Control over Desktop Computing, Infrastructure, and Quality of Work Life

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ABSTRACT

This article examines the role of computing implementation processes in mediating between the use of technology and changes in the nature of work life. Quantitative and qualitative data were collected from a self-administered survey and interviews in 38 work groups. End-users' participation in the process of implementing desktop computers in work groups is examined as a primary contributor to the quality of their work lives, as is the available infrastructure (training, supplies, consulting) to support computing in the work groups. Two primary implementation processes are examined — "Top-down" and "Grass-roots." We examined computer users' quality of work life along five dimensions: participation in decisions about work, job complexity, expertise and involvement in computing, changes in job enrichment attributed to desktop computing, and changes in work effort attributed to desktop computing. The quality of working life was most improved in work groups that computerized with Grass-roots processes and had adequate infrastructure to support their work with computing.

INTRODUCTION

This paper examines the social dimensions of computerization in work groups where computers are important technologies in their work places. Our central question is: What factors influence the quality of work life when computing is a pervasive feature of work and information handling? There are two primary reasons that we selected extensively computerized work groups to participate in our study.

First, some work environments make desktop computing so salient that its influences on work life are likely to be important and measurable. Some earlier studies of computerization and work have found modest changes in work because computerization was limited [15,17,18]. In the 1960s and '70s, information system users usually received printed reports. Data entry clerks often had terminals at their desks while professionals and managers used terminals outside their immediate work area. The new wave of desktop computerization in the 1980s is much more likely to restructure work when computing is not just an instrumentality, but also a key defining element of work places [18,20,32].

Second, desktop computing is a relatively new phenomenon that has affected millions of white-collar workers and will become even more intensive during the 1990s. Desktop computing (DTC) refers to computer-based services accessible through terminals or microcomputers near a person's immediate work area. More services, such as text-processing, communications, and programming, can be readily accessible to people when equipment is physically proximate.

Studies of the effects of computer-based information technology or the role of computerization in shaping work life are often contradictory. Studies that rely upon deterministic impact models often argue that computerization *necessarily* leads either to improvements [7,30] or to degradations [4,8,9,24,31] in the quality of work life. These studies may come to different conclusions because the work groups sampled to test their models differ along many unexamined dimensions that appear to moderate or mediate the effects of technology on work life [5,20]. In this paper we examine two central dimensions of work groups that influence workers' experiences with computerization in their work lives: (a) the process of implementing computing in the work group, and (b) the infrastructure quality to support computer use (e.g., training, supplies, and consulting resources). In addition, we examine the combined effects of implementation processes and infrastructure.

IMPLEMENTATION PROCESSES

Social processes that shape the implementation of computer systems are a key influence on organizational behavior [23]. Bikson [3] reports that most advanced computing implementations are carried out at the work group level. She also argues that implementations are a continuous process, though they are often falsely conceptualized as occurring in discrete stages [14,16,19,21]. We have found that computer-using organizations implement computer-based systems with one of two major control patterns: Top-down and Grass-roots approaches. Top-down and Grass-roots implementations differ in the locus of control over key issues pertinent to computerization — mix of equipment selected, what will be computerized, patterns of allocation, training resources, and so on. In a prototypical Top-down implementation, actors *outside* the computerizing work group, such as upper managers and technical experts in centralized support departments, make all the key decisions. Conversely, in a prototypical Grass-roots implementation participants *within* the computerizing work groups make all the key decisions. The concepts of "Top-down" and "Grass-roots" implementations are ideal types. In practice, the control patterns are more varied and subtle, but most computer implementation processes can be categorized as predominantly Top-down or Grass-roots. In the next section we present descriptions of a Grass-roots work group and a Top-down work group from our study.

Descriptions of Implementation Processes

Pension Systems Control (PSC) typifies a work group that computerized from grass-roots efforts. PSC is comprised mainly of application analysts for the Pensions division of a large insurance company, INSURE. PSC has a very heterogeneous mix of computing hardware, software, and systems. Some analysts have terminals connected to a Hewlett-Packard (HP) 3000 minicomputer, while others have microcomputers that are used as HP terminal emulators or in a stand-alone capacity. The software varies from machine to machine, though text processing software is standardized on all machines. Even the microcomputers differ in brand, memory capacity, type of disk drives (floppy vs. hard), etc. This heterogeneity of computing hardware and software stems from the incremental nature of computer systems development in Grass-roots work groups.

According to the manager of PSC, the systems developers (i.e., actuaries and programmers) and application analysts provided most of the impetus for software and hardware acquisitions and enhancements in the work group. An actuary, who was part of the PSC work group when it originated, convinced an INSURE vice president to allow the Pensions division to purchase the HP 3000. The Pensions division including PSC, had been using INSURE's centralized data processing department's IBM mainframe. The data center frequently had a backlog of applications because many programmers were forced to wait in line to work on their IBM mainframe. The shift to the HP 3000 minicomputer allowed the Pensions division to gain local control over their computing and work. They could develop their own systems and process their own data more readily. PSC's analysts continued to push for new equipment (e.g., to replace terminals with microcomputers or floppy drives with hard drives) and to negotiate how their computing environment was operated and maintained well into the late 1980s.

In contrast to the Grass-roots implementation process in PSC, the centralized Word Processing Center (WPC) at INSURE was computerized in a Top-down fashion. The vice president of the Information Resources Management department decided to implement IBM dedicated word processing work stations in WPC to replace the Want equipment used by word processing clerks. The clerks objected to a changeover because the IBM equipment's menu-driven program was designed for processing technical documents and was cumbersome for their primary documents, letters and memos. The vice president's main concern was to make WPC's equipment compatible with the rest of the organization which mainly used IBM equipment (except for the Pensions division). Typical of To—down implementations — and in contrast to Grass-roots groups — the computing equipment in WPC is very homogeneous. All word processing clerks use IBM 5520s which are dedicated word processing machines. Only one person has a terminal connected to an IBM mainframe in order to exchange documents and to use electronic mail. One benefit of WPC's implementation was that all workers got new, ergonomically designed work stations.

Most studies of computerization and work life assume that implementations are To-down even when there is no explicit discussion of the locus of control of the implementations [11,26]. In Top-down implementations, top managers decide upon specific processes and follow through with relatively large-scale implementations in planned stages. Top-down implementations are common to studies of computerization that focus on lower level staff, such as clerks [10] and machinists [29].

Grass-roots processes for implementing DTC are common yet receive little scholarly attention because they are unspectacular (see however, [28]). Grass-roots implementation processes typically start when a small coalition of professionals within a work group, often with their manager, convince resource controllers to allow them to adopt equipment for local computing. Additional equipment is gradually acquired as other work group members perceive benefits in local computing use and as users develop expertise.

Hypotheses About Implementation Process

This study examines the ways that implementation processes mediate between the use of computing and changes in the quality of and character of work life [3,13]. We have developed hypotheses pertaining to five dimensions of work groups' quality of work life and their members' experiences of computing that will be affected by implementation processes: (a) participation in decisions about and influence over work processes, (b) job enrichment, (c) expertise and involvement in computing, (d) work complexity and (e) work effort. While there is some interaction between these dimensions, we will explain their importance separately with the exception of work complexity and work effort which are so highly related they are discussed in the same section.

(a) Participation in Decisions About Work: The first hypothesis (H1) focuses on the degree to which work group members control their work and participate in work processes. We expect that Grass-roots groups will report greater influence over their work (i.e., more participation in work decision-making processes) than will Top-down groups (H1). We expect that greater influence over work will be a benefit for Grass-roots groups, because workers who value responsibility are often happier and more productive when they participate in work decisions and practices. We expect that members of Top-down groups will report greater managerial control over work behaviors than members of Grass-roots groups. Managers will be more interested in equipment use in Top-down groups because they have invested a lot of money and effort in implementing computerized systems. It is also likely that workers in Grass-roots groups will participate in decision making about a broader array of work-related decisions than workers in Top-down groups. Workers that influence development of computing in their work group probably have influence over other aspects of their work.

(b) Job Enrichment: The second hypothesis (H2) relates the extent to which jobs are enriched to computing implementation processes. Our definition of job enrichment does not focus on the development of worker skills or expertise, as do other constructions of this concept [2]. However, we treat expertise and skill development as a unique dimension of quality of work life (see below, H3). Our job enrichment index summarizes workers' reports of the extent to which DTC has increased or decreased the level of challenge in their job, how pleasant their work area is, how much unenjoyable work they do (reversed), the level of skills they need to do a good job, the amount of annoying rules (reversed), and how trapped they feel in their jobs (reversed). In addition, we measure perceptions of job enrichment that are independent of desktop computing.

We expect that Grass-roots groups will report more job enrichment resulting from DTC than will Top-down groups (H2). In part, we have developed our expectations from the research that has shown a positive relationship between end-user participation in the design of computing systems and their morale and motivation to learn [22,25]. However, previous research on relationships between participation in implementations and changes in work life has really examined the effects of limited participation of workers on systems that have mainly been implemented in a Top-down manner. Most researchers do not examine the effects of participation in computer implementations that are ongoing and intrinsic to the operations of the work group — as in our Grass-roots work groups. There is little relevant data or theory about continuous participation. But we expect that Grass-roots groups will report greater job enrichment as a result of their continuous participation in developing their DTC environment. In contrast, members of Top-down groups will probably find their jobs more constricted. They will, for example, have to contend with more annoying rules because top managers will want to exert greater control over the workers' use of computing in their work. We are less clear about the expected relationship between implementation and job enrichment that is not attributed to DTC. We do not have good theoretical predictions about the generality of the effects of implementation processes.

(c) Computing Expertise and Involvement: The third hypothesis (H3) is that Grass-roots groups will report greater computing expertise, skill, and involvement in discussing computing with co-workers. Marxists [4,8] suggest that increased automation and heightened managerial control degrades work as a result of job fragmentation in capitalist societies. Skill requirements for jobs decline and work becomes more simple and repetitive. Attewell [2] has challenged these conclusions of Braverman [4] and of Glenn and Feldberg [8,9], and argues that computerization generally increases work skills. Attewell and others [1,6] have argued that employers are not substituting skilled employees with sophisticated technology, but are automating the routine work in order to allow workers the time to do more interesting and complex work.

We see nothing inherent in computer equipment that degrades or upgrades work. We believe that job complexity, interest level and skill requirements are contingent upon a number of factors, including the way in which technology is implemented in the work group. Compared with workers in Top-down groups, we expect those in Grass-roots groups to develop more skills on the job than through formal training, to be more motivated to learn about the computer systems, and to discuss computing more often with co-workers because they have had some input into the design of the systems [22,25]. The relationship between implementation processes and skills is discussed in more detail below in the section on Infrastructure.

(d) Work Complexity and Work Effort: Hypothesis

four (H4) is that Grass-roots groups will report greater work complexity than Top-down groups. Hypothesis five (H5) is that Grass-roots groups will report greater decreases in work effort as a result of DTC than will Top-down groups. We do not have strong predictions about the relationship between implementation processes and levels of work effort that are independent of DTC. We predict that Grass-roots groups will report that DTC use has decreased their work effort more than Top-down groups, but their level of reported work effort will not necessarily be lower than Top-down groups.

The "deskilling" literature addresses the way that computerization alters work complexity and work effort [2]. The literature suggests that computerization increases productivity but that work is simplified and tasks are easier to perform. We see major productivity gains when increases in complexity are accompanied by decreases in effort. When workers can use technology to do more complex work than was previously possible — but with less effort — then there has been a considerable increase in productivity. How can respondents simultaneously report that DTC has increased the complexity of work and made tasks easier? We believe this relationship between complexity and ease of work can be explained by increases in workers' skill levels. On the basis of our skill hypotheses developed above, we predict Grass-roots groups to be more likely to attribute more complex work *and* decreases in work effort to DTC, in comparison with Top-down groups.

In summary, we have suggested that the social and organizational processes of computing work groups have important implications for workers' quality of work life and beliefs about computing. Specifically, members of work groups that have control and influence over their implementation process (i.e., Grass-roots groups) should respond more positively to our questions about quality of work life and attitudes toward computing than work groups whose members have had little or no say about the implementation of computing (i.e., Top-down groups). Another important organizational predictor of our outcomes is the infrastructure that has evolved in an organization or work group to support computer operations. In the next section we describe the expected relationship between infrastructure and implementation and the five dimensions of quality of work life.

INFRASTRUCTURE

One way of ensuring a successful implementation of computing is to develop an adequate computing infrastructure [12,13,28]. Computing infrastructure denotes all the resources and practices required to help people adequately use computer systems to carry out their work [16,21]. Computer systems often require additional resources besides hardware and software (e.g., paper for printers, space for equipment, support staff). These adjunct resources cannot be taken for granted, and often become an issue when computer users find them unavailable. Few organizations invest in large amounts of computing staff support for each user. Many firms seem to support microcomputers with about one person per 50 work stations. As a result, microcomputer support staff often become so backlogged in their work that they reduce their jobs to installing equipment and altering configurations. Users often find that they must resolve many operational problems themselves or work around them. Computer use requires skill and the "consequences of computerization" can hinge on a user's skill level. People who do not have the skills to use computing equipment in the way their managers, co-workers or clients expect, can feel greater pressure and perform less well on the job than their counterparts with computer skills.

Skill development comes with experience and training. Practices for training users of new systems or software vary from organization to organization. Some organizations routinely send workers to computer courses or provide "one-on-one" tutorials; other organizations offer no systematic training — all training is conducted informally by co-workers. In our interviews, we observed that supervisors of clerical work groups that process routine documents and transactions take greater pains to systematically train their staff than managers of professional work groups or groups with a mix of clerks and professionals.

Hypothesis About Infrastructure and Implementation Process

Hypothesis 6 (H6) focuses on the degree to which work groups have developed an adequate infrastructure to support their computing environment. We expect that Grass-roots groups will develop less adequate formal infrastructure than Top-down groups. Computer users in Grass-roots groups may receive little or no formal training; individuals may be expected to learn on their own or from other workers. Grass-roots groups will experience more problems as a result of the lack of support services provided by the central organization. When equipment breaks down, staff will often negotiate repairs with service shops themselves. Although workers in Grass-roots groups may report increases in work complexity as a result of computerization and computer-related work, they also should be reporting increases in their DTC skills because of their necessary involvement in troubleshooting. In addition, workers who have had to fight for and develop their own infrastructure for computing should report greater involvement with computers and more discussions with co-workers regarding computers than workers who have had little involvement in the implementation process.

METHODS

Sample and Data Collection

Our primary unit of analysis is the work group. Work groups are located within larger organizational units (departments, divisions) which shape some work group practices about the organization of work, the nature of internal labor markets, and computerization strategies. There are several plausible criteria for drawing work group boundaries. We used a simple criterion which works well most of the time: we clustered people who reported to the same supervisor into the same work group. We selected 38 white-collar work groups with enough DTC equipment that its use might significantly shape work practices and work life. Based on informal pilot studies, we decided to select work groups that had at least one terminal or work station for every two members. Work groups differed along many other dimensions such as number of staff, occupational mix, computer implementation process, turnover rates, and so on. We administered a questionnaire to every member of the 38 work groups in the spring of 1988. The questionnaire included approximately 200 closed-response questions covering topics such as the patterns of the individual's computer use, job characteristics, patterns of computer use and computing practices in the work group, and changes in work life that the respondent attributed to desktop computerization. We received 357 completed and usable questionnaires (86 percent response rate).

We aggregated individual scores in each work group to form a single score (the work group mean). Aggregated scores were used to measure work group characteristics. Alternatives to survey measures of work group characteristics were not feasible in this study because we had a very large sample of work groups. Instead, we supplemented our surveys with observations and in-depth interviews with work group members — including the supervisor from each work group. These data were used to develop our survey as well as to cross-validate survey responses. Thus, while our measures were not standard, we did use a standard measurement strategy by aggregating individual responses to the survey [27].

We complemented our quantitative data collection with approximately 70 hour-long, semi-structured interviews. We interviewed at least one person from each work group — usually the supervisor — though we focussed our interviews in eight work groups and selected informants who represented each job type and hierarchical level. We also interviewed some people outside the work groups who influenced computing arrangements in the groups, such as top managers and computer support staff who controlled key resources. During our initial interviews with the work group supervisors, we ascertained the extensiveness of computing in the work group (e.g., ratio of work stations to workers), the work group size, the mix of clerks and professionals, and how computing was implemented in the work group — in a Top-down or Grass-roots process. This information was coded and later validated with work group responses to questionnaire items about these aspects of the work group.

Twenty-five of the sample 38 work groups came from three large organizations — INSURE, AIRCRAFT, and COAST PHARMACEUTICALS. The other 13 work groups came from seven other organizations. These organizations can be characterized as providing especially good work places. At INSURE, women valued subsidized child care, good benefits, and pleasant surroundings. At AIRCRAFT, laboratory engineers mentioned good career ladders and respect from superiors. At COAST PHARMACEUTICAL, the organization pushed an up-scale image with tennis courts, an excellent cafeteria, and original art in public spaces. However, we noted some negative aspects of work life in each organization. At INSURE, work was relatively bureaucratized and routinized; significant innovations and individual initiatives were rarely rewarded. INSURE was also in the process of "right-sizing" or decreasing the size of some work groups by offering incentive lump-sum payments to people who would agree to leave. At AIRCRAFT, members of a large aerospace engineering laboratory expressed concern over a lack of funding for new research and development which might preclude future growth. There was also a space crunch so that lab employees were currently working in small windowless cubicles rather than in the larger two-person "private" window offices they had previously used. At COAST PHARMACEUTICALS, work groups were leanly staffed so that employees seemed to work under high pressure most of the time. Top managers often mandated new policies in work procedures or practices with little consultation or advance notice.

Index Construction

In addition to analyzing work group level responses to individual items, we created 12 composite indices for analysis: (a) two indices were developed to validate our a-priori coding of work groups' implementation process as primarily Top-down or Grass-roots; (b) one index was created to measure infrastructure adequacy for supporting computing; (c) seven indices were constructed to measure characteristics of work and computing: work complexity and participation in work decisions, current work effort, changes in work effort attributed to DTC, current quality or richness of individual's jobs, changes in richness of individual's jobs attributed to DTC, and expertise and involvement in computing. Two additional indices were developed to measure, respectively, changes in work complexity and participation in work decisions that could be attributed to DTC. Unfortunately, these latter variables were not sufficiently reliable (alphas < .55) and, therefore were not included in analyses.

The 10 most reliable indices are presented in Table 1 along with a sample item and a measure of their internal consistency (Cronbach's alpha). The original, self-administered survey questions were coded on a 7-point agreement scale ranging from 1 (No!No!No!) to 4 (Neutral) to 7 (Yes!Yes!Yes!) or on a 7-point changing scale ranging from 1 (Greatly Decreased) to 4 (No Change) to 7 (Greatly Increased). We recoded the work group level scores in the indices for clarity. Scores below four, the "neutral" or "no change" midpoints were recoded into positive numbers for agreement and increase scores. Certain items were reverse coded to match the direction of the index. After recoding items to match the direction of the scale, all items and indices ranged from -3 (disagree or decreased), to 0 (neutral), to +3 (agree or increased).

IMPLEMENTATION PROCESSES: GRASS-ROOTS VERSUS TOP-DOWN

We asked specific questions about implementation processes in the survey in order to validate the researcher-coded values of the implementation process. Two indices from items pertaining to participation in decision making related to computing were formed: NIDPART1 and NGDPART. We built NIDPART1 from respondent reports of their own participation in DTC decisions and NGDPART from respondent reports of other work groups members' participation in DTC decisions (see Table 1). The two indices were highly correlated (r= +.79, p< .01), as we expected.

On the basis of our interviews, we expected certain occupational characteristics and computing arrangements and uses for Grass-roots and Top-down groups. Our descriptive data confirmed our expectations: (a) Grass-roots groups were predominantly female (84 percent) (χ^2=61.42, df=1, p<.001); (b) Grass-roots groups were comprised primarily of professionals (80 percent), and Top-down groups were comprised primarily of clerks (67 percent) (χ^2=22.00, df=2, p<.000); and (c) a greater proportion of Grass-roots groups had a high (1:1) ratio of work stations to employees than Top-down groups (75 percent versus 56 percent), though the difference was not statistically significant.

Since the Grass-roots groups were extensively computerized, we were surprised that their highest ranked problem out of 15 questions about DTC problems was "Not enough equipment" (mean=2.0: sometimes a problem, sd=.67). In contrast, equipment shortages were only the fifth-ranked problem for Top-down groups (mean=1.7: sometimes a problem, sd=.98). Grass-roots groups were also more likely than Top-down groups to have stand-alone microcomputers rather than terminals and microcomputers attached to a LAN or shared computer (χ^2=11.32, df=3, p<.001).

In sum, the Grass-roots groups in our sample were primarily professional men who used stand-alone computers in an extensively computerized environment. On average, individuals in Grass-roots groups participated in decision making related to computing and had some influence over the computing arrangements in their work group. Top-down groups were mainly comprised of clerical women who used attached computers in a medium to highly computerized environment. Members of Top-down groups, on average, did not participate in decision making related to computing nor did they exert substantial influence over the computing arrangements in their work groups.

PATTERNS OF DESKTOP COMPUTER USE

Stereotypes of computer use in work settings range from highly positive accounts of usage that emphasize multifunctionality and flexibility [7] to more pessimistic accounts that emphasize the routine character of activities like pushing buttons — such as the enter key [32]. These largely deterministic views of computing and work do not match our empirical observations of the immense variations that are shaped by multiple and interacting factors [20]. We have found an immense amount of variation in patterns of desktop computer use, particularly between users in Top-down versus Grass-roots groups.

Access and Control

We have argued that social factors, such as influence over implementation processes, affect workers' daily control over and access to computing [20]. Grass-roots groups should have greater control over their available computing resources than Top-down groups. This hypothesis was partially confirmed by the data on work group participation in DTC decision making (see above). We also expected Grass-roots groups to report less access to computing than Top-down groups because they often had to fight for equipment.

[1] We used the mean work group scores on NIDPART1 and NGDPART to validate our a-priori codings of implementation process. We changed only 8 percent of our classifications on the basis of these data. Work groups in the positive range on both indices were kept or re-classified as Grass-roots work groups; work groups in the negative range were kept or re-classified as Top-down. Ambiguous groups (i.e., positive on NIDPART1 and negative on NGDPART), maintained our original implementation process classification. Grass-roots groups were in the agreement range on NIDPART1 (mean = +.81, sd = .63) and NGDPART (mean = +.66, sd = .70); Top-down groups were in the disagreement range on NIDPART1 (mean = -.26, sd = .65) and NGDPART (mean = -.53, sd = .55). Although the groups were in the disagreement range and some Top-down groups were in the agreement range — the difference between Grass-roots and Top-down work groups' means was reliable on NIDPART1 (t = 5.13, df = 35.2, p < .001) and on NGDPART (t = 5.80, df = 35.4, p < .001).

Table 1
Reliability, description, and example item from indices

INDEX (alpha)	DESCRIPTION	EXAMPLE ITEM
NIDINFRA (.64)	Respondent's assessment of training and computer support availability.	Most everyone has received adequate formal training about the systems and applications we use.*
NIDPART1 (.72)	Respondent's participation in decisions about DTC.	I have little influence over computerization of my work area (reverse coded).*
NGDPART (.60)	Work group's participation in decisions about DTC.	Individuals (in this work group) have little say in how they use DTC in their work (reverse coded).*
NIWPART1 (.79)	Respondent's participation in decisions about work.	I frequently give advice to my co-workers about work procedures or practices.*
NIWCOMP2 (.68)	Complexity of respondent's job.	I am often given new tasks and responsibilities.*
CIWWKEFF (.78)	Respondent's assessment of changes in work effort resulting from DTC.	The number of hours per day that you usually need to work to get your job done (as a resut of using DTC).**
NIWWKEFF (.70)	Respondent's assessment of current work effort — unrelated to DTC.	I usually need to work longer than the normal workday to get my job done.*
CIWJOBR3 (.69)	Respondent's assessment of changes in the quality of his/her job — emphasizing job enrichment — resulting from DTC.	The extent to which your primary place tc work is not a pleasant place to work (as a result of using DTC).**
NIWJOBR6 (.70)	Respondent's assessment of current quality of job — emphasizing job enrichment — unrelated to DTC.	In a normal workday, I spend far too much time doing things that I don't really enjoy. (reverse coded)*
NIDGEXPT (.69)	Respondent's involvement and perceived expertise in DTC.	I am the expert on some parts of the systems or applications that I use.*
* Scale:	-3=NO!, -2=disagree, -1=slightly disagree, 0=neutral, +1=slightly agree, +2=agree, +3=YES!	
** Scale:	-3=greatly decreased, -2=decreased, -1=slightly decreased, 0=neutral +1=slightly increased, +2=increased, +3=greatly increased	

Two measures of access were constructed on the basis of workers' reports of computer proximity (e.g., "on my desk," "within arm's reach") and computer sharing (e.g., "I do not share," "I share with only one other person"). Grass-roots and Top-down groups had comparable computer proximity (i.e., on desk) and sharing (i.e., unlimited access) (see Table 2). Members of both Grass-roots and Top-down groups reported they could get immediate access to computing.

The high level of access to computing in our sample probably resulted from two major factors: (a) we sampled work groups with a high ratio of work stations to employees; and (b) Grass-roots groups probably acquired much of the computing equipment for which they had negotiated. However, during our work group interviews we observed that no matter how computer-saturated or extensively computerized — Grass-roots groups continued to push for new computing equipment. They focused on acquiring more advanced or upgraded equipment (e.g., replacing dot matrix printers with Laser printers, adding communication lines) rather than acquiring equipment for the first time.

Table 2
Access to desktop computing as a function of implementation strategy

Access	Grass-roots (n=20*)	Top-Down (n=18*)
On my desk, or within reach from my desk	74%	66%
Access is virtually unlimited because I share my equipment with few people	85%	77%

* "n" refers to the number of work groups

Dependency and Amount of Use

Members of Grass-roots groups reported slightly higher dependence on DTC (M= 2.0: agree, sd=.6) than members of Top-down groups (M= +1.6: agree, sd=1.0).[2] Members of both Grass-roots and Top-down groups spend approximately 40 percent of their work weeks using their computing equipment.[3] We were surprised that Grass-roots groups reported greater dependence upon DTC than Top-down groups, because the groups reported equivalent hours of usage. Because our Top-down groups were predominantly clerical, and the literature portrays such groups as "tied to their terminals" [32], we also expected Top-down groups to report higher average hours of computer usage.

Use of Desktop Computing for Information Processing Tasks

Text processing was reported as the most common computer-supported information processing task (IPT) in Grass-roots groups (M=5.5: once or twice a day), but was only the second-ranking IPT for Top-down groups (M= 4.7: once or twice a week). The top-ranking IPT for Top-down groups was searching and retrieving records (M= 4.9: once or twice a week); which was a much less common usage for Grass-roots groups (M= 3.9: once or twice a month). Both groups claimed to be coding and entering data approximately once or twice a month, on average.

The only additional IPT that was used with any frequency by Top-down groups was transferring files using a communications package (once or twice a year). Other notable IPTs for the Grass-roots groups included the following tasks — each performed once or twice a quarter: using spreadsheets for numerical calculations, creating or restructuring spreadsheets, making tables or graphs, designing graphics, calculating statistics, programming computers.

In sum, Grass-roots groups tended to use DTC to support a much greater range of information processing tasks than Top-down groups. Grass-roots groups also used computing to assist them in more complex work than Top-down groups (e.g., calculations and analysis versus record keeping and data entry). This discrepancy in usage patterns and complexity of use may be explained partially by occupational differences. However, during our work groups manually doing some IPTs, such as numerical calculations, that easily could have been automated. Therefore, it appears that Grass-roots groups have been able to leverage the complexity of their work by seeking and acquiring more computing resources. This hypothesis is explored in greater detail below.

New Packages

Grass-roots groups reported that, on average, they are currently learning two new software packages (M= 2.0, sd=2.0); Top-down groups reported that they are learning approximately one new package (M= .93, sd=.4) (t=2.3, df=21, p< .05).[4] These results suggest that Grass-roots DTC

[2] The difference between groups was only marginally statistically significant (t = 1.4, df = 29, p < .10).

[3] Grass roots, M = +16.4 hours, sd = 6.0 hours; Top-down M = +15.0 hours, sd = 8.0 hours. The difference in the means was not statistically significant at less than the .05 alpha level.

[4] Degrees of freedom vary across t-tests because the separate variances were used in estimating t, rather than the pooled variance. All statistical analyses were computed using the SYSTAT v4.0 of July 1988.

environments are more dynamic than Top-down ones, but also that both types of work groups report some degree of dynamism.

Summary: Patterns of Desktop Computer Use

Members of Grass-roots groups have more influence over their DTC environment and are more likely to participate in decision making related to DTC than are members of Top-down groups. However, participation in the implementation of computing did not seem to differentiate their access to computing. Both Grass-roots and Top-down groups reported that computers were conveniently located and that sharing computers was minimal.

The function of DTC in the two kinds of work groups was also an important discriminator. Grass-roots and Top-down groups tended to use DTC for the same amount of time but in different ways. Grass-roots groups indicated greater dependence upon DTC to do their job well and tended to use it to support more information-processing tasks than did Top-down groups. Grass-roots groups also appeared to have more dynamic DTC environments because they are currently learning more new software packages than Top-down groups.

QUALITY OF WORK LIFE

The following analyses examine and compare each of the five aspects of quality of work life for Grass-roots and Top-down groups discussed above. Most researchers who examine the ways that computerization shapes work treat the presence or absence of computing as a binary choice. The limited research available on the impact of computing implementations on the quality of work life typically focuses on work groups that have computerized with Top-down implementation processes.

(H1) Participation in Decisions About Work

Grass-roots groups tended to participate more in decisions about their DTC environment than Top-down groups. Grass-roots groups also participated slightly more in work decisions and reported slightly greater influence over their work environment (NIWPART1) than Top-down groups. While the majority of both Grass-roots and Top-down groups reported that they had some influence over their jobs (NIWPART1), Grass-roots groups (M= 0.6, agree, sd=.6) had more control than Top-down groups (M= 0.0, neutral, sd=.4) (t=3.0, df=33.6, p<.01).

In addition, the context for computing seemed more supportive and conducive to skill building in Grass-roots groups than in Top-down groups. Although both Grass-roots and Top-down groups reported adequate computing access, Grass-roots groups reported slightly better access to DTC. None of the Grass-roots groups reported restricted access to computing, though a few of the Top-down groups strongly agreed (e.g., M= 5.2) that computer access was limited.

(H2) Job Enrichment and (H3) Computing Expertise/ Involvement

Grass-roots groups usually agreed (NIDGEXPT, M= 0.5, agree, sd=.5) that they were expert in some computing systems in the work group and that they were involved in discussing computing with others; Top-down groups usually disagreed (M= -.01, sd=.7) that they were experts or involved in discussing computing (t=2.7, df=30.6, p<.01). Both Grass-roots and Top-down groups tended to agree that job enrichment (CIWJOBR3) had increased as a result of using DTC. However, Grass-roots (M=.4, neutral, sd=.3) groups agreed slightly more than Top-down (M=.2, neutral, sd=.3) groups that computing enriched their work (t=2.59, df=35.7, p<.01). Overall levels of job enrichment (i.e., job enrichment not attributed to DTC) did not differ between Grass-roots and Top-down groups (t=.95, df=36, NS).

Table 3
Mean work complexity and work effort as a function of implementation strategy

Index	Grass-roots (n=20*)	Top-down (n=18*)	t	p
Changes in individual work effort attributed to DTC (CIWWKEFF)	-0.2 (decreased)	+0.1 (increased)	2.2	<.05
Current individual work complexity (NIWCOMP2)	+1.0 (slightly agree)	+0.6 (slightly agree)	2.5	<.01

* "n" refers to the number of work groups

(H4) Work Complexity and (H5) Work Effort

Both Grass-roots and Top-down groups reported that their work was complex (NIWCOMP2), though members of Grass-roots groups reported somewhat more complex work than members of Top-down groups (t=2.5, df=35.5, p< .01). The difference in reported changes in work effort attributed to DTC were more striking (see Table 3). As we predicted, Grass-roots groups on average, reported that DTC decreased individual work effort (CIWWKEFF), while Top-down groups reported the opposite — that DTC had increased individual work effort (t=2.2, df=25.3, p<.05). Levels of work effort not attributable to DTC were the same for Grass-roots and Top-down groups (t=.46, df=25, NS).

Summary: Quality of Work Life

The five central hypotheses pertaining to implementation processes and quality of work life were all supported by our data: Compared with Top-down groups, Grass-roots groups reported (a) greater influence over their work and more participation in decision making within the work group; (b) greater increases in job enrichment due to DTC (e.g., a pleasant work environment, few annoying rules); (c) higher levels of computer expertise and involvement in discussions about DTC; (d) more complex work; and (e) greater decreases in work effort because of DTC. Although changes in job enrichment and work effort attributable to DTC were statistically different for Grass-roots and Top-down work groups, they reported similar current (1988) levels of job enrichment and work effort.

Work groups such as Grass-roots groups that have highly complex work — and no concomitant increase in work effort — seem to benefit the most from computing. The combination of increased work complexity and decreased work effort reflects an increase in work efficiency. In contrast, those work groups such as Top-down groups that have highly complex work — and increasing work effort — appear to be burdened by computing. These results provide good systematic evidence that implementation processes are an important influence on work life and individual attitudes toward computing in extensively automated work groups.

IMPLEMENTATION PROCESS AND COMPUTING INFRASTRUCTURE

We developed a sixth hypothesis (H6) on the basis of our interviews and observations: Top-down work groups should have better computing infrastructures (e.g., training and support) than Grass-roots work groups. We found, however, that average scores on the infrastructure variable, NIDINFRA (see Table 1), were similar for Top-down (M= +0.1: neutral, sd= .6) and Grass-roots (M= +.3: neutral, sd= .4) groups. Moreover, members of both kinds of groups reported that their computer infrastructures ranged quite widely in adequacy: Grass-roots groups ranged from inadequate infrastructure (-.7) to adequate infrastructure (+.5); Top-down groups ranged from inadequate infrastructure (-.9) to adequate infrastructure (+1.0).

Because the Grass-roots and Top-down groups each had a considerable range on the infrastructure index, we were able to investigate the joint effects of implementation process and infrastructure on the quality of work and computing environments. We were interested in testing whether there were variations within our different implementation work groups based on the adequacy of the computing training and support in the work group. Because Grass-roots groups tend to benefit the most from working in an extensively computerized environment (e.g., make productivity gains, learn new skills), we expected these groups to support their computing (e.g., good training and computer consultants). Therefore, we predicted that Grass-roots groups with very adequate computing infrastructure would report the best working conditions.

Conversely, we expected that work groups with inadequate support for computing (e.g., little or no training, no consultants) would be the most burdened by working in an extensively computerized environment — especially if the work group had little input into the design of computing systems in the work group. Thus, Top-down groups with very inadequate computing support should be extremely burdened by working in an extensively computerized environment. However, Grass-roots groups with inadequate infrastructure also might be burdened. Because Grass-roots groups typically use computing for a very wide range of information processing tasks and for complex tasks, an adequate infrastructure could be more crucial for facilitating work in Grass-roots groups than in Top-down groups.

We expect Top-down groups with adequate infrastructure to report quality of work life somewhere in between the other three groups. Although Top-down groups have little influence over the computers and computing systems they use, they at least have sound training and adequate resources for solving computer-related problems and keeping their computer systems running.

We created a joint implementation/infrastructure variable with four levels to examine the subgroups of interest: (a) Grass-roots/Adequate Infrastructure (GRI+), (b) Grass-roots/Inadequate Infrastructure (GRI-), (c) Top-down/Adequate Infrastructure (TDI+), and (d) Top-down/Inadequate Infrastructure (TDI-). The five dependent variables related to quality of work life and the computing milieu were examined. One-way ANOVAs indicated substantial overall effects of the combined implementation/infrastructure variable for all of our dependent variables except for current work effort (see Table 4).[5]

[5] We examined the number of computer-related problems (out of 15) in each of the four levels of the Implementation/Infrastructure variable. Examples of problems included difficulties transferring data between equipment, not enough equipment, insufficient training, etc. Inadequate infrastructure groups (TDI-, GRI-) had a greater number of problems (seven problems) that occurred "sometimes" to "often" than adequate infrastructure groups (TDI+, GRI+) (one problem). Inadequate infrastructure groups also reported more minor problems, that occurred "rarely" to "sometimes" (17 problems) than did adequate infrastructure groups (14 problems). These results suggest that inadequate infrastructure increases problems and burdens on workers in intensively computerized offices. Implementation processes also seemed to influence the number and severity of computer-related problems, though not as strongly as infrastructure. Grass-roots groups (GRI+, GRI-) had 21 problems that occurred

Table 4
Work life and computing outcomes for work groups by implementation process and infrastructure

Dependent variable	Adequate Infrastructure: Grass-Roots (n=16*)	Adequate Infrastructure: Top-Down (n=10*)	Inadequate Infrastructure: Grass-Roots (n=4*)	Inadequate Infrastructure: Top-Down (n=8*)	F	p
Work Complexity[1] (NIWCOMP2)	1.2	0.6	0.4	0.6	5.2	.005
Change in Work Effort[2] (CIWWKEFF)	-0.3	0.0	0.0	0.2	2.2	.10
Current Work Effort[1] (NIWWKEFF)	-0.5	-0.7	-0.4	-0.3	0.0	NS
Computing expertise & involvement[1] (NIDGEXPT)	0.6	0.2	0.1	-0.5	6.0	.002
Change in enrichment of work[2] (CIWJOBR3)	0.5	0.3	0.3	0.1	5.0	.006
Current enrichment of work[1] (NIWJOBR6)	0.9	0.7	0.2	0.5	7.6	.009
Participation in Decisions in Work[1] (NIWPART1)	0.6	0.2	0.3	0.1	4.0	.02

* "n" refers to number of work groups

[1] Scale: -3=NO!, -2=disagree, -1=slightly disagree, 0=neutral, +1=slightly agree, +2=agree, +3=YES!

[2] Scale: -3=greatly decreased, -2=decreased, -1=slightly decreased, 0=neutral, +1=slightly increased, +2=increased, +3=greatly increased

We made post hoc comparisons using the Bonferoni method to test our major hypotheses (see Miller, 1985). Comparisons were made between the weighted means of dependent variables in the GRI+ cell and the average means of dependent variables in the combined cells of the other three groups. These comparisons confirmed our hypothesis that GRI+ work groups had the best working conditions.[6]

GRI+ work groups had these highest average scores:

(a) work complexity (p<.001) (NIWCOMP2),

(b) decreases in work effort attributed to DTC (p<.03) (CIWWKEFF),

(c) expertise and involvement in computing (p<.002) (NIDGEXPT),

(d) job enrichment not attributed to DTC (p<.009) (NIWJOBR6),

(e) changes in job enrichment attributed to DTC (p<.004) (CIWJOBR3), and

(f) participation in decisions in work (p<.01) (NIWPART1).

Summary: Implementation Process and Computing Infrastructure

The effects of implementation processes on the quality of work life are moderated by the computing infrastructure in work groups. Grass-roots groups with very adequate in-

with some degree of intensity (i.e., sometimes-to-often) while Top-down groups (TDI+, TDI-) had only 18 problems that occurred with the same degree of intensity.

[6] Although we expected work groups with inadequate infrastructure (GRI-, TDI-) to be the most burdened by working in extensively computerized offices, we did not directly test this hypothesis for two reasons — one theoretical, the other methodological. First, although we felt confident our predictions of good working conditions for GRI+ work groups were theoretically sound and grounded, there was little theoretical justification for predicting when TDI- groups would have better or worse work conditions than GRI- work groups. Second, Bonferoni post hoc comparisons are conservative tests and diminish in power rapidly as the number of unplanned comparisons increases.

frastructure leveraged their work to carry out more complex tasks and reported the greatest decreases in work effort because of DTC. That is, those groups that chose the computer systems and software appropriate for their work *and* had the training and resources to support their computer environment were most able to make substantial gains in productivity (i.e., increased complexity and decreased effort). Moreover, the joint effect of a Grass-roots implementation and a sound computing infrastructure positively influenced six-out-of-seven measures of quality of work life and computing environments. In contrast, Top-down groups, which had computing imposed on them from an external source (e.g., upper management) and did not have an adequate infrastructure, often appeared to be the most burdened by computing. For example, they were the only work groups to report, on average, a lack of expertise and involvement in computing. On other measures, such as complexity of work, change in work effort attributed to DTC, change in job enrichment, and participation in decisions about work, the means of TDI- groups were quite similar to those of TDI+ and GRI- groups.

CONCLUSIONS

This study provides the first comparative, quantitative assessment of the role of different implementation processes and infrastructures in altering working conditions in highly computerized work groups. It also breaks new ground by examining data about computerization and work at a work group level of analysis rather than only at an individual level of analysis.

We characterized implementation processes by the locus of control, and identified two ideal types: Grass-roots and Top-down. We found that DTC is used differently according to the type of implementation process in the work group. Although Grass-roots and Top-down groups tend to use DTC for the same amount of time each week, they use it in different ways. Members of Grass-roots groups are more dependent upon DTC to do their job well and they use it to support a larger variety of information processing tasks than do Top-down groups. Grass-roots groups seem to have more dynamic DTC environments than Top-down groups.

Our initial hypotheses regarding the relationship between implementation processes and infrastructure were not supported. We were surprised to find some Grass-roots groups *with* an adequate infrastructure and some Top-down groups *without* an adequate infrastructure. We suspect that variations in infrastructure are a function of the length of time the computers were introduced to the work groups: Work groups with a long history of computing should have a stronger infrastructure than those with a more recent implementation of computing. This hypothesis will be tested in a later analysis of our data.

Most of our hypotheses about the influence of control patterns in implementation processes on the quality of work life in work groups were supported. The quality of work life was neither downgraded nor upgraded by the mere presence and use of computing in our work groups. Rather, the quality of their work lives was improved when workers participate din implementing computer systems which they used routinely. Further, the quality of work life improved when there was an adequate computing support infrastructure. We found *substantial interactions* between implementation processes and levels of infrastructure: the Grass-roots groups with adequate infrastructure reported much better work life on several dimensions than did other work groups. While it takes significant time and effort to build a strong infrastructure for computing time and effort to build a strong infrastructure for computing [13], this study and other related research shows that there are substantial improvements in the quality of working life [12]. In summary, the social organization of computing shapes peoples' experiences of work much more than does the character of the computing equipment.

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