

ASSESSMENT OF AN EFFORT TO INTEGRATE COMPUTER FUNCTIONS IN AN ENGINEERING DESIGN FIRM

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This study is an assessment of a large engineering design firm's efforts to integrate diverse elements of computer use. The integration effort had two elements: the implementation of workstations capable of integrating project management, analysis, text production and graphics production, and a communication function that allowed system users to access both each others' work and data stored in a variety of other computer systems. Methods used were questionnaires and in-depth interviews. Three basic issues were studied: differential affects of the system on professional and clerical workers, impact of the system on document production, and effects the system had on the nature of work in the organization. Observed changes included better document production, growing reliance on the system, and higher productivity. People did either more of the type of work they did prior to using the system, or the same amount of work but better. There was also an indication that some users were able to do tasks they previously sent to others. Explanations are proposed as to why two other effects were not detected — differential impacts on professional and clerical workers, and a shift in the nature of work in the organization.

INTRODUCTION

How does a company's information technology impact people's work lives? Is the capacity for information processing important? Does equipment design make a difference? How important are differences in access patterns, implementation strategies, or the "corporate attitude" toward computers?

Empirical research has uncovered likely answers to aspects of the question of impact. For all of the research that has been done on this topic, two important issues have not been addressed. First, what is the impact of improving the computer capacity of an organization by integrating disparate functions? Second, how do computer systems affect technically oriented professionals for whom data analysis is a major aspect of their work? The research reported here is an initial effort to address these questions within the context of a large engineering design firm.

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The specific improvement we speak of is the integration of analysis, project management capabilities, and the production of high-quality presentation materials. The integration of these functions was effected by a network of workstations specifically designed to integrate graphics, text and equations in the same document, to allow many users to access each others' work, and to transmit information between the workstation and a variety of other computers. We reasoned that such capabilities would be important to professionals in a design setting because their work involves managing projects which are based on technical calculations, and because they are required to make frequent presentations based on these calculations.

We had the good fortune of finding a company which offered an ideal research opportunity. The company was a heavy user of the workstation system and had been so for more than a year prior to our study. Thus, we were dealing with a sample where the workstation, as an innovation in the organization, had achieved a reasonable degree of routinization. We did not have to be concerned with the impact of the workstation being diluted by the difficulties attendant upon implementing an innovation.

There were a considerable number of users who fell into two categories: clerical and technical. Thus, we were able to compare impact on two groups, one needing both analysis and document production and the other needing only the ability to produce documents. We hoped that such a comparison would shed light on the interaction between system use and specific job requirements.

METHODOLOGY

An *a priori* decision was made to include several basic issues in any questionnaire or interview used. A copy of the questionnaire can be obtained from the authors.

Experience with the workstation and with other available computer technology: This would allow us to assess computer literacy and the extent to which computers played a part in the respondent's work life. We felt that differences among respondents in this regard might help explain any differences we might find in the workstation's impact.

Impact on written documents: If the value of new computer technology lay with its ability to combine analysis with good presentation, one would expect changes in the form, content or frequency of written communications.

Changes in the work people do: Computer technology allows people to do their work faster and increases the range of tasks they might perform. This is a combination which could have a profound impact on how people actually spend their time at work.

Perceived advantages and disadvantages of the workstation: Since we were assessing a technological innovation this information was useful in its own right. More important for our purposes, it may help explain uses to which the equipment was put and its impact on people's work lives.

A draft questionnaire was developed and discussed during in-depth interviews with knowledgeable people in the company. These discussions served to help us refine the questionnaire and identify users of the workstation. These discussions also afforded an opportunity to chat informally with people and to observe work activities in the company.

One hundred sixteen users were identified. Of these, 63 could not be reached because of field assignments or vacation schedules. We excluded the staff of the information systems department because we felt that such personnel might interact in unique ways with new computer technologies. Data were collected from almost all of the remainder for a total sample of 28 technical personnel and 25 clerical personnel.

All efforts were made to develop closed ended questions for all items. Content analysis was used to develop response categories for items that could not be fit into a closed ended format.

Ideally, we would have confirmed these results through systematic observation of workers, but such a tactic was impractical. Several elements in this study, however, lead us to trust our findings. First, respondents did report many aspects of dissatisfaction with their systems. This is an indication that they were not simply providing responses that would be looked upon favorably by management. Second, our informal observations, which took place during the questionnaire development phase of the study, led us to believe that our findings were accurate.

Finally, we have done similar research using both interviews and questionnaires on a variety of populations, including military personnel, middle managers in the private sector, and workers in a number of government settings [3, 5]. In all of these cases we pre-tested our instruments by asking informed members of our research populations about the ability of our instruments to yield valid data. Although we have received many specific criticisms which led us to revise items, there has also been consensus on the fact that the instruments would be useful and valid.

This is not proof positive, but it does give us reason to feel comfortable about the general approach.

RESULTS

Differences Between Technical Workers and Clerical Workers

All respondents were asked to provide their official job title. This information was used to differentiate the two groups of workers. Our premise was that the impact of the workstation would differ for the two groups because of the unique way specific computer capabilities can interact with requirements. Thus, technical personnel would be expected to use the system in a manner that would capitalize on its ability to synthesize text and graphics. In contrast, the clerical group would be expected to take advantage only of the productivity increasing consequences of computerized graphics production and text processing.

We searched for these differences in many ways. Were correlations between pairs of items different for the two groups? Was the factor structure among items (using principle components analysis) different for the two groups? Were there differences in the frequencies of responses to the various items in the questionnaire? No differences were found regarding document production. No differences were found regarding changes in work life. There was only a suggestion of difference regarding perceived advantages and disadvantages of the specific workstation equipment. Only one reasonably clear difference emerged (see Table 1) — the professionals clearly felt a need for more data processing capacity.

Impact on Written Documents

One would expect workstation technology to affect the nature of written documents. To test this possibility we asked people if the workstation brought about changes in the length of written documents. Fifty percent answered yes.

Table 1. Technical/Clerical Differences

Reasons to Use Other Computers				
	More Capacity	Not Proficient with Workstation	Cost Less	Undefined Response
Technical	13	1	1	11
Clerical	1	2	0	7
Totals	14	3	1	18
Most Common Reasons for Disliking the System				
	Processing Capacity	Available Software	Equipment Availability	Ergonomic Factors
Technical	12	11	5	3
Clerical	12	6	4	2
Totals	24	17	9	5

DISCUSSION

Three issues will be discussed in this section: What does the study tell us about the importance of document production in organizations? What impact can computer systems have on work patterns in organizations? Why did we not observe greater effects of the new computer system?

Document Production

Almost all important uses reported for the system had to do with document production. Similarly, high ratings of satisfaction were centered on document production capabilities. Either documents could be produced faster, or with higher quality, or with better integration of graphics and text. The importance of this finding must be understood in terms of two facts. First, the company had many other machines capable of word processing and continued to make these machines available even after the new system was installed. Thus we are dealing with an innovation which marked a clear improvement over previous capabilities, but which was still a *relatively* small change.

Second, the nature of this company's business placed a high premium on quality technical documents. Because this company designed and managed very large and technically complex projects, reports with graphical and numeric data constantly circulated within the company and between the company and its clients. Thus, we have not demonstrated the *general importance* of a computer's ability to produce high quality complex documents, but we have shown that in the right circumstances such a capacity is highly valued and can have a clear impact on an organization — even when the baseline of comparison is already rich in word processing equipment.

Work Patterns

An important finding was that productivity increased as a result of people doing work faster and thus having more "free" time. As a result, people did more of what they did before, or the same amount but better.

Also important is the hint that the computer system may have sparked a *spontaneous* consolidation of tasks. Work previously done by many people is now being done by fewer people, not because of any conscious reorganization, but because of a natural interaction between the nature of people's jobs and the capacity of the technology. The effect in our data is not strong, but as we will see later, this may be due to special inhibiting circumstances in the setting where we worked. If such reorganization is common when new office automation systems are implemented, several questions require further research. How much more effective are workers who, because they can do a greater variety of work for themselves, do not have to coordinate with the schedules of others? What happens to those who have less to do?

Beyond the matter of individual activity is the impact of such changes on overall organizational productivity, which is likely to increase in some parts of the organization and decrease in others. Also, the linkage between organizational subunits will lessen. How can technology

be introduced to make the most of the changes in work patterns that it may bring about? How might an organization manage these changes to its best advantage? Under what circumstances will such changes occur on a large enough scale to be of practical concern to management?

All changes in work that were reported to us involved doing more of what was done before, rather than new tasks that did not previously exist. It is not obvious that this should be the case. In fact, previous research did find that computer technology generated new types of work for the system's users [1, 2, 4]. Why no such findings here? One possibility is the setting — no other study dealt with engineering professionals in a firm whose product was almost totally devoted to design and engineering in a mature technology. If so, our results offer a clue to the circumstances under which computer technology has particular types of organizational consequences. Another possibility is that more profound changes would have occurred had the system not had some important limitations. This leads us to the third part of this discussion section.

Magnitude of Effects

Responses indicate that the data handling abilities of the system were perceived to be limited. (Remember that limitations of processing capacity and available software were the most important reasons for people's dissatisfaction with the system.) Perhaps added uses would have developed had the capacity of the equipment been larger. If so, this may also explain the lack of observed differences between technical and clerical personnel. Clerical personnel needed good document production capabilities, which were adequate. Technical personnel needed both document preparation ability and analysis capability. The nature of their jobs may be such that changes in the substance of their work required the analysis potential they did not have.

Another explanation may involve access to the workstations. Although our questionnaire did not touch directly on this matter, the issue did come up in interviews and informal conversation. The workstations were not dedicated to any given individual. Rather, they were placed in areas of common access for anyone to use. Thus, an individual could not be sure that he or she would have access to a machine at a convenient time. Another aspect of access was the delay in log-on and document retrieval time, especially when data were entered in one workstation, but accessed from another.

Thus we have three possible explanations for the relative lack of profound impact of the system on people's work lives. Limits on data processing capabilities may have limited the value of the machines to the professional workers. Difficulties of access — to workstations and to stored data — may have kept people from exploring new applications. Limitations on the design of the research did not allow us to test these competing explanations.

CONCLUSION

The ability to integrate text, tables and charts to produce high quality documents is highly valued in the

setting we studied. This was evidenced by respondents' praise for the equipment's ability to produce such documents and the extent to which they came to rely on it. Considering that word processors were already common in the organization, it is noteworthy just how important the integration function became. There is also some indication that under the right circumstances, equipment such as this can loosen the links between organizational subunits by allowing people to do work they previously sent to others.

We did not observe a phenomenon that was found in similar studies in other settings. The equipment did not facilitate people's developing new types of work that were previously unknown in the organization. We hypothesize that this lack may be due to limitations on the processing capacity of the equipment, the nature of the industry, or problems of constrained access to the workstations.

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References

- [1] Bikson, T.K., Stasz, C. and Mankin, D.A. *Computer Mediated Work — Individual and Organizational Impact in One Corporate Headquarters*, R-3308-OTA, Rand Corporation, Santa Monica, California, 1986.
- [2] Fleischer, M. and Morell, J.A. "The Organizational and Managerial Consequences of Computer Technology," *Computers in Human Behavior*, Volume 1, 1985, pp. 83-93.
- [3] Fleischer, M. and Morell, J.A. "Managers as Information Technology End Users," *Proceedings of the 1986 International Congress of Technology and Technology Exchange*, October 6-8, 1986, Pittsburgh, Pennsylvania in press.
- [4] Majchrzak, A. "Effects of Computerized Integration on Shopfloor Human Resources and Structure," paper presented at the Society of Manufacturing Engineers AUTOFACT Conference, Detroit, Michigan, November 1985.
- [5] Morell, J.A. and Fleischer, M. "Survey and Interview Studies of Office Automation — Summary of Findings and Comparison of Methodologies," paper presented at the 1986 annual meeting of the American Evaluation Association, October 30-November 1, Kansas City, Missouri, 1986.