
# Adaptively Learning About the Impacts of Information Processing Technologies in the Office

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Based on a paper in the symposium: "Implementing the Office of the Future": "Innovations in Workplace Technology" at the Academy of Management annual meeting New York, August 16, 1982.

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# ADAPTIVELY LEARNING ABOUT THE IMPACTS OF INFORMATION PROCESSING TECHNOLOGIES IN THE OFFICE

## ABSTRACT

In this paper we make a case for the need to develop and use a research methodology that helps us learn about the impacts of information processing technologies in the office. We characterize this methodology as "adaptive research" and draw on our own experience to illustrate what it might look like. The case for adaptively researching automated office technology (AOT) is based on the fact that AOT is not only a change but is itself changing and changeable. Research methods need to reflect this reality. We provide examples of methods that: measure change (including fundamental changes in worldview), that themselves adapt to change, and that can handle the degrees of variety and complexity involved.

## INTRODUCTION

There are frequent calls for research on the impact of automated office technologies, e.g. (Uhlig, Farber, and Bair, 1979.) By Automated Office Technologies (AOT), we refer to the computer-based information processing hardware and software designed for office settings to provide the following: text processing, data processing, graphics, information bases, and communication linkages. Its impact is usually expected to be profound and to affect individual and interpersonal human processes as well as the fundamental nature of office organization. There is considerable concern about these potential impacts and their ripple effects throughout the organizations. How can we know what they will be? People concerned with human resource management in organizations, for instance, worry about the impact on compensation practices, training, career paths, and the like. There are some concerns about the cost of these technologies versus the benefits to the organization that are often expressed in terms of efficiency, effectiveness, and productivity. For these and other reasons there is a press toward researching this technology and its impact so we can understand the implications of what we have created. This paper addresses this question: what are the research methods that can lead to this understanding?

The technological developments in information processing have been compared in magnitude to the industrial revolution (Strassman, 1982). Much of our knowledge about organizations and the research methodologies we have used to obtain that knowledge are inextricably imbedded in the worldviews of the industrial revolution. If the information processing technologies do constitute a revolution, then we are faced with the possibility that our organizational knowledge and research methods need

to be similarly reconstructed. We want to investigate the appropriate nature of these research methods in the particular context of information processing technologies in the office.

The literature on office automation frequently makes the point: that automated office technologies do not necessarily result in a particular set of organizational and social consequences. One can readily describe examples of how the technology has been used to create "dehumanized" situations--fragmented jobs, assembly lines in the office, heaped with machinelike expectations of the worker and control systems designed to make sure appropriate behavior takes place--but also one can readily describe examples of the technology being utilized to engender a higher quality of work life--increased discretion, enriched jobs, development and enhancement of capabilities, power equalization, etc. The determinants are not in the technology per se, but in the intentions, worldviews, and belief systems of those who design the particular technological adaptations to the work place and the work place adaptations to the technology (e.g. Mankin, et al. 1982). In other words, the ways we use the technology will tend to fulfill our prophecies for it.

By deciding how to research these issues we are making choices about a framework for understanding what can be learned and how to use the knowledge. For example, experimental and quasi-experimental approaches, because they are based on cause-effect assumptions, will yield cause-effect images and engender a manipulative use of the findings (in the same sense that experiments manipulate independent variables to cause dependent results) (Argyris, 1968). We argue for an adaptive research methodology rather than an experimental one because we

believe it will yield organizational understanding appropriate to the characteristics of the information processing revolution.

## THE CASE FOR ADAPTIVE METHODOLOGY

A major purpose for researching office automation is to gain an understanding of the fundamental organizational changes that will accompany the technological "revolution." There are three reasons why an adaptive methodology is appropriate. First, the technology itself is still evolving, the research methods we use must be capable of adapting to unforeseeable technology changes.

But the continuing development of the technology is not the only source of change necessitating an adaptive research methodology. Whenever AOT is implemented in an organizational setting, it, like any other organizational change, creates a situation of ambiguity and uncertainty demanding research techniques capable of adapting to unforeseen organizational responses (Lawler, 1977; Roberts and Porras, 1982).

A third reason for an adaptive research methodology stems from the technology itself and will be present even when the first and second disappear. In most implementations of a new technology at least the technology itself is relatively static. The uncertainty lies in the human and organizational contexts (i.e., how people will respond and how organizational structures and practices will change). In office automation this human and organizational uncertainty is compounded by the capability of the technology to adapt to feedback. That is: the technology itself can be changed by those using it.

We can characterize this adaptation to feedback more completely. There are four orders of information feedback in goal oriented behavior

and technology (Schoderbek, Kefalas and Schoderbek, 1975).

1) No Feedback: The technology produces an output based on original input. No goal-oriented functioning occurs. Output is completely determined by the input and the technology.

2) First-Order Feedback: Output is adjusted based upon feedback about the degree to which it is deviating from or approaching its goal. The goal and the technology remain constant. Level of output varies to keep the system in a goal-oriented equilibrium.

3) Second-Order Feedback: The technology and goals change based upon the circumstances. Goals and the technology for reaching them are predetermined and preprogrammed. Essentially, the technology is one with multiple functions with switching rules activated by feedback. Goals and technology are contingent upon the situation but in a predetermined way.

4) Third-Order Feedback: The technology is adapted to achieve new goals. Feedback provides the inputs for these adaptations of goals and technology, neither of which were predetermined or preprogrammed.

Feedback can be performed in a number of ways, through various technologies or through human agents. All technologies are parts of systems with all four feedback states. Most industrial technologies, for instance, including many robotic and computer integrated manufacturing applications, are relatively inflexible once installed in a site. There is no third-order feedback loop in an organizational setting, or, if there is, the time duration in achieving adaptation is very long. On the other hand, there is a larger system in which there is a third order feedback loop that leads to redesign and evolution of industrial technologies. The important determination is in the locus of

the feedback loops. Eventually, all technologies can be changed to achieve different goals.

Recent developments in office automation have effectively allowed the third-order feedback loop to occur at the office and user level. This occurs because of the increased multifunctionality of the technology, the flexibility in hardware configurations, and the accessibility and flexibility of the software. Up to now the technology has been generally configured for use by specific organizational units and roles for specific purposes (e.g., word processing by secretaries, computer graphics by designers). There have been few linkages among different technological functions and over different organizational roles. Word processing technologies for secretaries could not access data analysis technologies for professionals, for instance. But now, we have networks linking specialized applications and multi-function workstations available to all office roles. The result is increased flexibility in how the organization and individual can choose to use the technology vis a vis roles and task structures. The degrees of variation and the prospects for continuing change are greatly increased. Unlike many industrial technologies, this one can literally be designed and redesigned by users--especially through software but also in component configurations. The prospect of continuing change through third-order feedback loops compels the use of adaptive research methodologies to learn about the impacts of AOT.

## EXPERIMENTATION AND IMPLEMENTATION

Ultimately, questions about technological impact can be answered only by implementing the technology and monitoring the impacts. This is what many organizations are currently doing.

There have been two basic approaches to implementation and experimentation. The first approach is to implement the technology in a flexible manner, allowing third-order feedback and adaptation, to "see what happens." Such high variety implementation is most compatible with the nature of the technology but requires a learning method of commensurate variety and flexibility, (Ashby, 1968). The second approach tries to limit the flexibility of the technology prior to implementation. Implementation then becomes a controlled evaluative experiment on the effects of the predetermined technology. Such experimentation assumes no more than second-order feedback loops will be present and, therefore, that goals are predetermined and technologies are preprogrammed.

Many organizations are presently learning about the new office technologies by monitoring "pilot" implementations. In such cases, learnings gained through the pilot are meant to guide the subsequent implementation of the technology organization-wide. Piloting will not remove the uncertainty stemming from the adaptability of the technology, however.

Figure 1 illustrates a pilot experiment in which implementation is equivalent to a design process that results in an emergent design successfully integrating the technology and the organization. The oscillating line signifies the alteration between changes in the organization and the technology and accents the unpredictability of the emergent state.

EMERGENT "PILOT" IMPLEMENTATION

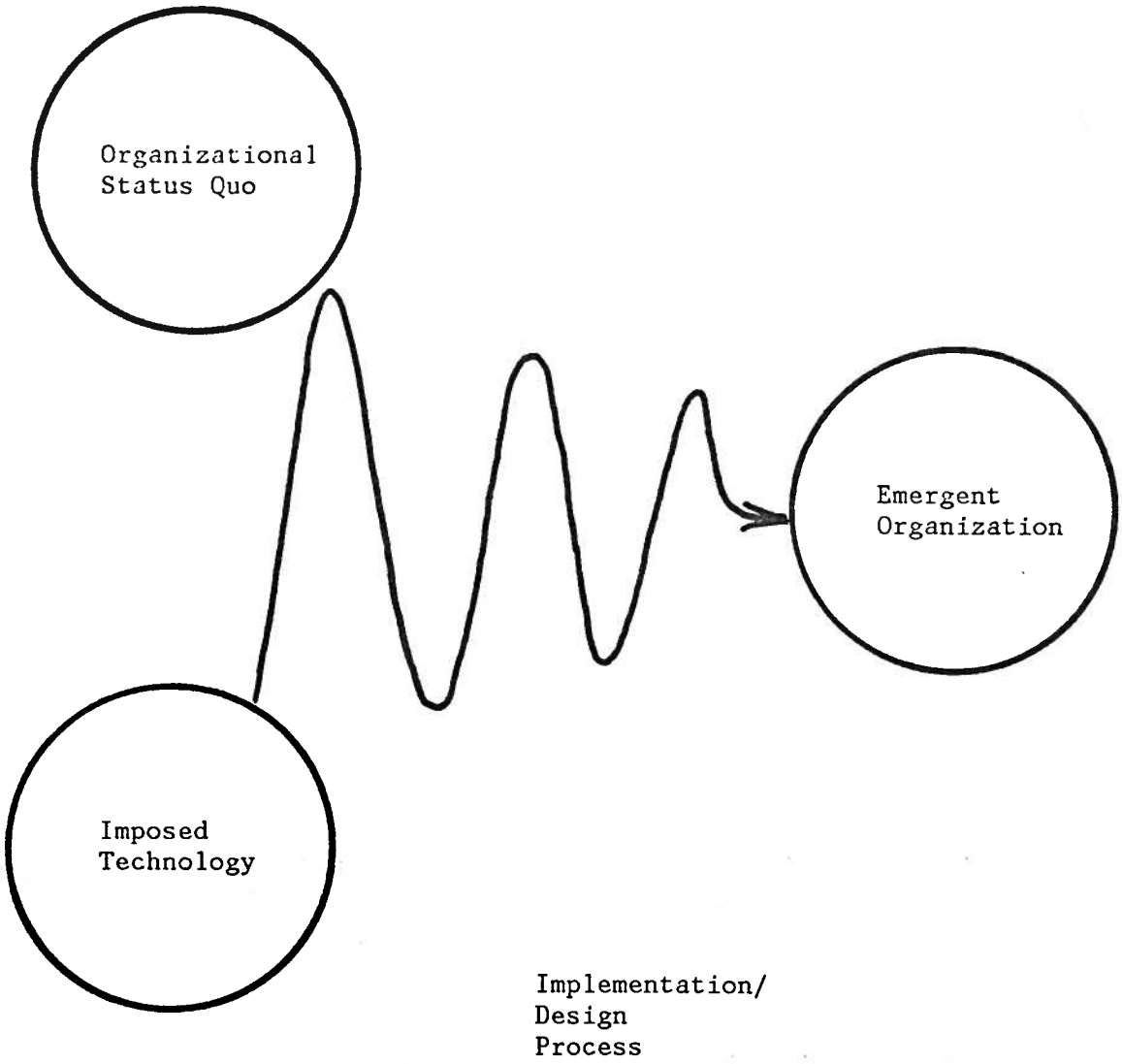


FIGURE I

Figure II illustrates the situation that can occur when a "fixed" prototype design is implemented--the prototype may be based on an emergent design resulting from a pilot as illustrated in Figure I. Figure II can apply to two situations: (1) in an experimental situation where the intent is to evaluate the prototype design; or (2) in an organizational implementation of a "proven" design. In both cases, the prototype is also the targeted goal of implementation. When the prototype is implemented, invariably there are contradictions set up between it and the previous organizational status quo of the office. Those contradictions need to be resolved during the implementation process. The process of resolution will result in an emergent organization different from either the original status quo or the prototype--especially when third-order feedback is present. In this way, implementation is tantamount to a design process comparable to the process in Figure I. There are likely to be significant differences between the goals and technology of the target organization and those of the emergent organization. When the resultant organization is unpredictable in this way, research methods predicated on an assumption of predictability and control are rendered useless.

Pilot implementations are traditionally viewed as a way to "get the bugs out" prior to broader implementation. But the very process of "getting the bugs out" will occur in every implementation. Subsequent implementations need to retain as many characteristics of pilot study programs as possible (i.e, responsiveness to informal feedback, latitude for improvisation by users, sharing of information acquired in the process of using the AOT--in short, flexibility and responsiveness to the on-going situation). Research methods need to be responsive to the tendencies for self-learning and self-design by AOT users.

"CONTROLLED" PROTOTYPE IMPLEMENTATION

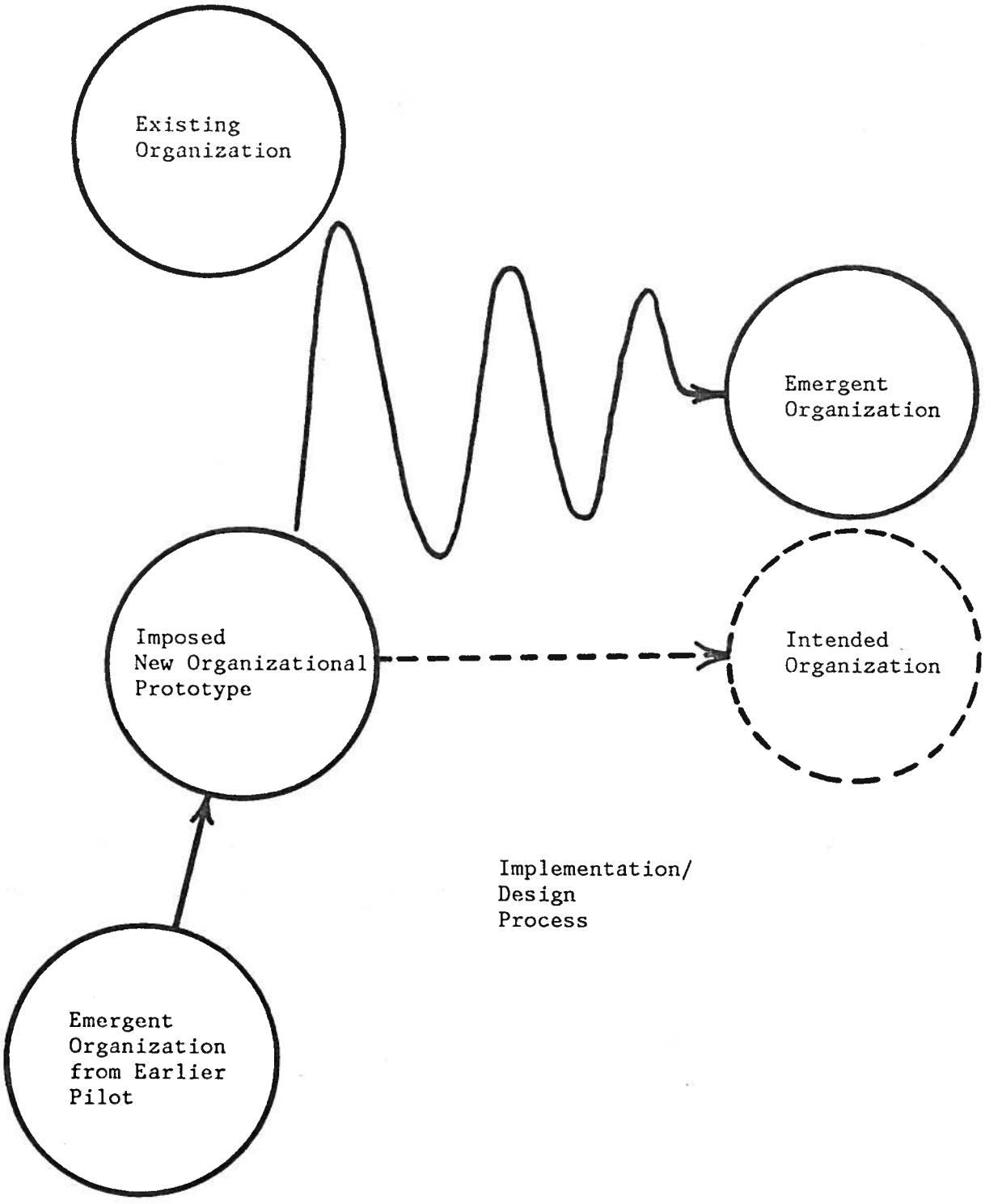


FIGURE II

## APPROPRIATE RESEARCH METHODS

An appropriate method is determined by a combination of the characteristics of the phenomena to be researched and the purpose for which the knowledge resulting from the research is to be used.

The salient characteristics of the technology are that it: is undergoing rapid change and development, has high variety and complexity, and is flexible (therefore is potentially susceptible to user-controlled change of how it is used and the goals for which it is used). Because of these characteristics, the ultimate uses and impacts of this technology are uncertain, unpredictable, and resist predetermination. The purpose of adaptive research is not to reduce such uncertainty and unpredictability prior to implementation but to allow the organization to cope with and reduce them during implementation.

In this section, characteristics of the new technology are paired with some possible research approaches. We use examples with which we have actual experience and, therefore, some indication of their potential usefulness.

### Source of Examples

The setting from which these examples are drawn is the corporate systems unit for a large organization. The unit consists of around 80 individuals who are systems analysts, technical specialists, unit managers, and secretaries. The technology implemented into this unit consists of professional work stations of a highly sophisticated multifunctional nature, more specialized word processing work stations, and a partial networking of these work stations with electronic file and mail capabilities. These work stations were made available to all the

employees. Some of these work stations are used on a shared basis in semi-public areas, but most are dedicated to certain individuals.

Measuring Change

Much of what has been argued above is predicated upon the assumption of change: that there will be change in the organization, that there will be change in the technology, that there will be change in the jobs people do and in the ways they see those jobs. These changes in perceptions can be the source of the third-order feedback processes that result in further change of organizational goals and technologies. Change needs to be measured to substantiate these assumptions and to determine the actual impacts the implementation has.

Measuring change is not a straightforward task. There are three types of change (roughly corresponding to the three types of feedback) that can occur and each requires a different comparison to measure it: alpha change, in which the change is along a constant scale of comparison; beta change, in which the change involves a shift or recalibration of the measurement scale itself; and gamma change, in which the change involves a reconceptualization of the appropriate dimensions and scales to be applied (Golembiewski et al., 1980; Terborg et al., 1980).

We measured these changes by administering Pre and Post questionnaires bracketed around a year of implementation and utilization of the freestanding workstations (therefore, changes do not reflect network impacts). On our Pre questionnaire we collected beliefs and perceptions held by the respondents at that time. On our Post questionnaire, we collected not only those beliefs and perceptions held at the later time, but also the respondent's memories of what their beliefs had been at the

time of the Pre questionnaire (we label these post-test memories of the pretest situation as "Then" perceptions).

In our study we provided the respondents a list of job activities. The respondents responded on a five-point scale how effective they felt they were doing in each activity. This was done for "Pre," "Post" and "Then" perceptions.

On several job activities the respondents reported no changes of any type in effectiveness. These were: "filing," "searching files," "mail handling," and "copying/collating." Respondents, on the average, reported the same level of effectiveness doing these things on Pre, Post, and Then questions. Very few of the respondents reported doing these activities using the workstation. (This should change in the future, however, when electronic filing and copying capabilities are added by the network.)

Alpha change refers to change in output in which the type, direction, and criteria for evaluating the output remain constant but its amount changes. Alpha change of pre-existing outputs is what is in the minds of many people when they contemplate office information technology, to increase productivity, for instance.

In our study we found that the job activities of "writing/composing," "proofing/revising," "preparing presentation materials," and "calculating" all showed alpha changes in perceptions of effectiveness. The respondents, on the average, accurately reproduced how effective they used to feel doing these activities and perceived themselves as being more effective doing them since the advent of the technology (i.e., Then was not significantly different from Pre, and Post was significantly greater than Then). This pattern of responses indicates

that respondents were using the same scale for evaluating their effectiveness on both the pretest and posttest. Thus when they referred to their level of effectiveness at the time of the pretest they tended to answer the same on both the pretest and the posttest. They also perceived effectiveness at the time of posttest to be significantly increased from its pretest level, thus indicating a positive alpha change.

With the exception of "calculating" these activities were those that over 85% of the respondents reported using the work stations to do. These are the activities for which the word processing workstations are explicitly designed. In addition, the department had experience (actual experience for the secretaries, vicarious for the others) with other word processors prior to this implementation and apparently people already understood their own effectiveness at these tasks in terms of the capabilities provided by the technology.

Beta change refers to situations where the direction and type of output remain the same but the criteria that the outputs are evaluated on become more stringent or lenient. In office technologies, for instance, one would expect the technology to open up new definitions of output potential so that what used to be considered optimal output given previous office methods would become suboptimal given the new technology. The scale by which output is evaluated would shift, although the level of output might not.

In our study, several activities showed scale shifts in the way respondents evaluated their own effectiveness in doing them. In most of these cases, the respondents, on the average, judged their pretest effectiveness to be lower on their posttest scale than they originally

judged it to be on their pretest scale. In these cases the scale shift is such that the technology had created a new scale that made pretest levels of effectiveness seem lower than they had seemed on the old scale. The job activities showing these scale shifts are: "creating/designing/conceptualizing," "scheduling/keeping calendars," "planning/organizing," "using the telephone," "conferring," and "meetings."

Gamma change refers to the situation in which it is not simply the output levels or evaluation criteria measuring the outputs that change but the perceptions of the outputs and their purposes that change. Gamma change reflects a shift in worldview so that the same activities before and after change cannot be compared because they have come to exist within different goal and technology frameworks. Gamma change can only be shown by changes of these frameworks.

In our study we measured gamma change by the use of factor analysis, a statistical technique that groups variables together based on the degree to which their values are correlated. The factors (groups of job activities) reflect perceived similarities among the activities they contain. Factor analysis reveals gamma change because, when the technology redefines the activities, it changes the ways in which they are similar and different. Factor analyses of pretest activity effectiveness will group activities into different factors than will factor analyses of posttest activity effectiveness.

Our results showed a shift in factor structure just as we expect for gamma change. Here are some examples of what we found.

At the time of the first survey respondents tended to similarly evaluate their effectiveness at doing the following: "creating/designing/conceptualizing," "analyzing/reviewing," "scheduling/keeping

calendars," "planning/organizing," and "preparing presentation materials." After a year of technology usage these activities were split among three new factors. "Creating/designing/conceptualizing" and "analyzing/reviewing" now grouped with "writing/composing." "Scheduling/keeping calendars" and "planning/organizing" now grouped with "record keeping." And "preparing presentation materials" now grouped with "proofing/correcting/revising." These new groupings indicate that the technology has engendered a redefinition of the original group of activities.

Apparently, "preparation of presentation materials," "scheduling," "planning," "creating," and "analyzing" were originally similar activities for the respondents. Perhaps doing these activities was originally dependent on the creative and analytic wherewithal of the respondent. One year later, the technology has redefined the activities. "Scheduling" and "planning" have come to resemble "record keeping" perhaps because they all involve the structuring of information and events. "Preparation of presentation materials" has come to resemble "proofing/revising" perhaps because both involve reuse of materials already in existence. "Creating" and "analyzing" have come to resemble "writing/composing" perhaps because all involve intellectual interplay between the user and the workstation.

Each of these activity groups interface differently with the capabilities of the technology. But only those activities for which people began to use the technology showed any gamma changes.

The new ways of viewing office activities were incorporated into respondents' memories of the past. When we factor analyzed the "Then" data (people's posttest memories of how effective they used to be at the

time of pretest) we found they tended to remember in terms of the new worldview. For instance, once the technology had defined "record keeping" as an activity different in kind from "filing," "mail handling," and "copying," but similar to "scheduling" and "planning," people could not remember their effectiveness at "record keeping" in the old way. Their memories became classified in the new way. Although their memories may be accurate they are interpreted and evaluated differently. There is reason to believe that unless this is pointed out people are generally unaware that it is happening.

In summary, these results show that the technology has led to some fundamental changes in the ways people view the activities they do. The changes are such that activity effectiveness may not even be comparable before and after the advent of the technology. A new office reality has been created that must be understood on its own terms and which redefines the past into those terms. As this reality continues to evolve, we must use research methods that allow us to understand it.

Flexible Research Design

The likelihood of change but the inability to predict its nature demands flexibility and constant monitoring of the research design itself. Changes nullify the ability to achieve some learnings but will open opportunities for others.

For instance, in the example installation there were some mechanical delays in the networking of the freestanding workstations. The delay in being able to link up these workstations was used as a fortunate opportunity for research purposes, not a contaminating factor to be controlled. It permitted assessment of the impacts of the

free-standing units prior to assessment of the additional impacts due to networking.

This inadvertent staged implementation promises to be very functional, a learning potentially missed if we had stuck with the original research plan. The emerging situation has forced us to become more and more flexible in our approach and alerted us to the need to more constantly monitor the continuous emergence of new practices and organization. The unforeseen mechanical difficulties also require flexibility in the piloting unit. By making the necessity for flexibility salient, this occurrence helped facilitate a self-design orientation in the unit.

Real Time Methods

Users of a technology inevitably want to adjust the technology itself (although they do not always feel it is legitimate or possible to do so). Not only is AOT immensely flexible in this regard, the adjustments and alterations that do take place occur in real time. Nothing short of real time research methods can hope to capture this rapid evolution and emergence of implementation and use issues.

In the example installation, user delight with each newly discovered or invented capability was soon accompanied by disappointment in a technological constraint made obvious by the discovery. During interviews, for instance, several participants were ecstatic about their ability to change their documents to get them "just right," yet complained about how slow the workstation was in entering corrections.

This above example illustrates how the criteria by which users register satisfaction with and measure effectiveness of the technology are constantly shifting, making traditional time series measures of

impact problematic. To some extent, these shifts can be followed by means of interviews--our interview practice has been to use semi-structured interviews of individual unit members spread over time in a randomly determined sequence. Such issues might also be followed by using logs or other instruments, electronically accessed directly by the user through the workstation.

Complex and High Variety Group Methods

The variety of technological possibilities and especially the compounding of them due to network interaction demand a multiple perspective and interactive research design. In our experience we have found that group interviews, for instance, can result in additional learning with greater efficiency compared to interviews with individuals. The group interviewees also learned quite a bit during these sessions.

We structured our group interviews as group discussions of data. We have so far experimented with two formats. In one, we follow a standard survey feedback technique in which data from a previously administered questionnaire are fed back and the interpretations of the patterns are discussed. In the other, we administered a questionnaire at the time of the meeting. Questions were arranged topically by page. In a group, five to ten respondents filled out the questionnaire page by page individually. After they completed each page, we engaged the group in a discussion of their responses. This technique has the advantage of yielding both structured questionnaire and emergent discussion-based data. While both have been successful techniques for eliciting information, we prefer the second.

Option one tends to sacrifice the real-time aspect of the change. No matter how swift, feedback of previously collected data is stale. It tells the receiver little that is not new. It engenders a strong sense that the meeting is being held for the researchers' and not for the interviewees' benefit.

The second method achieved a higher quality of discussion because we were tapping present perceptions, and the participants clearly were learning from one another as well as formulating and working out their own emergent ideas.

In both variations we felt the group mode elicited knowledge and data not brought out by other research methods. There were "synergistic" products of the group. These discussions were most helpful in confronting issues of productivity, value added, design, innovation utilization, and the like. Such information is equally as useful to the participants as to the researchers. We recommend that research in this field begin to include more systematic methods for utilizing groups in working through these issues. Not only can these groups consensually validate or invalidate findings, but when they develop consensus on some emergent issue, it can serve as an indicator of a new reality. We envision using nominal group techniques, for instance, to investigate and generate productivity, effectiveness, efficiency, and value added contributions of AOT. These groups used for generating and interpreting data could be easily extended into design-oriented groups.

## SUMMARY

In summary, the paper presents a rationale for a research methodology, with some examples, that is appropriate for learning about the impacts of change to information processing technologies in the office. To the extent that organizational learning is a necessary outcome of any innovation implementation, the methodology is a useful component of the implementation activities, design activities, policy decisions, and justification processes.

This is not "exploratory research" to discover issues and hypotheses to be later verified in a more traditional experimental mode, but is a method of research that tracks that which is inherently nonverifiable, i.e., the constantly changing realities that this technology spawns. While many have called for such a research approach with regard to other social and organizational issues, the advent of information processing technologies has provided an instance where the utility--indeed the necessity--of such an approach is apparent. We must realize that these technologies, their uses and impacts, are only knowable and defined by the human subjects of our research and indeed are extensions of their own subjective views of the world. This calls for a subjective and adaptive research approach.

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