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Office Design Measurements for Productivity--A Research Overview

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U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Building Environment Division
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U.S. DEPARTMENT OF COMMERCE, C. William Verity, *Secretary*

NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

ABSTRACT

The Public Building Service of the General Services
Administration sponsored the present investigation to:

1. Determine the effects of building design, and "high quality
design" in particular, on productivity
2. Determine the state of the art of productivity measurement,
applicable to the study of office tasks
3. Identify the various factors that influence productivity to
better determine those which can be attributed to design issues.

The study is primarily based on a comprehensive literature search
of 15 data bases, supplemented by personal contacts with
specialists on this topic. The report reviews and distills the
major findings of more than 550 publications.

The most significant findings of this investigation are:

1. The preponderance of productivity literature is concerned with
macro-economic studies which cannot be readily related to the
influence of building design on productivity.
2. The few studies dealing with productivity have often drawn
sweeping and questionable conclusions from information that is
largely subjective, e.g. self-estimates of productivity
improvement.
3. Some analytic techniques are available which can be used to
study the "micro" office environment.

Key Words: Productivity, design, design criteria, ergonomics,
office automation, quality of worklife

PREFACE

This report is the most recent in a series of studies performed by the National Bureau of Standards (NBS) for the Public Building Service of the General Services Administration (PBS/GSA) to examine the effects of automation on office design and in turn on building occupants. Earlier investigations cite the need to consider office automation design in the context of several interrelated issues: organizational, informational, technological, and ergonomic. The results of these studies are reported in the following publications:

1. "The Automated Office - An Environment for Productive Work, or an Information Factory?: A Report on the State-of-the-Art" (NBSIR 83-2784-1), November 1983.
2. "The Automated Office - An Environment for Productive Work, or an Information Factory?: Executive Summary" (NBSIR 83-2784-2), December 1983.
3. "Interim Design Guidelines for Automated Offices" (NBSIR 84-2908), August 1984.
4. "Revised Interim Guidelines for Automated Offices" (NBSIR 86-3430), August 1986.

Automation has proliferated in federal and private sector offices as a means of increasing office productivity. A question that has been asked repeatedly of late is whether productivity has increased with the advent of automation. Surprisingly, despite the expenditure of billions of dollars on automated information, communication and building management systems, the effects of automation on office productivity are not well understood.

PBS/GSA has sponsored this activity to respond to the productivity requirements of organizations housed in federal office buildings.

The primary purpose of the present study is to summarize and evaluate the state-of-the-art of productivity measurement. The long term goal is to upgrade design criteria for federal buildings to enhance user satisfaction and organizational productivity. As a step in this direction, a comprehensive literature search of 'productivity' was undertaken. The report summarizes the findings of this activity.

The report is organized under a limited number of major categories as a matter of convenience: design, organizations, productivity, and ergonomics. These factors are closely interdependent, which precludes a separate discussion of each.

ACKNOWLEDGEMENTS

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1. BACKGROUND

The present report is a continuation of the work performed for PBS/GSA to upgrade the design criteria used in federal office buildings. The earlier research focused on the impacts of office technologies on building design and performance. Since the primary function of offices is to serve organizational goals, the next logical step is to determine how design can enhance the productivity of individuals and organizations in the federal sector. The current study is designed to be an initial step in accomplishing these goals.

For more than a decade there have been countless reports by economists, industrialists, researchers and others bemoaning the fact that productivity in the United States has declined. The white collar sector has been a special target for those studying productivity. It has been estimated that productivity in offices has remained virtually stagnant for many years. The rush to automation in offices has been largely attributed to these findings. The general view expressed is that technology can be used to offset the decline in productivity and lead to a radical restructuring of the office environment to take advantage of the new means of developing, processing and transporting information to enhance organizational effectiveness (1).

However, the results of the office automation bandwagon are unclear. While automation has led to changes in the ways that many office tasks are performed, there is little conclusive evidence that it has achieved its goal; enhancing office productivity (2). The pace of automation is accelerating, not because it has been proven to achieve its goals; instead automation is driven by the technology itself. That is, vendors have been producing new hardware, software, information and communication systems that are being purchased because of their reputed capabilities to improve office operations. Organizations have largely responded to the vendor and competitive marketplace, with the assumptions that new technologies will perform effectively, and it is vital to keep up with competitors, who pursue the same strategy (3).

The old acceptance of poor working conditions, badly designed equipment and inappropriate environments is disappearing, especially among younger workers. The upgrading of existing offices is a valuable part of organizational change and represents a vehicle for changing attitudes and making a new corporate culture visible and meaningful to the staff (4).

Earlier research performed for the General Services Administration (GSA) by the National Bureau of Standards (NBS) investigating the effects of office automation on design indicated that automation should not degrade the quality of the office (5). Naisbitt (author of Megatrends) makes the same point: "the more technology around us, the more the need for human touch ... the more we'll be looking for ways to reconnect as human beings" (6).

A reflection of the importance of working conditions is the increased interest expressed by many organizations and researchers in the 'Quality of Worklife' (QWL). This is a general formulation including

management, design and ergonomic issues. A rationale for improving environmental conditions as a means of increasing productivity is that improved conditions can lead to greater satisfaction and more motivation, which can result in improved productivity. Improvements which include operational factors such as communication and autonomy on the job are more likely to have beneficial effects (7).

QWL is a process whereby all organizational members have some say about their job design and the general work environment. In this participative organizational climate, suggestions and comments that can lead to improvements are encouraged. Increased productivity and environmental enhancement is expected to result from worker involvement. An improvement in organizational communications and a reduction in the number and intensity of adversarial relationships is also anticipated. As individual workers and management agree on common goals and the means to achieve them, they are more likely to agree on how to improve organizational effectiveness (8).

Prerequisites for successful QWL programs are:

* Management should be committed to a participative style; inviting employee involvement.
* Provide employees with opportunities for career advancement.
* Overcome traditional status barriers between management and workers.
* Train supervisors in participative management techniques.
* Provide employees with feedback and recognition for improved performance.
* Analyze and evaluate positive and negative results; use findings to further improve system.

The assumptions for a QWL orientation to improved productivity are:

* Workers are good sources for ideas to increase productivity.
* Work should be rewarding and satisfying.
* Workers take pride in their work.
* Greater job satisfaction results in increased productivity.
* Employers should show more concern for welfare of employees.
* Improved feedback on performance will result in improved attitudes and greater motivation.
* An improved work environment will result in greater satisfaction, leading to improved performance.

Evaluating the effects of improved QWL on productivity depends on the existence of appropriate productivity measures. This is one of the major goals of the present project - identifying productivity measures likely to be affected by design. .

The design challenge is for a well integrated planning process to enhance productivity and not diminish environmental quality or productivity.

2. DESIGN AND PRODUCTIVITY

2.1 Background

In the past, office designs often just "happened"; they evolved from many small scale changes. A major weakness in this approach was that space and office quality standards were based on status not on job requirements. The "ideal" design for any facility varies from company to company; each has a unique personality and culture (9).

Designing buildings to enhance productivity is a growing trend. People are becoming more aware of the effects of design on productivity. More investments are made to enhance the environment to attract customers, assist worker recruitment, retention, and increase comfort, well being and health. A major reason for upgrading office quality is the growing number of white collar workers and the recognition that they are the key to increased productivity.

Making a building environment more productive includes considerations of layout, flow of people, and activities. Designing for productivity often does not affect the mechanical, electrical or heating costs. Higher construction costs can be incurred if spaces such as atria or break areas are included as amenities in larger office buildings (10).

The search for the effects of design on productivity can be readily traced to the Hawthorne studies performed in the 1920's and 1930's (11). These classic investigations started with an examination of lighting levels on a variety of tasks. Initial findings suggested that by increasing levels, productivity increased. But, thanks to the skepticism of the researcher, followup studies of decreased lighting levels also resulted in productivity increases. After many years of investigation, the researchers concluded that many factors influenced measured performance levels, including psychological, social and organizational influences. They pointed to the hazard of trying to find a simple relationship between an environmental change and productivity. The lessons learned during this pioneering investigation still form the basis of most behavioral research conducted in the field, and are central to the current investigation.

Unfortunately, as noted above, while productivity research constitutes a major body of work, studies directed toward an understanding of the influence of design issues has not received much attention in recent years by trained researchers. As an illustration of the neglect of this topic, Tuttle (12) reviewed hundreds of productivity studies and categorized them with respect to subject areas. While design was one of the research topics examined, it was not included in the final report because of the absence of relevant studies.

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2.2 Goals

Today, the goal of office planners and designers is to bring automation to the general office population. Automation equipment is leaving the controlled environment it once enjoyed, and is being moved into the office environment, sharing space with other office technologies. This change creates new environmental demands in general office areas.

Traditionally, equipment was located in special areas and used by a selected number of trained people. They used the equipment all day long and became very familiar with it. Today, in many cases, office automation (OA) equipment is one facet of a complex job, and is used occasionally. It should be convenient and easy to operate. The key to design is to consider the user and equipment as a system, which accomplish tasks together (13).

Systems analysts rarely consider the effects of physical layout in the systems they develop. On the other hand, layout specialists tend to group similar functions without considering information systems flow. Charting information flow is possible with architectural and engineering drawings and complete floor plans (14).

Layout should optimize the flow of data and people, interactions; files should be accessible to users, people having visitors should be near office entrances. Common use facilities (elevators, copiers) should be close together and accessible by direct routes. Workstations should be isolated from noise and other distractions, e.g. areas used for frequent conversations (15).

Desks and groups of people should be located to facilitate work effectiveness. For example, in computer facilities the information flow system channel should be measured. The people along that channel should be identified. The number of stations, entry computer operations, trips to the data library for disk packs to run computer jobs should be detailed. Workstations should be arranged to shorten traffic routes; and functions grouped from the standpoint of systems supporting activities.

Among the issues to be explored are:

* Whether transactions backtrack or move in one direction.
* The cost of floor space.
* Proximity of people, adjacencies.
* Physical security; susceptibility to damage and/or vandalism.

Good office design combines efficiency, economics, function logistics and aesthetics. Office planners must accommodate equipment, environmental features and people. The needs of the users should be identified before making any planning decisions (16). The office must allow people to work, create and communicate effectively.

Office facilities are expected to function effectively for a long period of time, yet maintenance requirements to maintain appearance and efficiency are often overlooked. A maintenance audit can be usefully employed to accomplish this goal. Among the issues to be covered when considering material, furnishings and equipment are (17):

1. Can it be repaired?
2. Can it be replaced?
3. What special maintenance requirements exist?
4. How long will it last?
5. Will it retain its appearance?
6. How much will it cost to maintain the item's "like new" properties?
7. What periodic maintenance schedules are appropriate; e.g. cleaning ducts, replacing lamps?

2.3 Practice - Research

Good office design traditionally has as a major objective the fostering of organizational productivity. However, the documentation of how this is achieved is very sparse. In recent years, a few major studies were performed to examine issues of design and productivity. These will be addressed below.

The most comprehensive and widely cited investigation of the effects of design on productivity was a questionnaire-based study performed by BOSTI (18). The report authors concluded that productivity is substantially influenced by design. The four year study analyzed 23 basic design factors such as lighting, accessibility and temperature and concluded that well-planned design is essential for increased productivity. The study gathered data from 4000 managers, professionals and workers. Proper design includes consideration of esthetic, environmental, structural and technical elements of the office. Employee participation in the design process was considered an important determinant of job satisfaction.

Among the major findings were:

* Temperature fluctuations decreased job satisfaction for 30% of the respondents; air quality was a problem for 10% of them.
* Lighting quality problems were glare, shadows and lack of control. Workers with the most demanding tasks were the most dissatisfied.
* In open office areas, the greatest satisfaction was expressed by those with three of the four panels located above eye height while standing, surrounding the work area.
* Design elements important for worker comfort were chair design, work surface height, width and depth, room to move and degree of enclosure.
* Among the hazards noted were floor obstacles such as raised electrical outlets and wires. Snagging clothes and bumping into furniture were other sources of complaint.

While the general findings of this investigation appear to be consistent with other related research, the conclusions drawn concerning the effect of design on productivity are difficult to substantiate based on published reports. There are two major problems. First, there is no detailed description of the methodology used to collect information. Secondly, the primary means of acquiring data is described as questionnaire findings based on respondent opinions of design impacts on productivity (19).

Unfortunately, personal assessments of productivity obtained by questionnaires is employed in most productivity studies and has the problem of being highly subjective. Without additional supporting information it is difficult to determine whether the findings are valid. Objective measures of the physical environment and of productivity are also required to draw meaningful conclusions about the relationship of design to productivity.

Another major study of office productivity was sponsored by Steelcase (20) and indicated that workers believed they could be more productive in an improved workplace. The key to improvement is that designers be concerned with the people not the space. Workers indicated they want comfort, privacy, status, storage, flexibility, adaptability to change and ease of communication to perform better. Offices must be designed to accommodate new technology, while being comfortable and enhancing productivity. An attractive environment is also important.

Workers suggested that they wanted to improve performance. Middle managers are caught in the middle, they are responsible for improvements but have insufficient authority to carry out needed programs.

The Steelcase studies indicate that comfort and productivity are interrelated in the view of office workers. Filing and storage needs are changing with the electronic office and the increasing cost of space. Systems furniture is inherently more efficient than a conventional desk because it utilizes vertical storage space, primarily above the work surface. A systems approach is needed when viewing the office environment. The workplace must be viewed in its

totality, with systems being a combination of parts forming a unitary whole. (Like the BOSTI investigation, the findings are based on opinions about productivity.)

2.4 Problems

Many organizations are not utilizing their offices effectively to accomplish their goals, and are often not prepared for technological changes. Little attention is given to the office design's impact on productivity despite the fact that white collar jobs already comprise more than 50% of all work.

Too often, the work environment, office equipment, desks and filing cabinets a re chosen and planned by management to overcome isolated problems. Typically, little thought is given to planning or future technological changes (21).

Employees with insufficient work surface areas have to work around the problem. Desks are cluttered with material because of insufficient storage space or an inadequate arrangement of resources, such as files. The time to access materials can be substantially reduced by proper design. Another productivity inhibitor is the sharing of equipment, away from the primary work area, e.g. copiers and printers.

A major difficulty is the placement of high technology devices on work surfaces and environments designed for paper based tasks. Problems of lighting, noise and thermal conditions often accompany equipment and systems placed in offices without proper planning.

Another important considerations is the need for workers to have a measure of control over their workstation and furnishings. People differ in terms of size, preferences and requirements and the work environment often does not accommodate these differences. For example, studies have repeatedly shown that people working at VDT's often require readily adjustable ergonomic chairs to avoid problems of back strain.

The need for attractive break areas is also intensified as more workers spend most of their time at VDT's, with little social contact.

Putting together all of the furniture, equipment, engineering, ergonomic, and design components appropriately is the major challenge, and this responsibility is often left to the user.

2.5 Possible Solutions

The advent of the workstation has changed basic office design. Rather than a series of furniture items, it is a flexible piece of equipment in its own right, designed for the individual and the task supported. Proper design can permit privacy without isolation by swiveling a chair and using selected modular components; e.g. in a three sided configuration. The availability of a range of modules provides design flexibility, while facilitating additions, as well as replacement of damaged and worn components (22).

The key to the electronic office is flexibility, while ensuring that the space is attractive and conducive to productivity (23).

The desire for private offices, and the convenience and status it represents, has to be overcome for those who move from them to open plan workstations. Conference areas with high panels can be employed to ensure privacy for those activities requiring confidentiality, but intrusive noise can still be a problem.

Techniques are available which can be employed to collect objective information about productivity. Six of them have been traditionally used to measure performance (24).

1. Historical records of performance to determine work output for a predetermined period
2. Employee reports, including making records of activities covering a given time period
3. Work sampling, consisting of observers recording activities performed, using a sampling procedure of tasks and individuals
4. Stop-watch readings for highly repetitive tasks to determine methods of avoiding time-wasting actions
5. Predetermined time standards compiled by efficiency experts on the basis of a fine grained tasks analysis
6. A recent development is a Maynard Operation Sequence Technique (MOST), which examines the motions used to perform light or heavy duty work. It describes body movements such as bend, stretch, walk, grasp, etc and links them in a sequence of operations.

Another key requirement is to involve workers in the office planning and design process. Recommended steps in this process are (25):

1. Identify office objectives.
2. Determine the specific functions critical to accomplish objectives.
3. Define the space and equipment needs for each office function.
4. Define the interrelationships among office functions with the help of the staff.
5. Determine the office facility location.
6. Generate alternative space plans.
7. Evaluate alternative plans by identifying critical criteria and weighting them accordingly.
8. Implement the plan chosen.
9. Maintain and adapt the plan as changes require; employee involvement is critical to identify equipment needs and provide feedback information.

Knowledge of organizational dynamics can be used to assess whether the desired level of face to face contact occurs. It can also help to structure activities and environments to facilitate performance, based on how people behave; e. g. physical space can be altered as can timing and frequency of meetings (26).

3. ORGANIZATION

An examination of productivity must start with the organization. Any
organization has a reason for being, and general goals to be pursued
using resources of staff, technology, materials, and finances. Each
organization performs its work idiosyncratically, within a given
cultural framework reflecting the values of management, and sometimes
of the staff as well (27).

The pace of automation is accelerating, not because it has achieved
the goals set for it; instead the trend is driven by technology.
Vendors produce new hardware, software, information and communication
systems, purchased because of their reputed capabilities to improve
office operations. Organizations have largely responded to vendors and
the marketplace; they assume the new technology will perform
effectively, and they must match their competitors, who pursue the
same strategy (28).

Office work can be analyzed at three levels, the individual, the
department and the organization. At all levels there is great
diversity in the tasks performed. At the individual workstation,
especially for knowledge workers, individual systems are often needed,
together with generic tools. Communication and information acquisition
and use are the primary requirements for these users (29).

At the department level, the tasks performed can be categorized as the
routine and structured activities typically performed by data
processing, and those which are non-structured - management and
professional functions. The latter are characterized by moving across
organizational boundaries and requiring text and data handling
capabilities.

Organizational productivity may be defined in terms of organizational
processes completed on schedule. It includes end-products such as
reports and routine maintenance functions such as updating files.
Improvements in productivity occur when obstacles are removed. This
definition implies the interdependence of organizational processes,
e.g. the output of one is an input to another (30).

Managers define productivity as efficiency, effectiveness, and
performance of individual organizations. Included in the concept are
the absence of disruption, quality and quantity of output, customer
satisfaction, absentee and turnover rates (31). These latter variables
include objective indicators, useful in measuring productivity.

The organization requires tools that integrate various systems
employed by departmental units - information and communication.

<u>Analysis of office tasks required for increased productivity.</u>

Phase 1   Macro Functional Analysis "Top Down"

* Understand overall charter and objectives
* Determine operations in major functional areas
* Determine internal/external functional relationships
* Develop input/output profiles
* Understand information management process
* Determine data base needs for Phase 2
* Obtain management feedback

Phase 2   Micro Activity Analysis "Bottom Up"

* Develop generic activity list describing current operations
* Develop technology indicator log (time spent on tasks)
* Conduct tracking of activities by time
* Analyze results and determine activity changes required
* Obtain management feedback

Phase 3   Concept Formulation and Implementation

* Develop overall automation concept
* Select and evaluate proposed technologies
* Develop before and after scenarios for each automated activity
* Prepare final recommendations
* Obtain management concurrence
* Recommend implementation plan

A five part methodology was developed by Sink (32) for productivity measurement.
1. Strategic planning process. This is used to project organizational goals 10 - 15 years in the future. Plans are then developed for achieving 2-5 year goals for organizational units; programs, techniques and a measurement and evaluation system.
2. Input/output analysis. Analyses by each working group of what they do, how they do it. It includes identifying purposes, services performed, customers for products (and their needs), inputs and outputs of system and process in creating outputs.
3. Identify impediments to productivity and develop techniques to overcome problems.
4. Develop consensus measurements of productivity within working groups. The system should be organized to help individuals improve their own and their group's performance. It should not be seen or used as a threat.
5. Information developed among groups should be communicated throughout the organization, within and between departments.

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Productivity measures for white collar workers can be built on a conceptual framework as below (33):

Inputs---> Function Performed ----> Outputs (used by "customer")

The customers can be inside or outside the organization, but they determine meaningful outputs.

A strategy for improving productivity should include:

1. Involve employees in productivity effort.
2. Provide job security, ensuring that improvements will not result in job loss.
3. Define outputs consistent with organizational needs.
4. Identify client groups for the output, and user value measures for them.
5. Define inputs and how to measure them (e.g. labor hours).
6. Develop appropriate measures, providing feedback for group and/or individuals monitored.
7. Employ technology appropriately.
8. Provide management leadership and support for activity.
9. Provide for ongoing education and training.

The development of measures can have many benefits:

1. Involvement of many people with organizational goals and improvement of performance measures.
2. Improving the understanding of the functions performed by the organizational unit and how it fits in the "larger picture".
3. Important outputs are identified and understood by all people involved.
4. Relationships with other organizational elements are better understood.
5. Training will upgrade the skill levels of the staff.

The development of indicators starts with understanding the purpose of the unit. This can be clarified by answering:

* What was it organized to do?
* What is the major transaction flow?
* What are the end products or services?
* Who are the customers for the products or services?
* What is the value to the customers?

The typical approach is to develop a ratio of person/hours of work to particular outputs.

Drucker and Peters/Waterman compared organizational systems performance criteria as follows (34):

Drucker	Category	Peters and Waterman
Consumer satisfaction	Effectiveness	Stick to knitting
Social responsibility		Bias for action
Employee performance	Efficiency	Close to customer
Management performance	Quality	Hands-on, value driven
Internal productivity	Productivity	Productivity through people
Employee attitude		
Management development	Quality of worklife	
Operating budget	Profitability	
Innovation	Innovation	Autonomy

The input and output variables carry quality, quantity and financial attributes. Three basic productivity measures are identified: static productivity ratios (a snapshot, not time sensitive), dynamic productivity indices (time period comparisons) and surrogate measures. The latter refer to activities highly correlated with productivity, such as absentee rate and customer satisfaction (34).

3.1 Goals/Criteria

The QWL concept assumes that people should be looked upon as a long term capital investment; e.g. training for equipment use should be included in organizational planning (35).

The basic management function of planning, organizing, leading, controlling and adapting, exist at all organizational levels. Every manager is responsible for controlling the performance of particular organizational units. Systems are developed to monitor performance and provide feedback information in accomplishing this function. The systems should determine what performance is achieved and if not adequate, what it should be.

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Among the criteria for judging the adequacy of performance measures are the following:

1. Quantifiable
2. Reliable
3. Must be Information System (IS) products or services
4. Understandable
5. Under IS control and responsibility
6. Linked to organizational need
7. Cost accountable
8. Improved individual performance indicative of improved productivity
9. Not subject to manipulation and free of bias
10. Data should be available
11. Measurement should not influence performance

Measures of Organization Performance:

There are at least seven measures of organizational performance: effectiveness, efficiency, product quality, productivity, quality of work life, profitability, and innovation.

The priorities given to these performance criteria will vary in accordance with:
* The size of the unit/organization
* Function of the unit/organization
* Type of unit/organization
* Maturity of the unit/organization
* The culture of the unit/organization (political, economic, managerial, social features)

3.2 Practice

In recent years there has been a trend toward a change in style in many organizations. There is a tendency to move from an autocratic leadership style, where all decision making is from the top down, to an approach where workers are included in many decision making processes. This change is reflected in many management, behavioral research and and productivity publications (36,37). Industrial and office automation has intensified this change.

A primary moving force in this direction has been a change in the staffing of organizations. White collar work now dominates the job market. More than 50% of all jobs are now in this category, and it is anticipated to grow indefinitely (38). More importantly, most growth has occurred in the management and professional white collar work force, the knowledge workers. These workers have been trained to expect and demand jobs to challenge their intellectual capabilities. They want to be actively involved in most aspects of their jobs. They are less likely than other office workers to accept being subordinated to machines or unquestioningly follow management directives (39).

3.3. Problems

Advances in office automation technology, especially those associated with multifunction systems, pose many problems to organizational management concerning informational requirements for decision making (40).

* Devices for information processing and networking are merging into multifunction systems.
* Office automation requires organizational changes in procedures used in administration, records management and distribution.
* Many managers and workers resist technological change.
* The explosive growth of technology makes it difficult to make appropriate decisions in planning and implementing office automation.
* Most information about technological capabilities comes from vendors; they are not expert in the needs of particular organizations.
* Office automation is thought to be product oriented, but it is a process involving an integration of equipment, people and procedures.

The introduction of productivity measurement in organizations poses several threats to the staff. They are inexact and require interpretation with knowledge of their limitations (41).

* Their purpose can be misunderstood and results misinterpreted. For example, introducing new technology often lowers productivity temporarily. Employees and managers might fear harmful action as a result of this result.
* People are concerned that their performance will not be judged fairly; uncertainty about expectations is also threatening.
* Increased record keeping (paper work) might be added to the job, with little understanding of potential benefits of measures.
* By its choice of measures, management signals are being sent to staff as to what is important. Performance can be distorted to respond to the particular tasks being examined.
* Knowledge workers want job autonomy and measurement is seen to concentrate efforts in particular directions, threatening autonomy in performing jobs.

The acceptance of a measurement system depends on all levels of an organization. Often, top management has a different view of its potential than other levels of the organization. The following illustration indicates forces for and against the initiation of measurement by a top manager and that of line managers and employees(42):

Top Management View

Forces for: Forces Against:

Productivity Improvement   Cost
 Necessary for survival
                                               Employees limited
                                               knowledge
Improved Management Control
                                               Difficult measurement
Early Problem Diagnosis

Improved Planning

Ability to Recognize Good Performance

Staff View

Top Management Wants System   More reports

                                               More control

                                               Might be
                                               embarrassing

                                               Nothing in it for me

                                               Excuse to cut costs

                                               Work not measurable
---

3.4 Possible Solutions

A QWL approach to productivity is becoming more common in organizations concerned with productivity improvement (43).

Eight features are cited as affecting QWL:

1. Adequate and fair compensation.
2. Safe and healthy working conditions.
3. Opportunity to use and develop human capacities.
   * Autonomy: does the work permit adequate job control?
   * Multiple skills: are a wide range of skills employed?
   * Information and perspective: is adequate information available about the work process and results of ones own action?
   * Whole tasks: does the work encompass complete tasks?
   * Planning: does the work include planning as well as activities performed?
4. Future opportunities for continued growth. Does the job contribute toward building a career; e.g. more responsible work, broader perspectives?
5. Social integration in the work organization.
   * Egalitarianism - minimal stratification and status differences.
   * Mobility - opportunities to advance
   * Supportive work groups
   * Community - a sense of common purpose.
   * Interpersonal openness
6. Work organization rights - privacy, right to dissent
7. Work and total life space - how the job fits in with the persons overall life; home, social and community obligations.
8. Social relevance - is the organization a responsible one; e.g. good community relations.

The nominal group technique (NGT) has been employed to identify productivity improvement opportunities and measurements. It is a means of achieving group acceptance, consensus and commitment to the products achieved. A facilitator plays an important role in ensuring that the meeting is focused on the stated objectives. The steps used are as follows (44):

1. Each participant independently generates a written list of suggestions and ideas.
2. In round-table fashion, each person presents ideas for recording on a flip chart by a facilitator.
3. Each idea is then clarified, evaluated and classified into major groupings.
4. Participants vote to establish priorities on the initial list, which is refined during later cycles until a final product is completed.

One approach is for a performance evaluation, e.g. a scale from 1 to 10, with excellent being 10, 5 being average, and 0 being the lowest possible. Another scale could depict the number of complaints

associated with an activity, bounded by 0 at one end and the maximum number received at the other end of the scale.

Three general planning approaches for office automation are:

Top-down

Planning is treated as a problem solving activity. The first step is to determine organizational requirements. Then information is collected on the available technologies and the experience of similar organizations dealing with the issue.

These activities are intended to define the problem, specify requirements for a solution and provide alternative methods of solving the problem. Implementing a plan entails the setting of goals, measurement of movement toward them and assessing the impact of changes on the organization and employees.

A major drawback to this approach has been the lack of participation by end-users in the process.

Bottom-up

This approach relies heavily on end-users in the planning and implementation process. Key stake holders are identified and participate in the activity. The activities performed are the same as cited above.

This method is very time consuming and often it is difficult to obtain concrete results due to the lack of focus.

Focused process

Participation of end-users is stressed but a strong team leader is employed to ensure that discussions are focused toward tangible objectives. During the planning phase it is essential to define problems generically. The focus should be on what, not on how. A "straw man" plan is employed to elicit methods of improving it; this helps keep the process moving in the direction sought.

The goal is to strengthen the forces "for" and weaken those "against" the institution of a system.

A major reason for the discrepancies in viewpoints is that top management has access to more and better information than subordinates. One method of overcoming this problem is to share more information.

Many of the negative forces can be defused by involving staff in the measurement process and creating a "shared vision" of what the organization is and where it is going.

An approach is recommended which makes the following assumptions:

1. Participation in the development of measures enhances understanding and acceptance.
2. People who do the work can and will assist the process.
3. An appropriate role of management is to define and prioritize "key result areas"; critical organizational functions.

The methodology employed has six phases:

1. Preplanning. The organization is described in systems terms.
2. Development of key result areas.
3. Development of key indicators. Identification of performances to be measured - those in key result areas.
4. Review of indicators. Indicators are reviewed by target organizational unit to ensure their relevance and feasibility of being measured.
5. Establishing weights and baseline performance - determining the relative importance of indicators and agreeing upon norms.
6. Data collection, analysis and interpretation - tracking indicators over time, and modifying procedures as required.

4. PRODUCTIVITY

Productivity is an elusive concept. Traditional definitions,
measurement techniques and improvement strategies have neglected
several important aspects of productivity:

* Productivity issues are complex and thus require multiple measures.
* Productivity has been defined in many different ways.
* Productivity measurement and improvement can be optimized by the
right mix of technical and behavioral approaches (45).

Total productivity measures take into account partial measures of
labor, material and energy; this is difficult to do because of the
number of variables taken into account, e.g. overhead expenses as
partial indirect costs. In white collar situations, the nominal group
technique is being used (46).

Productivity measurements are part of a total measurement system for
an organization. Good productivity measures help define the concept of
'productivity' and help guide behaviors to reach organizational goals.
Employees will emphasize the things measured.

The outputs of staff departments may be their contribution to primary
organizational activity. A partial measure is a ratio of output to
just one of the input factors. A total factor measure includes
manpower, materials, energy and capital (47).

4.1 Goals

A productivity strategy must be based on:

* Consideration of the entire organization
* Behavioral changes achieved through management-employee agreements
* A consideration of technological and human resources
* Measurements aimed at motivating workers, not just appraising
progress
* Gains achieved shared throughout the organization (48)

Criteria for studying office activities:

* Measurable information sufficient to support meaningful conclusions.
* Arranged for straightforward implementation
* Relevant to productivity assessment
* Sufficiently general to permit use in multiple environments
* Adequately supported through self-instruction, reference
documentation and automated tools to facilitate use

Study procedures:

1. External monitoring; using trained observers
2. Self monitoring
3. External appraisal; differs from monitoring in that judgments are made rather that mere description of activities
4. Self appraisal; general assessment by respondent, usually questionnaire, rather than detailed record keeping in 2 above

4.2 Practice

The typical office measurements of productivity, such as letters and reports produced, must consider interrelated organizational and personal functions. The office must be considered in systems terms. Factors such as the usefulness of outputs, their effect on the intended audience and their inter unit impact must also be considered. The following factors require attention in any productivity measurement system:

1. Inter unit impact - the extent to which a product or service of one unit enhances or detracts from the performance of other units.
2. Need - the extent to which the product is needed to make decisions or contribute to other major organizational functions.
3. Usefulness - the extent to which products are useful to their intended customer.
4. Quality - the acceptability of the product.
5. Timeliness - the extent to which the product is available when needed.
6. Quantity - the number of products or services provided.
7. Cost - the direct and indirect long and short term costs and the estimated value of the products (50).

The most basic measure is a work standard; the time and effort required to make a product or perform a service. In an insurance company an office can quickly determine its efficiency by calculating the number of claims adjusted per employee for a given time period. If automation is added then its cost is taken into account in making before and after comparisons.

Output has both tangible (physical) and intangible properties in many instances. Productivity studies have focused on these. The quantity of units produced and the time required to do so are popular measures. Yet, client satisfaction, added value and feelings associated with services are important features of many outputs.

Routine work is easier to measure than non-routine work. Therefore, the amount of routine in work should determine the types of measures possible, and how numbers are used. Yet, this aspect of performance has not received much attention. The author contends that as task ambiguity increases, then:
   * Measurement validity and reliability decrease
   * The utility of efficiency ratios decreases
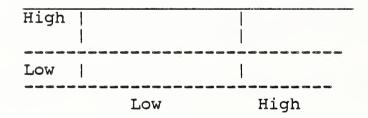   * The importance of effectiveness ratios increases
   * The possibility of a single productivity measure decreases

As task ambiguity increases, managers must increasingly:
   * Have employees assist in developing and evaluating productivity measures
   * Rate productivity on a group rather than an individual basis
   * Take higher risks in predicting outcomes; the process is more uncertain (49)

Output measures have several dimensions- quality, quantity, timeliness and service.

Typology of white collar work:

```
Specificity          High |                      |
of Procedure              |                      |
                     -----------------------------------
                     Low  |                      |
                     -----------------------------
                              Low          High

                      Tangibility of Product
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A single performance indicator is often insufficient, and multiple productivity measures are required. This process includes several steps:

1. Define the purpose of the unit.
2. Test the definition of purpose with higher management.
3. Identify the outputs which define achievement of purpose.
4. Determine how to measure each output.
5. Calculate productivity for base period, before change is initiated.
6. Establish a rating scale (e.g. 1 to 10) and define performance levels for each output, with base level at the center of the scale.
7. Develop a rating form depicting current outputs and scale position.
8. Determine weights for each output and combine for total.
9. Identify inputs and measures for them.
10. Monitor performance trends for each output.

Productivity measurements may be analyzed in the following ways (50):

1. Output and input elements
2. Purpose of measurements
3. Functions of productivity indices: cost minimization, profit maximization, industrial comparisons
4. Measurement methods

The American Productivity Center conducted a survey to determine the type of performance measured as productivity indices (51). Among those identified were:

* Error reduction
* Task difficulty reduction
* Improved product quality
* Reduction in response time
* Improved space utilization
* Improved communication

Advantages and disadvantages of basic productivity measures

Advantages   Disadvantages

Single Factor Productivity

1. Labor productivity is   1. The whole production system
easy to measure   is not measured.
2. Man-hour increases has   2. Can be readily
been traditional result of   misinterpreted
technology advances.
3. Labor input is large   3. Can increase rapidly by
component of total.   technology
4. Man-hour statistics are   4. Can be misleading in labor
readily available.   negotiations.

Multi-factor Productivity

1. Considers capital and   1. Value added improvements
labor.   ignored.
2. More resources included.   2. Causes of changes not
                          examined.
                                    3. Relative use of capital and
                          labor not specified.

Total Productivity

1. Most inclusive index.   1. Is too broad to use as tool
                          for specific improvements.

2. Provides rate of growth   2. Doesn't show interactions
for entire company.   of each input and output.

Productivity is measured for three reasons:

* It is a means to determine how well the organization is doing.
Problems and opportunities are identified.
* It provides a basis for future planning.
* It identifies the activities that management thinks is important.

Traditional industrial engineering (IE) methods have focused on
technical solutions; making systems more efficient. Efficiency
measures seek to assess how well available resources are used.
Effectiveness measures focus on organizational goals and are harder to
define and obtain (52).

4.3. Problems

Reasons for the lack of progress in increasing productivity:

1. There are too many loose definitions of productivity. It takes on different meanings depending on the frame of reference. IE's want to establish standards or piece work rates; economists look for aggregates based on all inputs and outputs. Managers want increases in direct labor, considering only those which directly control observable, countable output.
2. Society has changed. Organizations are no longer closed systems; their work is impacted by many outside forces. Workers values have changed; they pride themselves on their uniqueness, not their ability to fit into an organization. Their expectations are higher.
3. The term 'productivity' has negative connotations to workers; it is equated with speed-up of work.
4. Measurement is difficult.
5. Management is overdependent on technology as the answer to improved productivity. The relationship of the staff to the technology is overlooked; e.g. training, participation, involvement.
6. There is limited understanding of the organizational implications of introducing technology and changing work processes. The behavior of employees is seriously impacted and must be changed for productivity programs to work.

Until recently, measurement research has been hampered by the emphasis on macro productivity measurements. Many economists have concluded that what is most needed in productivity measures at the company level, where improvement can be expected to take place. There is no single formula to gauge the efficiency of each company activity; instead a family of measures are being pursued.

White Collar Productivity

In measuring white collar productivity, on the input side often only the labor component is considered; yet, capital, materials and energy costs are also important. The latter approach would be a total factor measurement. This would entail not only, e.g. reports produced per hour worked, but reports per dollar of word processors, files, square feet of floor space, paper, file folders, and per dollar of energy consumed.

Measuring white collar worker performance poses several problems:

1. It is difficult to define inputs and outputs as well as the nature, value, and appropriate measurement units.
2. Analysts measure activities rather than results; e.g. countable units of work such as program lines written, or pages typed. These might not be appropriate productivity indicators since they are not linked with final useful products..
3. It is difficult to match inputs and outputs for a given time frame. Resources expended may not show results for some time.
4. Quantity and quality of outputs are often inseparable.
5. The distinction between efficiency and effectiveness is not always considered.

6. White collar workers are not accustomed to being measured. It can
be a threat.

Traditional measurement techniques do not work well for white collar
jobs (53):

1. The techniques employed require quantitative data.
2. The problems attacked are based on short-term needs.
3. The lack of quantitative data make it difficult to evaluate the
severity of the problems examined.
4. The problems addressed are not important ones to operating units.
5. Recommendations for actions are made by a small unit and
implementation is difficult because it often requires approval by
"higher authorities", unfamiliar with the particular issues addressed.

4.4 Possible Solutions

There are five ways of increasing the output/input ratio of
productivity:

1. Increase output faster than input; managed growth.
2. Decrease input more than output; curtailing inefficient operations.
3. Produce the same amount with fewer inputs; cost reductions, greater
efficiency.
4. Increase outputs with the same inputs; working smarter.
5. Maximize the increase by a combination of 1-4 above.

Behavioral Anchored Rating Scale (BARS)
* Critical incidents are used to determine job related behaviors, and
important performance dimensions.
* Job-related behaviors identified in critical incidents are
retranslated - behavior is linked with performance.
* Behavioral incidents that can be performance linked are scaled to a
given performance level.

An example of the use of BARS follows:

Supervisors wrote examples of effective and ineffective job behavior
incidents - observable behaviors. Incidents were arranged into
homogeneous job behaviors and summary definitions written.

Then the definitions were reviewed to determine whether:

        * The factors were meaningful and important
        * Significant performance components were represented
        * There was too much overlap
        * The definitional language was suitable for the work
        performed in the organization

Next, participants were asked to write additional items, representing
more moderate behaviors to augment the extremes identified earlier.

All items were then rated on a nine point scale after being arranged
into particular dimensions.

The dimensions resulting from this procedure were:

1. Ability to absorb and interpret policies and procedures.
2. Adaptability - adjustment to new situations.
3. Effective use of resources
4. Interpersonal relationships
5. Job involvement
6. Knowledge and judgment in performing work (54)

Another evaluative process is described by Kristakis (55).

1. Identify major work input and output categories.
2. With more than one category, rank order them for greatest potential for improvement; costliest, need for improvement.
3. Identify operations and the time needed for completion.
4. Evaluate operations; needed, possibly combined, reduce frequency of preparation, performed by lower paid people, etc.
5. Identify targets for improvement; largest potential for improvement, importance.
6. Develop plan for change.

5. ERGONOMICS

5.1 Goals/Criteria

The criteria for acceptance of new office technologies are the same as those for older ones; they should make office work more convenient, manageable and/or productive. The specification of office criteria is a primary goal of ergonomic studies.

Ergonomic needs in the physical environment include the work area of the _individual_; the equipment, furniture and environmental systems supporting the equipment and the _shared space_, including circulation paths, walls, ceilings, lighting and acoustics. In a broader context the QWL issues discussed earlier are based upon the social and psychological needs as well.

A key to effective ergonomic design is a systems approach to workstation design, based on human effectiveness, flowing outward from the end-user (56).

5.2 Practice

The human factor is the overlooked component in office automation. A management commitment must be made to employees if automation is to fulfill its promise. Supervisors and staff members should participate in the planning process and be thoroughly trained in new technologies before they are implemented. A conscious effort is needed to overcome the fear, uncertainty and reluctance associated with the introduction of new equipment and procedures into the office (57).

With respect to the emphasis today on open office planning, there is little evidence to indicate whether this approach helps or impairs productivity. Current data concerns _attitudes_ toward the concept, subjective evaluations about effectiveness (58).

Ergonomic requirements in offices have been discussed in detail in many publications and it is beyond the scope of the present study to treat it in detail. (See the bibliography for reference sources.)

5.3 Problems

* Sophisticated computer hardware and software have been developed and may not suit the actual work processes or needs.
* Designers have developed equipment that is often unsuitable for users
* Managers have introduced equipment into the workplace without sufficient consideration of whether the users can use it or are capable of being trained to use it.

In the rush to take advantage of powerful technologies, its user is often overlooked. Work is being polarized into two extremes; routine operations and knowledge work. Some work is being deskilled and thoroughly routinized by means of standardized units (59).

Studies have indicated a high level of stress among many office workers: mental and physical. Working in a mechanically controlled building can contribute to stress. The air is self-filtered, windows cannot be opened, daylight is often excluded and temperatures are kept within ranges optimal for equipment, sometimes to the detriment of workers.

Mental stress occurs by machine pacing of work, loss of job control to the computer, and the fact that a computer processes some types of information much faster than the worker. Electronic monitoring is another contributing factor (60).

When terminals are first introduced into an environment, they are used for only a small percentage of the work performed, yet the terminal and its peripherals are likely to occupy a considerable amount of table top space. More work surface area must often be found to accomodate paper work, telephones, etc (61).

Much office furniture prevents satisfactory workstation design. Many organizations select and place terminals with little thought given to good viewing conditions; prolonged VDT use combined with poor lighting often causes headaches and eyestrain.

Even work formerly considered creative often becomes a choice between a range of predetermined elements and processes. Decision making is frequently restricted by software design.

Ergonomic features are usually an afterthought to compensate for faulty design. Equipment and furnishings are not designed to be "user friendly" at the outset; planning is often non-existent or deficient in this regard. The proper design of chairs, VDT's, and keyboards are critical to ensure worker comfort and avoid physical stress.

The primary change in the office environment resulting from automation is the prevalence of VDT's. A summary of the primary interactions between VDT's and the environment is presented below (62):

Component	Environment	Problem	Impact
Display Screen	Lighting	Vision	Fatigue, glare discomfort
Keyboard	Seating	Posture	Fatigue, strain
Printers	Acoustics	Noise	Distraction, Stress
Black Boxes	Space layout	Cramped workspace	Inefficient work
Wiring	Installation	Safety	Obstruction, hazards

5.4 Possible Solutions

Workstation design must reflect a range of human needs:
* Anthropometric - body dimensions, physical capabilities such as sitting and standing height, reach lengths. The best design reflects economy of effort, minimizing fatigue.
* Sensory - visual, auditory and thermal comfort needs.
* Social - interpersonal relationships among colleagues and others.
* Privacy - the ability to regulate and control social interactions and avoid interruptions
* Territoriality - an area with boundaries under control
* Status - workstation design is commensurate with organizational role.

Humanizing the workplace can lessen the frustration of the job and the increasing technological emphasis. People need the feeling that they are controlling the system and not being controlled by it (63).

* Before purchasing equipment, a realistic needs assessment should be performed.
* A systems approach to design is essential; components must be compatible.
* Operators must be trained to operate new systems and software.
* Equipment, systems and software should be selected on the basis of performance and ease of use.

Workspace surface design includes the need for writing, sorting and storage of materials. Location of reference materials must be convenient to all users of the information. Workstation design must balance the particular needs of the individual and supporting equipment with the requirement to standardize components and furnishings from an organizational viewpoint - to minimize costs.

Flexibility offers the opportunity to make generic choices which can be modified to suit individual needs.

Individual space requirements should be based on a consideration of the cubic dimensions of: the equipment, the space occupied by the person, the actions performed and the support spaces - file and storage (64).

An office should reflect the working style of the user. It should permit the worker autonomy within a range of possibilities; rearranging furnishings, using a task light that can be positioned at the user's discretion.

Stewart (62) suggests the following planning approach to improving productivity, based on a study of what people require to do their jobs.

Ergonomics inputs to office system design

Stage of life cycle	Ergonomics input
Analysis	User-needs analysis
Planning	User profiles
	Allocation of function
Design	User interface design
	Office Design
Implementation	Management of change
Operation	Ergonomic evaluation

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6. CONCLUSIONS

The literature review indicated that the subject of productivity has received extensive treatment by many disciplines. The publications in the field are quite extensive, but they do not treat the subject on design and productivity in much detail. Consequently, methods to foster productivity by building design features must be developed. Two general approaches seem feasible based on the research:

1. Developing an environment which makes a contribution to productivity.

2. Eliminating or minimizing factors which are detrimental to productivity.

Much of the <u>research</u> literature reviewed is devoted to identifying problem areas with office automation that can be overcome with proper design. These papers range from a concern with environmental issues such as glare and noise to the need for adjustable chairs and a voice in design decisions. In many instances proper practices are well known and merely need to be applied. In other cases, such as the advancement of QWL issues, the research findings are mixed - programs being effective in some situations and not in others.

While researchers have examined the effects of variables such as noise and glare on performance such as legibility of materials (glare) and the ability to understand speech (noise), studies of 'productivity' are rare.

With respect to positive design contributions, the claims are widespread but the proof is not readily available. Many popular articles have been written about the effectiveness of various technologies in increasing productivity but supporting material is typically absent or described in such general terms that general conclusions cannot be drawn with any assurance.

The Hawthorne studies have provided a model for productivity studies in demonstrating the need to consider the context in which field investigations are performed. That is, organizational, social and psychological factors must be examined when instituting and examining environmental changes, such as lighting levels, as a means of increasing productivity. The QWL formulation is one which is consistent with this approach, being concerned with the "whole" worker. This includes the need for a proper working environment to playing a part in the decisions affecting the job.

A simple solution to the design-productivity problem doesn't appear to exist. However, researchers and practitioners have developed a number of approaches which seem to be promising, and identified several "dead ends".

Two of the key judgments to be made in any line of investigation is to determine what <u>not</u> to study and how not to study it. These decisions

are vital in narrowing the scope of the work. The review of past work provided several insights in making these choices.

The first studies of office productivity were focused on word processing activities and employed the measure(s) of word and/or page counts. Similarly, data processing studies often focused on "lines of codes" written. These measures appear plausible when first considered, since they deal with a product and can be readily counted. In short, they are measures of "efficiency". After some experiences with these metrics however, it became apparent that they are difficult or impossible to relate to organizational "effectiveness". For example, quality considerations are not taken into account. Moreover, is it plausible to assume that five drafts of a report using a word processor completed in the time needed for three drafts on a typewriter, is "more productive"? The primary caution is to be skeptical of measuring something related to productivity <u>because</u> it is easy to measure.

Another "blind alley" is the search for factors that directly impact "organizational productivity". The macro economic studies reviewed strongly suggest that it is extremely difficult to isolate all of the factors that influence organizational performance (66). While this is the most important measure of effectiveness, the likelihood that design issues can be traced to organizational productivity is slight.

Despite the attraction for comprehensive measures of productivity, modest initial programs capable of future "modular" or incremental extension are more likely to prove viable. Concentration on a critical or bottleneck activity with a potential early payoff can win support for more ambitious later programs. An important criterion for selection of department or group to study is its autonomy: the greater the autonomy, the easier it is to attribute productivity changes to design issues.

The follow-on work of the current project is the identification and measurement of critical organizational activities, sensitive to building design features and the development of productivity measurement procedures where needed. This work, sponsored by the PBS/GSA, is under way at the new federal building in Portland, Oregon. This effort entails the administration of detailed questionnaires, interviews, examination of records and physical measurements of environmental conditions and spaces. It is being performed in several phases, including pre-move, shortly after move-in (approximately six months), and one year after initial occupancy.

The activities examined in detail are being selected by researchers and members of the using organization, the Bonneville Power Administration (BPA). The latter are represented by those with first hand experience of the activities examined and high level management representatives who can ensure the tasks examined are important from an organizational goal perspective. An important research criterion is that the activities are potentially generic in nature, i.e. not limited to narrow specific functions. This will facilitate the development of a viable design-productivity model.

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The findings of this study, which includes the examination of systems
furniture on productivity, will also be used to further upgrade the
PBS/GSA design criteria for office buildings.

7. CASE STUDIES: FINDINGS AND RESEARCH APPROACHES

Many studies have been performed by federal and private sector organizations to increase productivity. These reports for the most part appear in non-technical publications and do not provide much detail concerning the procedures employed in collecting information. The findings therefore are difficult to evaluate from a scientific standpoint. However, they do provide insights as to the problems encountered and often suggest approaches that are worthwhile to consider in formal studies. A sample of these investigations are described below:

Based on several case studies Kinne (67) identified several warning signals of a failing office environment:

* There are rising expenses for communications, document production, reproduction, storage, and information retrieval
* There is inadequate integration among planning, design, and development of data processing applications and office automation
* Services quality has declined; turn around times have increased.
* Significant changes exist in individual work loads and expressed dissatisfaction by staff members.
* Unrealized benefits or cost savings from office automation equipment are available.

These issues lead to the question of what areas can benefit from automation planning. A suggested planning strategy is as follows:

1. Define organizational goals and develop a strategy to achieve them. The components of such a strategy include:
    * What should be the scope of the project? Should it cover all operations or be limited to specific functional areas?
    * What level of system integration is appropriate for the organization? Are shared data bases needed? What are future plans for integration?
    * What criteria are relevant?
    * What level of resources should be committed to the project?
    * What is an appropriate time frame for the study and its implementation?
2. Analyze the existing situation.
    * What problem areas exist, procedural and technical?
    * Identify areas for short and long term improvement in policies, practices, organization, and systems.
3. Develop a comprehensive improvement plan and program.
    * Identify equipment needs, system requirements, training and control mechanisms.
4. Prepare a Request for Proposal (RFP) and bid for the systems desired.
5. Evaluate vendor proposals and select one.
6. Design a systems implementation plan and document new procedures and policies. Develop a checklist, covering the following:
    * What should be done with existing equipment, software and data?

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        * Establish a delivery schedule.
        * Develop a plan for staffing and training.
7. Conduct acceptance tests and monitor performance.
        * Conduct training for all affected staff members.
        * Conduct on-going reviews to improve and fine-tune the system.
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Wright (68) stresses the linkage between QWL and productivity, indicating improvement in one realm should not compromise the other. Productivity improvement programs should be evaluated on QWL impact. He describes a case study designed to enhance QWL and productivity.

The program started with a commitment from top management to support the program goals. All organizational levels were included in the process. A productivity manager was assigned to oversee the program, assisted by a steering committee. The committee set productivity goals, planned resources for initiatives, monitored policies and activities, provided funding and implemented management controls.

A productivity/QWL council was formed as a working group to enact the program. Its responsibilities were to:

* Report to the steering committee
* Spearhead projects
* Develop productivity measurement methods
* Lead quality circle teams
* Ensure that productivity initiatives are in plans
* Solicit and disseminates ideas
* Publish periodic scoresheets
* Develop an employee awareness plan
* Schedule and measure departments

Major topics of discussion include plans for facility layout, automation efforts, methods of managing programs, communication within and between organizational units and informational requirements at the individual, department and organizational level. These initiatives begin at the department level. Initial activities are auditing paperwork flow, project planning, eliminating duplicate functions and developing training programs.

A key to the success of office automation programs is the method used to introduce it into organizations.

Anthony (69) describes a case study of introducing a productivity measurement system at a banking institution. The tasks examined were professional, technical, managerial and administrative.

The process employed started with a one sentence description of the units mission. Task descriptions and the times required to perform activities are obtained by means of interviews, time diaries kept by employees for completing tasks, and observations. After the data were compiled, total time, total work units, time per unit and total time percentages for each task. Standards are then developed by analyzing the steps performed to complete each task, simplifying the process by

eliminating unnecessary steps or activities, providing better tools or developing an alternative means of performing work in less time.

McMillan (70) describes another procedure used to introduce automation into an organization. A committee was formed to oversee its planning and implementation. The first step was a pilot study to select a particular workstation among several to be tested. It was to be first used as a word processor, and later linked to a mainframe providing an interactive system with shared access to electronic files, electronic mail and other capabilities.

Management involvement and commitment was seen as a necessary prerequisite for the study. A top-down approach was employed to ensure that the focus of the investigation was on professional and managerial activities. Among the recommendations made after the completion of the initial study were:

> * Training support. Full time personnel are required to handle the ordering of supplies, furniture, equipment location and on-going training.
> * Installing equipment has important implications for the facility. Among the questions to be addressed are:
>> - Where should the workstation be located?
>> - Will it be connected to the mainframe?
>> - Will special furniture be needed to accommodate peripheral devices such as printers?
>> - Do the workstations require assembly? If so, who will do it?
> * Planning is needed to ensure that the final system operates effectively and has the proper integration.
> * A top-down approach is recommended. If the person at the top of the organization is for it, others will follow.

Dupre (71) describes a study performed for the Exxon Information Center, the main business and economics library of the Exxon Corporation. An on-line system was developed to provide immediate access to information.

Among the measured benefits of the system were:

* Lower overhead costs; staff was cut from 18 to 14.
* Status reports on wanted items given periodically.
* Database searches can be edited and reformatted using text processing.
* Statistical usage patterns of individual users and departments are possible.

Among the lessons learned are:

* Use knowledgeable professionals for information on microcomputing and telecommunications directions and products.
* Appoint a representative from the using group to help select the system.
* Plan for the future; at least for the next 3 - 5 years.

* In planning a system, important considerations are:
    - Adequate storage capability
    - System flexibility to allow for change and expansion
    - Hardware/software compatibility
    - Availability of software to meet specific needs
* Assign someone responsibility for support:
    - Software maintenance
    - Training and documentation
    - Protection of data loss through accident
    - Ensuring against unauthorized access
    - Destruction of data when no longer needed

Bolte (72) studied productivity at the Intel Corporation. His major finding was that improving productivity depends on managers becoming "change agents". Every department establishes goals for quantity and quality of output. In the course of the investigation he identified a number of specific productivity measurements useful in his work: accounts payable- number paid; materials - line items issued; maintenance - work orders completed; custodial - sq ft cleaned; marketing - orders shipped.

Peeples (73) evaluated the productivity of the data services at 14 data centers of GTE. The initial objectives established were to:

1. Establish standard levels of performance for each project or center acceptable to organizational unit.
2. Record and report total performance acceptable to management and customers.
3. Provide a standard to compare all projects and centers.
4. Maintain historical records of performance, service.
5. Measure and compare performance at various centers.
6. Foster competitive spirit among units.
7. Publicize the interest in increased productivity internally and externally, to customers.

The measurement program dealt with timeliness in meeting output schedules, development of local system support for individual customers and computer efficiency.

Manoocheri (74) conducted a study of processing insurance claims and loans and back office bank operations, which exemplify high volume office work. These activities lend themselves to highly structured stable tasks. Structuring jobs for performing these activities to increase productivity has led to problems. Job simplification has increased the monotony of work; a person does one routine job all of the time. The de-skilling of jobs eliminates a good deal of the interest and challenge of work. It ignores involvement of the workers and commitment to their tasks. It makes the job more abstract; workers are less in touch with how their job relates to other tasks. The worker can become insensitive to the importance of the job and become careless. There is a loss of a feeling of accomplishment and pride in doing a good job.

The initiative and creativity of the individual worker is limited.
Also, automation has increased the isolation of the individual from
his or her colleagues and from the organization as a whole.

Psychological requirements to offset these problems are:
* Job content should be reasonably demanding from an intellectual
standpoint.
* There should be an opportunity to expand skills on the job and by
means of formal training.
* Some job decision making should be permitted.
* Social support and recognition is important.
* The job should not be perceived as a "dead end" activity.

Garen (75) examined the formation of an information center and cites
the need to better understand the concept of 'productivity'; sometimes
defined as the efficiency of data flow; at other times concerned with
the decision support effectiveness of office automation.

The goal of an information center is to improve the productivity of
end-users by helping them recognize and solve their most important
problems and best utilize new technologies. It is to be staffed by
professionals whose greatest task is to upgrade the skills of all
employees while serving their organizational needs.

End-users require systems that are highly responsive, easy to use and
attuned to individual styles and practices. Workstation and other
interface designs should vary according to individual and group
requirements.

Zeppo (76) reports the results of an extensive survey of managers and
secretaries. The survey sought to learn how secretaries and managers
view themselves, their work, the work in the office, office
productivity and office automation. The major findings were:

    * Managers overestimated the time secretaries spent on
    traditional tasks and underestimated the time spent on non-
    traditional ones.
    * Managers spent more than 10% of their time supervising routine
    tasks. They don't delegate because they assume that secretaries
    do not have the time to perform them.
    * Secretaries felt that their productivity would be increased
    with better communications from managers and if they had fewer
    interruptions.
    * Managers said that their productivity would be increased with
    fewer interruptions and if secretaries would take on more
    responsibilities.
    * Secretaries said they want more responsibilities.
    * Managers believed that automation would improve productivity
    (40%) to a greater extent than secretaries (26%).
    * Users of automated equipment thought that it increased
    productivity; more work, better quality, more time for
    challenging tasks.

* Based on experience with equipment, users suggest better
       training and improved briefing on how equipment should be used,
       and more input in equipment selection.

Teger (77) summarizes the findings of an extensive questionnaire
survey of 300 major organizations and more than 5000 individuals.

Three major factors have provided an impetus for office automation:
       * Corporate and organizational needs
       * End-user requirements
       * Technological availability

Successful organizations require high quality information and good
communication resources to make better decisions and improved
productivity. Information must be accurate, timely and relevant. The
specific approaches used to justify automation have been cost
displacement and value added.

Cost displacement is directed to reducing the cost per unit product;
improving the efficiency of routine tasks or eliminating tasks. This
has been applied to word processing primarily and to a lesser extent
to records management. The measurable outcomes of these approaches
have been in reduction of staff, office space and outside services.

Value added systems are those which improve organizational
effectiveness, often by performing tasks not possible before. They
typically are aimed at freeing up the time of managers and
professionals. Tools provided are intended to provide better and more
timely information, resulting in more creative work and improved
decisions.

Better performance of office employees depend on:

       * Job satisfaction
       * Recognition of individuality
       * Stability
       * Status

The tools to assist office workers should have 'functionality' and
'usability'. Functionality refers to the capability to perform the
tasks required, e.g. accessing informational needs. Usability refers
to ease of use, e.g. hardware and software should not require great
training or skill requirements.

Office communication encompasses two areas of importance: people
communicating with others, and with machines by means of hardware and
software systems. Communication by telephone comprises a vital part of
office activities, especially for knowledge workers.

About half the calls made go to persons other than the intended one.
Response is by another person, a busy signal or no answer. When a
message is left, it is not complete, requiring another call. With
respect to receiving calls, 60% of them were regarded as

interruptions; disturbing more important activities. Most calls (56%) were considered delayable; they could be postponed.

A solution to this problem is a voice mail system. This approach always indicates that a message is available, and optional ones such as assigning priorities and forwarding messages. Telephone tag is avoided and the timing of receiving communication is dictated by the recipient, minimizing disruptions of ongoing work.

Campbell (78) describes the result of a survey of 80 Canadian corporations who have instituted programs of productivity improvement. The characteristics that most of the successful ones share are:

1. Top management support
2. A productivity steering committee to guide the program, staffed by key line and staff managers
3. A productivity manager with administrative, human resource and technical experience
4. Coordinators at lower organizational levels
5. The use of measurement tools to track performance
6. Productivity is of central concern to the organization.
7. A limited number of goals are established initially; they should be achievable and measurable.
8. Staff participation is essential, e.g. quality circles.
9. Minimum performance standards are established.
10. Expectations are communicated and well understood by the staff.
11. Tasks are constantly monitored.
12. When the initial goals are met, the process is refined and repeated.
13. Appropriate training programs supplements the program.
14. The staff has a sense of responsibility for productivity improvement.

Curley (79) summarizes the experiences of several organizations which have introduced office automation into their operations.

In a legal department, the addition of a research data base, Lexis, added 18% in case load without additional staff. Part of the increase in output is attributed to the electronic indexing system which gave 50 attorneys access to one another's briefs and memos. Research, writing and typing time can be saved. The thoroughness and timeliness of data was improved as search time was lowered. Output measured included cost per case, which was substantially lowered.

An MIS group found the span of control of supervisors was increased using an electronic mail system; fewer managers were needed as a result of better communications.

Another saving identified was the time needed to prepare documents and complete delivery of ordered parts.

Among the lessons learned in the review of experiences are:

1. The introduction of office technology should be tied to achievable, desirable goals. A specific performance objective should be identified and monitored as systems are introduced. Among the measurable factors to be considered are "time", "better quality information", "faster turnaround time", "improved communication".
2. An ongoing learning process should be instituted. Goals should be modified as a result of evaluation of experiences.
3. Pilot projects are an important element in an overall strategy. They can be performed in selected smaller organizational elements at relatively low cost. One important reason for this approach is that benefits cannot always be predicted accurately. Assessments can include issues such as:
* If original objectives were not met, why not?
* Were there any benefits not predicted?
* What problems were encountered?
* Were resources used appropriately?
4. Managers must actively support the learning process needed to take advantage of office automation. Training is an integral part of effective use of technologies.

An illustration of the evaluation of a legal productivity program is given by Gardner (80).

Benefits	Users		
	Atty	Non-legal Profs	Secretary
Quality of work improvement	XX	. XX	XX
Less time to produce reports	XX	X	X
Ready access to research	XX		
Sharing of typing simplified	XX	XX	XX
Work schedule flexibility improved	XX	XX	X
Management effectiveness improved	XX	XX	X
Research time shortened	XX		
Research accuracy improved	XX		

XX High impact

X Moderate impact

Meyer (81) conducted an in-depth study of office automation programs in 35 organizations and describes the factors that led to successful programs.

Office automation has been used to improve the efficiency of well-structured administrative processes. They focus on reducing costs. The other general goal has been to add value to products of office work. These are directed toward increasing managerial effectiveness and/or productivity. The latter are considered to be have the most potential for improving organizational improvement.

Office automation is defined as the direct use of information tools by managers and professionals. Given that organizations change slowly, successful practitioners start at a small scale; using value added applications for a limited group of users.

The study raised the following questions:
1. How did the idea of office automation originate with the organization?
2. What is the organizational climate?
3. How was the concept of office automation "sold"?
4. What is the role of the person responsible for office automation?
5. What organizational considerations were important?
6. What has been accomplished to date?
7. What was the "charter" for the office automation activity?

Successful approaches included:

1. A capability to deliver a broad range of tools was developed. This included knowledge about available technology and its use and the ability to manage implementation. A leader was selected to head the effort and a team formed representing users, data processing, administrative, business and behavioral science skills.
2. A pilot study is needed to ensure decisions are made based on hands-on experience with tools and systems. The pilot program should not have to be cost-justified; rather it should be a research effort. Training is essential for all system users.
3. Organizational momentum should be fostered by identifying key functional areas and problems to be addressed, those likely to respond to technology.
4. Users should be organized into an advisory "council" to identify organizational needs that can be met by technological systems. An important function of this group is to identify potential new targets for pilot studies.

A summary of the experiences and observations over ten years of work in the area by Sink (82) indicates:

* You usually get what you measure.
* What you measure implies what you or the system feels is important.
* What you measure implies what you will reward or punish for.
* As jobs get more complex, feedback is difficult. People need to know how they are doing on their jobs.
* There are aspects of the job difficult to measure - qualitative.

* Parts of job cannot be measured directly.
* The best measurement and evaluation systems blend subjective and objective, qualitative and quantitative, implicit and explicit, analytical and intuitive approaches.

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10. SUPPLEMENTARY NOTES

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11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here) The Public Building Service of the General Services Administration sponsored the present investigation to: Determine the effects of building design, and "high quality design" in particular, on productivity/Determine the state of the art of productivity measurement, applicable to the study of office tasks/Identify the various factors that influence productivity to better determine those which can be attributed to design issues.

The study is primarily based on a comprehensive literature search of 15 data bases, supplemented by personal contacts with specialists on this topic. The report reviews and distills the major findings of more than 550 publications.

The most significant findings of this investigation are: The preponderance of productivity literature is concerned with macro-economic studies which cannot be readily related to the influence of building design on productivity./The few studies dealing with productivity have often drawn sweeping and questionable conclusions from information that is largely subjective, e.g. self-estimates of productivity improvement./Some analytic techniques are available which can be used to study the "micro" office environment.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

Productivity, design, design criteria, ergonomics, office automation, quality of worklife

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