximation.		

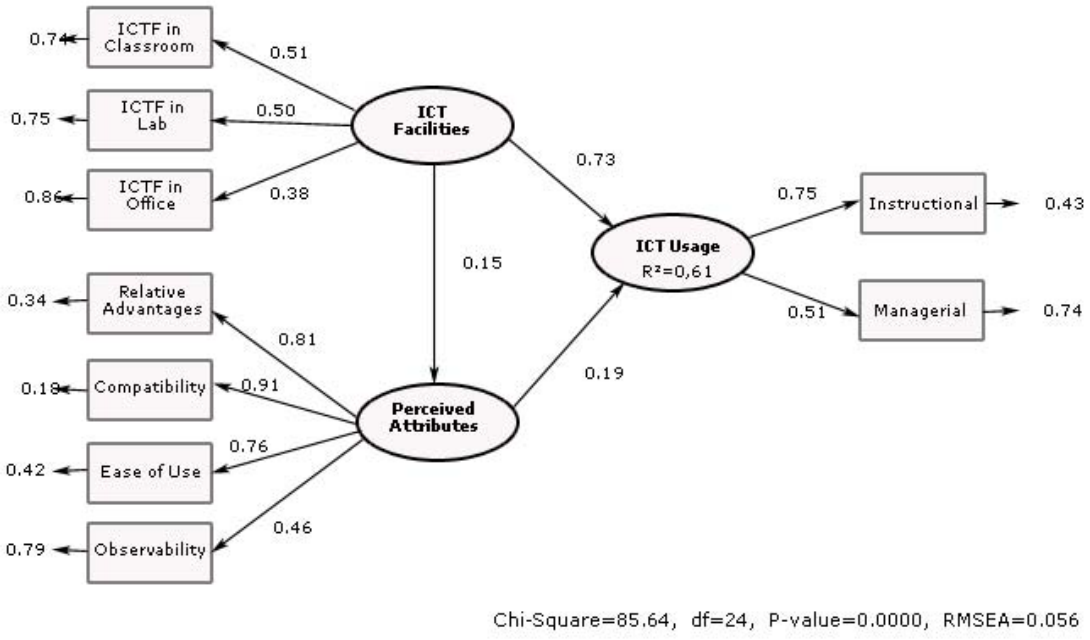

Figure 2. LISREL test of Research Model

Graphical presentation of the results is shown in Figure 2. Figure 2 shows the standardized LISREL path coefficients with their respective significance levels. The proposed structural model explained 61% variance in the ICT usage.

Figure 2 illustrates the significant structural relationships among the study variables. Hypothesis 1 and 2 are postulated that ICT facilities and perceived attributes have a positive effect on ICT usage. The direct path ICT facilities→ ICT usage is significant since the regression coefficient (β) is 0.73 with t value of t= 11.46, and p< 0.05. Therefore the hypothesis is supported, which means that ICT facilities significantly has a positive direct effect on ICT usage. Moreover the direct path perceived attributes→ICT usage is significant since the regression coefficient (β) is 0.19 with t value of t= 4.01 and p<0.05. The third hypothesis is also accepted because the direct path ICT facilities → perceived attributes is significant since the regression coefficient (β) is 0.15 with t value of t= 2.70 and p< 0.05. The perceived attributes and ICT facilities accounted for 61% of the variance in ICT usage.

The results showed that ICT facilities in higher educational institutions exhibited the strongest direct impact on ICT usage which is composite of both instructional and managerial tasks.

Discussion and Conclusion

This study tends to identify, within the framework of DoI theory, the ICT diffusion in universities on the basis of faculty members' ICT usage. Two dimensions of ICT usage are taken into consideration: Instructional and managerial.

The findings of the study show that the use of ICT is getting more widespread in higher education and that the faculty members make use of ICT mostly as a means of communication and for doing research about the course through the Internet; and the least, for publishing their lecture notes and the announcements concerning the course (assignments, projects) on the Internet. This situation seems like a one-way communication though, this could be attributed to the faculty members' skills in publishing tools on WWW as well as the lack of an institutional regulation concerning the web publishing of course contents. Moreover, intercultural difference may also appear as a variable and this aspect of the topic should also be researched respectively.

This study has investigated the underlying relationship between ICT facilities, perceived attributes, and ICT usage for higher education. The empirical examination of the usage of the ICT using a structural model based on the DoI has been tested and validated. All hypotheses postulated by the structural model are supported. The study provides further evidence of the appropriateness of DoI to measure the ICT usage in Higher Education in Turkey.

As a result, ICT facilities was found to have a strongly positive effect on ICT usage and positive effect on perceived attributes. Having this stronger impact of ICT facilities than perceived attributes on faculty members' ICT usage emphasizes that it is required to re-arrange the ICT facilities in classrooms, particularly for instructional purposes. Nevertheless, this result highlights that to re-arrange ICT facilities, cannot conclude the attempt also will be sufficient alone.

Under these circumstances, it is significant that ICT usage in classrooms should be more widespread, and faculty members should be supported both technically and educationally and the process should be institutionalized via the framework of the policies and strategies of universities.

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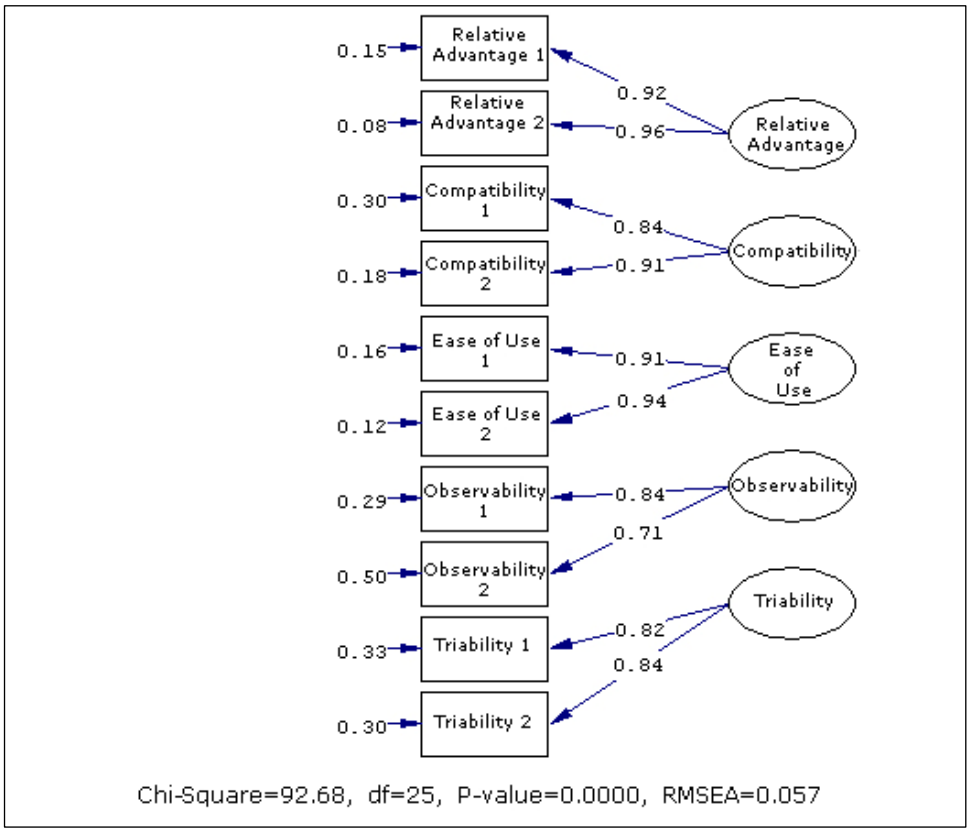
Appendix 1

Covariance Matrix of "Perceived Attributes of ICT Scale"

	Relative Advantage 1	Relative Advantage 2	Compatibility 1	Compatibility 2	Ease of Use 1	Ease of Use 2	Observability 1	Observability 2	Triability 1	Triability 2
Relative Advantage 1										
Relative Advantage 2										
Compatibility 1										
Compatibility 2										
Ease of Use 1										
Ease of Use 2										
Observability 1										
Observability 2										
Triability 1										
Triability 2										

Confirmatory factor analysis for the factorial validity of "Perceived Attributes of ICT Scale"



The covariance matrix and standard deviations of the variables in the model

	ICTF in Classroom	ICTF in Lab	ICTF in Office	Relative Advantages	Compatibility	Ease of Use	Observability	Instructional	Managerial	sd
ICTF in Classroom	1.59									1.138
ICTF in Lab	0.60	1.51								1.205
ICTF in Office	0.45	0.22	1.29							.763
Relative Advantages	0.46	0.32	0.31	1.45						1,684
Compatibility	0.14	0.19	0.20	0.19	0.58					1,878
Ease of Use	0.21	0.11	0.02	0.10	0.01	2.84				1,983
Observability	0.54	0.32	0.20	0.19	0.02	2.35	3.53			2,107
Instructional	0.60	0.37	0.15	0.18	0.00	2.05	2.55	3.93		1,261
Manegerial	0.29	0.25	0.35	0.14	0.14	1.36	1.60	1.59	4.44	1,230