Implementing New Technology: A Multiorganizational Study of Implementation Effectiveness

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Abstract

This research examines the implementation of computer and telecommunications technologies in science education in a sample of 69 schools. Implementation effectiveness is proposed to be a function of the organization's receptivity toward change, climate for implementation, and the fit between the new technology and end user values. The results provide strong support for the hypothesized relationships between receptivity toward change, climate for implementation and implementation effectiveness.

Keywords

Technological innovation, implementing new technology, implementation effectiveness

INTRODUCTION

Contemporary organizations face increasing pressure from consumers of their products and services to be more effective, more responsive, more efficient and provide more value. Increasingly, organizations have adopted new technologies, in particular information and telecommunications technologies, in an attempt to improve their performance and adapt to new environments. Despite these facts we have made relatively little progress in our understanding of how to successfully implement technological innovations in organizations. Repeatedly researchers comment that despite a growing body of empirical work, no real theory has emerged that permits researchers to predict the extent to which a given organization will successfully implement a given technological innovation (Klein & Sorra, 1996; Nord & Tucker, 1987). Moreover, the literature that has looked at how organizations implement technological innovations has been characterized by large-scale, qualitative, case studies (eg. Barley, 1986; Leonard-Barton, 1988a, 1988b; Nord & Tucker, 1987). Because these studies involve so many different types of innovations, implemented at different times and under very different circumstances, they provide only a preliminary understanding of implementation effectiveness.

Clearly our understanding of implementation processes and outcomes would be aided by strong theory that is field-tested using quantitative methods in multiorganizational samples. This paper tests a model of implementation effectiveness in a multiorganizational sample. First, the theoretical model under test is reviewed. Then results from this multiorganizational, quantitative study are presented and discussed. Finally, directions for future theory development and research are given.

IMPLEMENTATION EFFECTIVENESS

Implementation effectiveness can be conceptualized at the individual and organizational levels of analysis. When conceptualized at the organizational level of analysis implementation effectiveness has been variously operationalized as the intrafirm rate of diffusion of the innovation (eg. Mansfield, 1963) or the time lag between adoption and implementation (eg. Ettlie & Vellenga, 1979). These measures, however, fail to capture the quality of the implementation (Nord & Tucker, 1987; Tornatzky & Klein, 1982). Klein and Sorra note that implementation failure occurs when "…[targeted] employees use the innovation less frequently, less consistently, or less assiduously than required for the potential benefits of the innovation to be realized." (1996:1055). Thus, dependent measures that capture both the *consistency with which targeted users use the innovation* and the *quality of us*e more closely reflect implementation effectiveness.

Several researchers have distinguished between implementation effectiveness and innovation effectiveness (eg. Griffith & Northcraft, 1996; Klein & Sorra, 1996). Implementation effectiveness is the consistent and skillful use of the innovation by targeted users. Innovation effectiveness is seen as a function of both implementation effectiveness and the soundness of the strategic decision to adopt the innovation. Thus, implementation effectiveness is a necessary, but not sufficient condition for innovation effectiveness.

In this paper we focus on implementation (vs. innovation) effectiveness. Our focus on implementation effectiveness presupposes the decision to adopt the innovation has already been made by senior decision-makers in the organization. The technological innovation under study is one that is intended for use by multiple organizational members. Thus, the unit of analysis is the organization. Accordingly, an organization in which a majority of the targeted users use the innovation consistently and well is more effective in its implementation than an organization in which only a few of the targeted users use the innovation consistently and well. Implementation is defined as "the process of gaining targeted employees' appropriate and committed use of the innovation" (Klein & Sorra, 1996:1055) and implementation effectiveness results when targeted employees use the innovation in a skillful and consistent way.

DETERMINANTS OF IMPLEMENTATION EFFECTIVENESS

Climate for Implementation

A plethora of implementation policies and practices have been documented in the literature as related to implementation effectiveness, eg. access to technical competence (Nord & Tucker, 1987; Mirvis, et al., 1991); listening to staff (Nord & Tucker, 1987; Leonard-Barton, 1988a); adequate training and technical support (Mirvis et al., 1991); quality of upward communication (Nord & Tucker, 1987; Mirvis, et al., 1991). Recently, several researchers have concluded that it is not a specific set of policies and practices that lead to implementation effectiveness, but rather, employees' perception of the collective set of practices and policies as a whole that leads to implementation effectiveness (Casson, et al., 1997; Holahan & Aronson, 1999; Klein & Sorra, 1996). These researchers propose that the process of implementing technological innovations in organizations is best understood when conceived of as a process that is equifinal. The conceptualization of innovation processes as equifinal presumes that different implementation practices and policies across organizations can lead to the same level of implementation effectiveness.

To capture this notion of equifinality and the collective influence of an organization's implementation policies and practices Klein and Sorra introduced the construct of climate for implementation. "The more comprehensively and consistently implementation policies and practices are perceived by targeted employees to encourage, cultivate, and reward their use of a given innovation, the stronger the climate for implementation of that innovation." (1996:1060). Prior research has shown that studies examining specific dimensions of climate, such as climate for technical updating (Kozlowski & Hults, 1987), climate for safety (Zohar, 1980), etc., explain a significant amount of variance in behavior-specific dependent variables. An organization would be characterized as having a strong climate for implementation if, for example, targeted users collectively perceived training in the use of the innovation to be readily available, on-site assistance with innovation use as accessible, time to learn and experiment with the innovation as available, use of the innovation to be rewarded, etc. Thus, these collective perceptions are in part a result of the objective policies and practices an organization puts into place to support implementation.

The notion of climate for implementation pushes researchers away from the search for a precise set of practices or policies that will lead to implementation effectiveness and focuses attention on looking at targeted users' collective perceptions of the extent to which innovation use is encouraged, supported, and rewarded in the organization. Thus, we propose that:

H1: Climate for implementation is positively related to implementation effectiveness.

Organizational Receptivity Toward Change

Another organizational variable of interest with respect to implementation effectiveness is the organization's general receptivity to change. Organizations have been shown to differ on the extent to which they are open to change and value it as a goal (Siegel & Kaemmerer, 1987; Smith, Maehr & Midgley, 1992; Zmud, 1984). We propose that an organization's openness to change or general receptivity to change is causally antecedent to its implementation climate.

Zmud (1984) found strong support for an organization's general receptivity toward change and the successful implementation of technological innovations. Mirvis, et al. (1991) found an organization's receptivity to change to be related to its implementation of policies and practices that directly support innovation implementation (e.g. training policies, the provision of support services, etc.). Ettlie (1988) and Leonard-Barton (1988b) found that better performing organizations synchronize the adaptation of administrative policies with the introduction of new technology. Thus, it may be that an organization's general receptivity toward change indirectly affects its implementation climate through its effect on policies and practices put in place in support of the innovation and its use. Accordingly, we propose the following hypothesis:

H2: Implementation climate will mediate the effect of organizational receptivity toward change on implementation effectiveness.

Innovation-Values Fit

Several researchers have proposed that the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of the targeted end users is positively related to innovation adoption and implementation (see for example Rogers & Shoemaker, 1971; Leonard-Barton 1988a; 1988b). It is commonly held that successful innovation implementation depends on the acceptance of the innovation by targeted end-users, and that end-user evaluations of the innovation are largely influenced by individuals' personal interests, needs and skills. Technical innovations primarily impact task behavior within an organization's technical core. The willingness of organizational members to change their task behavior may indeed be affected by their perception of the extent to which the innovation assists them in the fulfillment of important workplace values or needs.

In this research, we focus on the fit between the values of the targeted users as a whole and their collective perception of the innovation -- our goal being to predict implementation effectiveness at the organization level versus explaining individual differences in innovation use. Innovation-values fit is the extent to which targeted users perceive that the use of the innovation will foster the fulfillment of the group's values. Toward this end, we offer the following hypothesis:

H3: Innovation-values fit is positively related to implementation effectiveness.

Figure 1 presents a summary of the hypotheses tested in this research. Implementation effectiveness is hypothesized to be a function of the organization's general receptivity toward change, its climate for implementation, and the fit between targeted users' values and the extent to which they perceive the innovation to foster the fulfilment of those values. The organization's general receptivity to change is predicted to impact implementation effectiveness via its influence on the organization's climate for implementation.

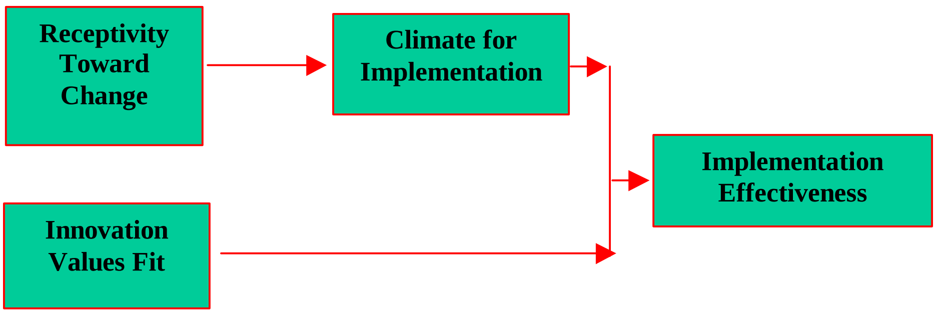

Figure 1: The research model

THE INNOVATION UNDER STUDY

The innovation under study is the use of advanced computer, telecommunications and Internet technologies by K-12 science teachers to teach science. Implementation processes entail both the integration of these technologies into K-12 classrooms as well as the development and use of new science curriculum materials by K-12 science teachers. Clearly, the implementation process is complex -- new technology must be purchased and installed, technological skills acquired, new teaching methods mastered, and in many cases new content areas learned. In the context of the larger innovation literature, the innovation under study would be characterized as a technological process innovation. Technological innovations primarily impact task behaviors within the organization's technical core, in this specific case the science faculty (Damanpour, 1988; Kimberly & Evanisko, 1981). Process innovations necessitate modifications in the work context and the nature of the work itself (Zmud, 1984).

METHODS

Research Sample

The research sample consists of 200 K-12 schools located in the state of New Jersey, USA. The sample of 200 schools was randomly selected from a larger population of 500 New Jersey K-12 schools. The principal at each of the selected schools was contacted and their participation in the study was requested. Of the 200 schools contacted, 164 agreed to participate in the study and provided a list of the science faculty at their school. All schools confirmed they had made the decision to adopt computer and telecommunications technologies to teach science and had initiated the process of implementation by committing resources to the training of their science faculties in the use of these technologies.

Data Collection Methods

Two questionnaires served as the data collection instruments. One questionnaire was mailed to the school principal (n=164). The other questionnaire was mailed to the science teachers at each of the participating schools (n=534). Of the 164 schools in the sample, 116 schools returned questionnaires from both data sources (70 % response rate). Nine of these schools indicated that their science teachers did not have access to computers or Internet resources for teaching science and were eliminated from the analysis. To ensure that we had a representative sample of the science faculty from each of the schools in our sample we established an additional criterion for inclusion -- 50% or more of the science faculty must have returned useable questionnaires. This resulted in a final sample size of 69 schools. In 45 of these schools questionnaires were returned from 100% of the science teachers.

Measures

Unless otherwise noted, subject matter experts developed the measures used in this study. For each measure, a panel of science teachers reviewed these items and identified items that were irrelevant or hard to understand. In addition, the science teachers were asked to identify items that were not included that would be important descriptors of the construct under study. All measures used in this research are available upon request from the authors.

Climate for implementation was defined as the shared summary perceptions of the extent to which the science teachers' use of computer and telecommunications technologies is rewarded, supported, and expected within a school system (Klein & Sorra, 1996; Schneider, 1990). The climate measure reflected six perceptual dimensions: (1) availability of training in the use of computer and telecommunications technologies to teach science; (2) availability of time for teachers to get familiar and experiment with computer technology; (3) the presence of incentives/rewards for using computer technology; (4) classroom access to computer technology and Internet resources, (5) access to technical and pedagogic assistance when needed; and (6) the responsiveness of the administration in removing obstacles to using technology when encountered. Typical items included: "Hands-on training in the use of computers and the Internet is readily available to science teachers in this school"; "Time is set aside for teachers to practice, reflect and get familiar with computer technology." All items were rated on 5 point Likert-type scales ranging from strongly agree to strongly disagree. Cronbach's alpha for the climate for implementation scale was .95. A school's climate for implementation score was computed as the average of the aggregated individual teacher's ratings.

Innovation-values fit refers to the extent to which targeted users perceive that the use of the innovation (in this case the use of computers and Internet resources to teach science) will foster the fulfillment of their important workplace values (Klein & Sorra, 1996). To measure innovation-values "fit", we measured both the science faculty's values and their perceptions of the extent to which classroom use of these new technologies fostered fulfillment of these values. From these data we then calculated a fit score.

Seven scales were constructed to measure seven different group values. Examples of the group values that were measured included: wanting to be known as a very progressive group of teachers with respect to the teaching methods used, wanting students to place high in inter-school science competitions, and wanting to develop/deliver science lessons that are highly relevant to students' everyday life. Seven corresponding technology scales were also developed to measure teachers' perceptions of the extent to which classroom use of the new technologies fostered fulfillment of these values. All items were rated on 5 point Likert scales ranging from strongly agree to strongly disagree. When responding to the seven value scales and the seven technology perception scales, teachers were always asked to characterize the views of the science faculty *as a whole* at their school.

Cronbach alphas for the seven group value scales ranged from .73 to .90. Cronbach alphas for six of the technology perception scales ranged from .87 to .93. One technology perception scale had an alpha of .55. For both the group value scales and the technology perception scales, individual teacher's responses were aggregated and averaged to arrive at a school score. A school's innovation-values fit score was then calculated as the grand mean of all the technology scales for which the school mean on the corresponding value scale was ≥ 3.5. This score provided a measure of the extent to which the innovation was perceived to support the important values of the science faculty as a whole.

The scale measuring organizational receptivity toward change was adapted from the research by Siegel and Kaemmerer (1978). The scale measures the extent to which the organization is perceived to be open to change and its' general receptivity toward change. Sample items include: "This school can be described as flexible and continually adapting to change", "This school seems to be more concerned with the status quo than with change" (reverse scored). All items were rated on 5 point Likert scales ranging from strongly agree to strongly disagree. Cronbach's alpha for this scale was .92. A school's receptivity toward change was computed as the average of the aggregated individual teacher's ratings.

Two measures of implementation effectiveness were used in this research. In the first measure, implementation effectiveness was operationalized as the <u>quality</u> with which science teachers at a school employed these new technologies in the classroom. For this measure, the school principal was asked to rate each of the science teachers at their school on their quality of use. The school principal performs bi-annual performance reviews for all the teachers at a school. Therefore, school principals should be good assessors of the extent to which a teacher is currently using a specific technology and the quality with which she or he is using it. Implementation effectiveness for each school was then computed as the mean of the aggregated ratings of the teachers. In the second measure, implementation effectiveness was operationalized as both the <u>quality</u> with which the science teachers at a school employed these new technologies in the classroom and the <u>consistency</u> with which they used these technologies in the classroom. For this measure, the science teachers were the raters of these behaviors and an index that included these two dimensions of effectiveness (quality and consistency of use) was computed.

RESULTS

Preliminary Analyses

T-tests were conducted to determine if schools included in the analyses differed from the larger population. The 69 schools included in the analysis were compared to the remaining schools from the initial sample of 200 randomly selected schools with respect to three district level variables: dollars spent per student, average scholastic achievement test scores, and high school graduation rate. These district level data for our sample of 69 schools are not significantly different from the larger population ($p > .10$). Given these data and the fact that we had responses from 50% or more of each school's science faculty, we conclude that the results to be presented here are representative of the population of K-12 schools from which the sample was drawn.

Descriptive Statistics

Means, standard deviations, and correlations among the measured variables included in the tests of the hypotheses are shown in Table 2. The climate, receptivity toward change, and innovation-values fit variables were measured on 5-point scales with "5" representing a higher degree or frequency of the measured variable. The measure of implementation effectiveness as rated by the school principal was measured on a scale ranging from 0 to 13. A score of "0" on this scale indicates that although teachers have access to computers for classroom teaching, they are not making use of them to teach science. The index of implementation effectiveness which used the data from the teacher surveys was computed by first standardizing and then combining the means on the consistency of use and quality of use scales. It is interesting to note that the two measures implementation effectiveness – i.e the principal rating and the teacher rating – correlate .59.

	Mean	SD	1	2	3	4	5
1. Climate	2.87	.64					
2. Org'l Receptivity Toward Change	3.26	.65	.61**				
3. Innov-Values Fit	3.59	.48	.22	.19			
4. Impl. Effec (Principal Ratings)	5.12	3.64	.45**	.23	.11		
5. Index of Impl Effec (Teacher Ratings)	0.00	1.84	.63**	.41**	.29*	.59**	1.00

*$p < .05$, **$p < .01$

Table 1: Means, Standard Deviations and Intercorrelations Among the Measured Variables

Tests of the Research Hypotheses

Regression analysis was first conducted using implementation effectiveness <u>as rated by the school principal</u> as the dependent variable (see Table 2). As can be seen from Table 2, the predictors account for a significant portion of the variance in the dependent measure ($F = 4.58$, $p < .01$, $R^2 = .20$) and the beta coefficient for climate for implementation is significant ($p < .01$). These results provide strong support for H1 -- climate for implementation is positively and significantly associated with implementation effectiveness. The innovation-values fit variable was not found a good predictor of implementation effectiveness. Thus, no support was found for H3.

Predictor	B	SE	Beta	*r*	*t*
Climate	2.76**	.91	.48	.45**	3.00
Org'l Receptivity Toward Change	-.36	.85	-.06	.23	-.42
Innov-Values Fit	.24	.91	.03	.11	.26

F-Ratio for the Regression 4.58**
R = .45 $R^2 = .20$

*$p < .05$, **$p < .01$
Table 2: Regression Results Using Implementation Effectiveness (Principal) As The Dependent Variable

Using Baron and Kenny's (1986) procedure we tested H2 -- if climate for implementation mediated the relationship between receptivity toward change and implementation effectiveness. Strong support was found for H2 – climate for implementation mediated the relationship between receptivity toward change and implementation effectiveness.

Next, regression analysis was conducted using implementation effectiveness <u>as rated by the science teachers</u> as the dependent variable (see Table 3). As can be seen from Table 3, the predictors account for a significant portion of the variance (F = 11.63, $p < .001$, $R^2 = .41$) and the beta coefficient for climate for implementation is significant ($p < .001$). Again, the innovation-values fit variable was not found a good predictor of implementation effectiveness and no support was found for H3.

Predictor	B	SE	Beta	*r*	*t*
Climate	1.75***	.41	.61	.64**	4.22
Org'l Receptivity Toward Change	-.09	.39	-.03	.41**	-.23
Innov-Values Fit	.60	.41	.16	.29*	1.48

F-Ratio for the Regression 11.63***
R = .64 $R^2 = .41$

*$p < .05$, **$p < .01$, ***$p < .001$
Table 3: Regression Results Using Index of Implementation Effectiveness (Teacher) As the Dependent Variable

Using Baron and Kenny's (1986) procedure we tested if climate for implementation mediated the relationship between receptivity toward change and implementation effectiveness when using the teacher ratings of implementation effectiveness as the dependent measure. Strong support was found for H2 – climate for implementation mediated the relationship between receptivity toward change and implementation effectiveness. Thus, the results using the teacher ratings of implementation effectiveness are unchanged from the results when using the principal ratings of implementation effectiveness.

DISCUSSION AND IMPLICATIONS

The results support the role of climate for implementation as a key predictor of implementation effectiveness. Moreover, climate for implementation was found to mediate the relationship between receptivity toward change and implementation effectiveness. Thus, organizations high on receptivity toward change appear to more readily enact strong climates for implementation.

It may be that organizations high are receptivity toward change are endowed with structures or norms that enable greater flexibility in implementing and/or adapting policies and practices that support innovation use. This is consistent with the findings by Nord and Tucker (1987). Thus, future research may want to focus on how organizational structures or norms may mediate the observed relationship between receptivity toward change and climate for implementation.

No support was found for the relation between innovation-values fit and implementation effectiveness. Given the general support in the innovation literature for the linkage between user values and users' willingness to adopt new technologies the lack of an observed effect is surprising. It is notable that the effect was in the predicted direction and the zero order correlation between the innovation-values fit variable and the teacher measure of implementation effectiveness was significant. An examination of the innovation-values fit scores suggests that there may be some restriction of range on this variable in our sample. This will make it difficult to detect an effect where one may exist. Future research should explore the relationship between innovation-values fit and implementation effectiveness further. The lack of an observed effect in the present study may indeed be a statistical artifact.

The results of this study have implications for enhancing implementation effectiveness. The support for Hypotheses 1 and 2 confirms the influence of organizational variables on the implementation of new technology (Hattrup & Kozlowski, 1993; Tracey, et al., 1995). Managerial actions that send a message that change and adaptation are important and valued, and cues that suggest that the organization is open to change, appear to facilitate the implementation of new technology. The findings regarding climate for implementation suggest that implementation efforts should focus on creating appropriate climates that support implementation rather than the implementation of a precise set of policies and practices. The practices and policies put in place to support implementation may indeed be organization specific. Given the perceptual nature of the climate construct organizations may want to solicit feedback from targeted users on the efficacy of their efforts to create climates that support implementation.

While this study makes an important contribution to our understanding of the implementation of technological innovations, several limitations should be noted. First, the unit of analysis in this study was the organization. Thus, results of this study are not generalizable to the individual level of analysis. Moreover, our sample consists of not-for-profit organizations. Thus, the results of this study may not be generalizable to implementation efforts in for-profit organizations (Damanpour, 1991). Finally, data for this study were collected at a single point in time. Although such data are adequate for examining relationships among variables, these data are not adequate for the purposes of inferring causation. Finally, this field of research would benefit from studies whereby longitudinal data were collected. Implementation occurs over time. In cases where the innovation entails complex new technologies the cycle time for implementation may indeed be years. Antecedents of implementation effectiveness may be different for the early vs. later phases of the implementation effort. As the organization gains experience with the innovation feedback from these experiences may indeed influence determinants of implementation effectiveness at the later stages of the implementation process. Thus, research that overcomes these weaknesses and investigates the implementation process over time is needed.

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ACKNOWLEDGEMENTS

This research was supported by a grant from the National Science Foundation (REC-9603458), Principal Investigator, Patricia J. Holahan. The support of the National Science Foundation is gratefully acknowledged.

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