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Measuring Perceptions of New IS/IT

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Abstract

To manage the process of introducing change into an organization, it is essential to be able to measure what determines workers' attitudes to new information systems and information technology. Previous research has identified perceived characteristics of IS/IT as paramount in this attitude formation. This paper applies a set of questions that explore perceptions of characteristics of new IS/IT on eight dimensions. The conclusion is that relative advantage, compatibility and result demonstrability are significant and ease of use could be useful with more careful measurement. The research covers four different IS/IT and confirms that the questions are generalizable to a range of technologies.

Keywords

IS/IT adoption, Diffusion of Innovation

INTRODUCTION

Very few changes in business and industry do not include the introduction of new information systems or information technology (IS/IT) (including computers, software, telecommunications, procedures and related technologies). There are conflicting forces in this situation. On the one hand, it is well known that change provokes negative and obstructive reactions that can lead to ineffective use of new IS/IT and sometimes abandonment. Against that, new IS/IT often involves a substantial investment of time, money and resources from which management expect an appropriate rate of return. Measurement and understanding the acceptance of change is essential to managing it successfully. There are several models covering the process of acceptance of technology but all include an evaluation of the technology based on perceptions of its characteristics (Davis 1989; Rogers 1995). Data collected by a number of different means and applied to these models has confirmed the importance of measuring and modeling the difference between the evaluation of such technologies by adopters and non-adopters as a precursor to influencing attitudes (Davis, Bagozzi et al. 1989; Mathieson 1991; Chin and Todd 1995; Taylor and Todd 1995). This paper reports progress in establishing the validity of a single instrument across a range of technologies and contributes to the understanding of which characteristics of the technologies are most important for distinguishing between adopters and non-adopters.

This research is relevant to a range of situations. In a large corporate setting, the development of a new information system is often a major project spanning several years and impacting multiple departments. Finding a way of anticipating resistance early in a development project provides the opportunity to make corrections to both the proposed system and the method of introducing it (Ginzberg 1981). At the other extreme, the decision to adopt a new personal computing product is similar to deciding to purchase any consumer good. In this situation, measuring attitudes of adopters after purchase is important for ensuring continued use which in turn leads to purchase of upgrades and enhancements. Many new information systems are a combination of corporate information system and personal hardware and software. Both need to break the natural barrier of resistance and sustain usage for the overall change to be effective.

RESEARCH QUESTIONS

There is similarity between persuading people towards a new use of IS/IT and classical diffusion of innovation work. Some researchers have argued that classical diffusion theory as expounded by Rogers (1995) is not appropriate because the implementation of a new information system is generally an organizational rather than an individual decision (Eveland and Tornatzky 1990). However, many organizations today have a growing number of what are termed knowledge workers (Bell 1976) who provide information analysis services. This class of workers functions within a framework dictated by the decisions made in the organization but have sufficient autonomy to accept or reject innovative ways of working (Leonard-Barton and Deschamps 1988). Although the adoption decision is made by the organization, the individual has control over the extent of their use (eg using a newly acquired modeling package rather than continuing with a familiar spreadsheet approach)

which can therefore be classed as voluntary. In this situation, the diffusion of innovation literature is relevant (Fichman 1992).

One of the primary determinants of acceptance of a technology are the perceptions that people hold of its characteristics (Rogers 1995). The number of salient dimensions considered by researchers varies from two in the Technology Acceptance Model (TAM) (Davis 1986) to nearly thirty (Zaltman, Duncan et al. 1973). The instrument chosen for this research focuses on eight dimensions chosen based on a combination of literature review and an exhaustive process of sorting by judges (Moore and Benbasat 1991). The resulting instrument was checked for content and construct validity and reliability using a single technology (Personal Work Stations) (Moore and Benbasat 1991). A short form of the instrument with twenty four questions instead of the full thirty was also suggested but not validated (Moore and Benbasat 1991). The first objective of this work was to explore the validity of the short form and the generalizability to other technologies.

The second objective of this work stems from the discrepancy between the number of characteristics measured by this instrument and that of a widely referenced approach known as the Technology Acceptance Model (TAM) (Davis 1986). TAM focuses on only two characteristics of a technology – perceived usefulness (synonymous with relative advantage) and perceived ease of use. The work has been replicated and extended by several others (Adams, Nelson et al. 1992; Segars and Grover 1993; Subramanian 1995). While ease of use has sometimes been shown to be insignificant, usefulness has consistently been confirmed as a key determinant of intention to use the technology in question. A further factor from diffusion of innovation theory, compatibility, has been included in some work (Taylor and Todd 1995) but no attempt has been made to extend the model to include all the factors measured in the instrument under investigation here. Consequently, this research seeks to establish whether the limited TAM model should be extended to include the more comprehensive list of characteristics measured in this instrument.

RESEARCH METHOD

In the search for a general model that describes the role that innovation characteristics play in the adoption decision for any IS/IT, it is important to collect data across several innovations at the same time and from the same subjects (Tornatzky and Klein 1982). The research described in this paper replicated the original study on Personal Work Stations (PWS)(Moore and Benbasat 1991) but this time using the short form instrument. It also extended the work to three other technologies, Presentation Software (PS), Multimedia (MM) and World Wide Web (WWW). These were chosen because, at the time of the survey, each was at different stage of diffusion (ranging from 26% to 92%) within the target organisation.

Validation and reliability checks were performed as in the original work, and the suggested model with eight latent factors was tested using exploratory factor analysis. In addition convergent and discriminant validity were tested with the multitrait-multimethod (MTMM) approach used by Davis (Davis 1989; Adams, Nelson et al. 1992). Finally, logistic regression was used to assess the usefulness of constructs that are additional to Davis' TAM for the objective of understanding the difference between adopters and non-adopters.

Relative Advantage (Usefulness)	Improvement in the current situation that is expected. Measures used for comparison vary with the nature of the innovation and the character of the potential adopter.
Compatibility	The amount of change forced on the adopter by adopting an innovation. The change may be in the way of working (operational compatibility), thinking or feeling (normative compatibility)
Ease of Use	How easy it is to use a technology once the adopter has become familiar with it. This is distinct from the barrier to learning or learning curve.
Image	How much the person's image would be enhanced by being seen to be using the technology
Visibility	Some technology is highly visible (like personal workstations) while others are much less so (like use of world wide web).
Result Demonstrability	How clear the results are, how easy it is to attribute results to the innovation and what hurdles exist to communication of those results
Trialability	Whether potential adopters can try working with the innovation before making a total commitment to adoption either by incremental use of the innovation or a trial period.
Voluntariness	Whether the decision to adopt is individually optional, collective or dictated by authority.

Table 1: Characteristics of Innovations

A convenience sample of all the academic staff at the author's university was chosen. The focus of the work is the instrument – its validity and generalisability across other technologies – applied to knowledge workers within an organization. While academics may have some idiosyncrasies they do fit the requirement that they have

autonomy to choose from the technology tools available and that the same respondents are used for each technology. The survey collected data on eight characteristics (Table 1) across four technologies (Table2).

Personal Work Stations (PWS)	The PWS usually consists of a personal or microcomputer with one or more software packages, such as a word processing program or a spreadsheet, that is used directly by yourself for teaching purposes.
Presentation Software (PS)	Presentation Software facilitates the preparation and delivery of lectures and course materials. PowerPoint and Harvard Graphics are some examples. The software can be used only for preparation, with the final overheads being printed and displayed using a standard overhead projector. Alternatively, the lecture can be delivered using a computer linked to a data projector
Multimedia (MM)	This is technology that allows the lecturer to present information using more than just text. Typically, Multimedia includes a combination of text, graphics, sound, voice, animation and video. Hyperlinks that allow the student to follow the material in a non sequential manner, distinguish multimedia material from books, videos and other recordings. Multimedia productions are used as teaching and learning aids in a variety of fields from geology to medicine, art to sport.
World Wide Web (WWW)	The World Wide Web provides access to computer based material through the Internet. At the simplest level it can be used to make lecture notes and other course material available to students. It can also be used to provide hyperlinks to other sites with relevant study material. Web pages can be a full multimedia presentation or just text.

Table 2: The Four Technologies Used in the Survey

The only word changes that were made were that ‘my boss’ was changed to ‘my head of department’. Responses were on a seven point scale from Strongly Agree to Strongly Disagree. The questions were worded to allow non-adopters to record their perceptions as well as those who are already using the technology. Usage of each of the technologies was represented by a yes/no option. The questionnaire was pre-tested on ten academic staff in three different departments and no further changes to the questions were found to be necessary for clarity.

RESULTS

The survey was completed by 250 academic staff, representing 34% of the academic staff who were available at the time. The data was collected through three waves of requests and then a final appeal to a sample of non-responders to enable a check of non-response bias. There was no evidence that those who responded in this last group were systematically different from those who filled in the survey earlier, except for the voluntariness construct. While this does not guarantee that actual non-responders would be no different from the results collected, it is the best available surrogate.

Respondent Characteristics

The responses came from eighty female (32%) and 170 (68%) male academics although the population is distributed 23:77 (Chi square 4.57, p=0.03). Eighty five percent of the sample were spread evenly within the age group 30-60 with 5% over that age and the rest younger. Sixty four percent are qualified to PhD level, 18% to masters and the rest have an honors degree or another qualification.

Technology	Adopters	% age of total	label for non-adopters
Personal workstation	228	91.2%	Laggard
Presentation software	127	50.8%	Early/Late majority
Multimedia	66	26.4%	Early majority
World Wide Web	185	74%	Late majority

Table 3: Numbers of adopters, labels of non-adopters

Seventeen professors replied, 44 associate professors, 68 senior lecturers, 84 lecturers and 37 associate lecturers. This matches the profile of university academic staff very well in the middle (p=.21) but is significantly lower than expected at the top (professors) and higher at the bottom. This indicates that the data over-represents the views of junior staff. Ninety four percent of the respondents have a personal computer on their desk, 89% have one at home, 71% have access to a machine with a CD Rom drive and 95% are connected to the Internet either at work or at home.

The percentages of respondents who use the four technologies are given in Table 3. The labels commonly used to describe non-adopters at each stage of the diffusion cycle (Rogers 1995, p265) are given in the last column. The early/late majority grouping covers 34% of the population either side of 50%. Using the common 'S' shaped curve (Nolan 1973) the four technologies would be evenly spaced as in Figure 1.

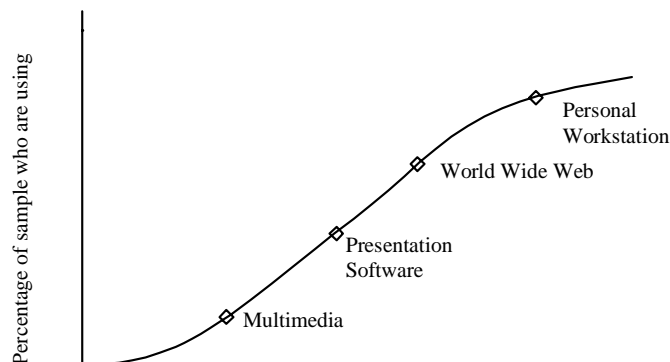


Figure 1: Relative position of the technologies on the 'S' curve

Reliability

The groupings of the items into scales to measure the expected eight characteristics were tested for reliability (the items within each group are all measuring the same underlying perception) using Cronbach's alpha and found to be acceptable according to the standards recommended by Nunnally (1967).

Using the multitrait-multimethod (MTMM) approach used by Davis and Adam et al (Campbell and Fiske 1959; Davis 1989; Adams, Nelson et al. 1992) convergent and discriminant validity were tested. With the exception of the items measuring voluntariness, the items measuring the same construct have correlations significant at .05 level, irrespective of the technology to which they refer, which confirms convergent validity. For discriminant validity the within trait and method correlations should be higher than all others. Testing this required 6960 comparisons for relative advantage from which only 58 violations were found (less than 1%). The other constructs had even fewer violations.

Factor Analysis

Unrestrained factor analysis was used to confirm that the instrument was measuring eight different constructs. First, the correlation matrix was checked for all items. KMO measure was 'meritorious' (between 0.817 and 0.863) (Norusis 1993, p53) and Bartlett test of sphericity rejected the hypothesis that the population correlation matrix is an identity, thus indicating that factor analysis is a suitable technique for all four technologies. However, correlations involving Question 15 were all low; preliminary runs of factor analysis gave very low communalities for this item, and it was decided to omit it from further analysis.

Between 74% and 86% of the variance was explained by the factors in each case. The items that measured perception of Image, Visibility, Trialability, and Voluntariness loaded cleanly across all technologies for adopters and for non-adopters except Personal Work Stations. As reported by other researchers, the relative advantage and compatibility questions loaded against a single factor for adopters of all four technologies, despite the expectation that they would represent two separate constructs. Non-adopters of multimedia and presentation software showed the same pattern.

Non-adopters of PWS showed a very different result with several items loading on more than one factor. The results for WWW were not at all well behaved over the first fourteen questions with all items loading on only two factors, instead of the expected three, and several on both. Using eigenvalues greater than 1 as the cutoff, only six factors were necessary to explain 84% variance for PWS non-adopters and 80% variance for WWW.

Distinguishing Between Adopters And Non-Adopters

Repeating earlier work, Mann-Whitney U-tests were applied to the hypothesized scales for each technology (Moore and Benbasat 1991). Trialability was not significantly different between adopters and non-adopters for any of the technologies. Image was only different for multimedia. The other scales detected a significant difference for each technology.

Relative Advantage And Compatibility

To investigate the confirmed loading of both relative advantage and compatibility questions on the same factor, the correlation table for these items was reviewed. There is certainly high multi-collinearity, but the manner in which the items were generated (repeated grouping by experts) does not allow for the automatic conclusion that there is only one construct. There needs to be a substantive argument for combining the items (Chin and Todd 1995) and the efforts of others to argue this case are not convincing (Taylor and Todd 1995). This is discussed further below.

Logistic regression

Finally, since the ultimate objective is to produce an instrument that is useful in differentiating between adopters and non-adopters of a technology, logistic regression analysis was used to investigate the efficacy of the postulated constructs. With a dichotomous dependent variable, multiple regression is not an appropriate technique to model the relationship between the independent measures of the eight characteristics and the dependent usage, because the assumption of a normal distribution of errors is not valid. Discriminant analysis is a possible alternative but this requires the multivariate normality of the independent variables (Norusis 1993). Logistic regression was chosen because it is a more robust technique and yet provides good results even when the assumptions for discriminant analysis would have been satisfied.

In Table 5, the column labelled Wald statistic is used to test the null hypothesis that the regression coefficient is zero, and thus the variable does not make a significant contribution to explaining the variance in the dependent variable in a model including the other variables (analogous to t test in linear regression). Any that are significantly non zero are indicated with asterisks .

Model chi-square is a measure of goodness of fit for logistic regression that is similar to the F test for multiple regression. It tests the hypothesis that the coefficients of all the terms except the constant are zero and the results reject this hypothesis, confirming that the explanatory power of this combination of independent variables is greater than might happen purely by chance. Lastly, % correct is shown for the cases on which the regression model was developed (Norusis 1993).

Intuition and previous research would indicate that relative advantage should be the variable that is most significant in the logistic regression model, but presentation software shows significance of compatibility and not relative advantage, while for personal workstations neither is significant. Bearing in mind the multi-collinearity between relative advantage and compatibility discovered through factor analysis and the review of the correlations, this regression analysis was repeated without the compatibility variable. The resulting models showed that relative advantage was highly significant for both personal workstations and presentation software. This replacement of compatibility with relative advantage confirms the overlap of information provided by the two variables. While it is acceptable to include both in the regression model, the interpretive value of the coefficients is severely limited.

	Personal Workstation	Presentation Software	Multimedia	WWW
Relative Advantage	2.77	3.02	5.27*	8.32**
Compatibility	.56	4.31*	.04	.10
Ease of Use	.02	.69	2.48	.08
Result Demonstrability	.72	8.52**	7.00**	7.28**
Image	1.46	2.41	.00	2.64
Visibility	1.09	2.76	1.67	.96
Trialability	.39	4.56*	.00	2.37
Voluntariness	4.70*	.72	3.75*	3.16
Constant	2.21	7.33	5.50	9.64
Model chi-square	33.02**	97.57**	71.45**	60.61**
%correct	92	76	82	76

* p<.05 ** p<.01

Wald is used to test the null hypothesis that the coefficient is 0

Table 5: Logistic Regression Results - * indicates significance

DISCUSSION

This cross sectional research used a sample of knowledge workers with the autonomy to decide whether to use information technologies that have been made available to them. The questions collected data on their perceptions of eight characteristics of the technologies that were expected to be significant in differentiating

between adopters and non-adopters in situations where the decision to use was voluntary. Perceptions were found to be different between the two groups for most combinations of technology and characteristic.

The introduction to this paper posed several questions. Firstly, is the short form of the instrument reliable and does it satisfy tests of convergent and discriminant validity? Is it generalizable across technologies other than that on which it was developed? The short answer to this is 'yes' with some minor caveats discussed below.

The second question is whether collecting data on a longer list of characteristics (than is usual eg TAM) contributes to our understanding of the difference between adopters and non-adopters. Here the answer appears to be that it is worth adding in result demonstrability but probably not any of the others. Relative advantage is, unsurprisingly, conspicuous in differentiating the two groups whatever the technology in question and this matches the results with perceived usefulness in TAM. This is discussed further below.

Validity Issues

A major cause for concern is the poor factor loading for non-adopters of personal workstations and for all respondents about World Wide Web. Since the object of the research was to establish the generalizability of the instrument this is an important finding and worth trying to rationalize. Looking at personal workstations first, this technology is in the final stage of adoption when new adopters are often termed 'laggards' (Rogers 1995) and this may be the reason for the instability in perceptions of non-adopters. It is unlikely that non-adopters were unfamiliar with the technology given the pervasive nature of personal computers, but clearly their perceptions are unusual and inconsistent. It is recommended that this short form instrument not be used with technologies in the last stage of diffusion.

The diffusion of WWW had been adopted by approximately 50% of the population, so the same reasons do not apply. One possible reason for the failure to observe the expected factor structure is that the rate of diffusion is very rapid for this technology and so perceptions of its characteristics are changing more rapidly than in most diffusion processes. This needs further investigation.

Salient Characteristics

Relative advantage taps into a rational evaluation of the technology; a sort of cost/benefit analysis. Because of this, many of the factors that influence people in their decision to use a technology are covered in a general way by this five item scale. Its importance in this data is shown by the significance of the term in the logistic regression results confirming the findings of researchers looking at usefulness using TAM model (Davis 1986).

However, the logistic regression results (Table 5) also show that under some circumstances compatibility is the most significant variable. The truth is that these two constructs, as measured by this instrument, are highly correlated. One explanation for this is that compatibility is necessary for a favorable assessment of relative advantage. For the data collected, either could have been used to predict the likelihood of adoption. This confirmation of the overlap is one of the most significant results of this research and is especially highlighted by this research design because it covers more than one technology.

Most of the other variables contribute little extra to our understanding except for result demonstrability. This construct is significant in differentiating between adopters and non-adopters across three of the four technologies (and use of the instrument for the fourth has been questioned on validity grounds). Further research is necessary to confirm this but it appears that other models like TAM should now be extended to include items that measure result demonstrability.

It should be noted that again ease of does not contribute to understanding the difference between adopters and non-adopters, despite the intuitive appeal. Certainly there are complicated issues involved in evaluating ease of use that are not captured in the items of this instrument, including barrier to knowledge (Attewell 1992) and self-efficacy (Bandura 1977). Extending the ease of use scale to incorporate these more complex issues may reveal a higher significance for the concept.

Further Work

This work has addressed whether this measurement instrument can be used generally across technologies other than that on which it was developed. The survey used a sample of knowledge workers from the researcher's home institution, who have high control over the technologies they choose to use. While the instrument has satisfactory general validity some important issues have been raised that point to the need for further investigation particularly concerning technologies in a high rate of diffusion. It is also necessary to confirm the results for people in other environments and cultures.

This work did not try to address the issues surrounding collecting data on the adoption decision, such as the tendency for people to justify their actions after the event and the influence of using the technology on their perception of it. The most that this data (or much of the other published work) can say about the difference between adopters and non-adopters is that at the moment of the survey they differed in their perception of the technology in significant ways. This has value for the continued use of new technologies but does not guarantee insight into what triggers the adoption decision. Longitudinal research would be necessary to approach real understanding of the decision process.

CONCLUSION

The instrument investigated here (Moore and Benbasat 1991) makes a valuable contribution to the IS research field. Its development was rigorously performed and tested. This paper reports replication of that validation and the results of additional MTMM validation analysis. Results point to an instrument that is reliable and valid that can be generalized across most other technologies.

Results using this instrument indicate that a more extensive list of constructs should be used than is common in research following the TAM model. In particular, it is recommended that the construct result demonstrability be incorporated in the TAM model.

Lastly, the overlap of information carried by the data on compatibility and relative advantage is confirmed and serious investigation of how adopters separate and combine these apparently distinct ideas is urgently required. Similarly, the poor contribution of ease of use is highlighted and the need for an expansion of this scale is signalled.

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