Organizational and Process Differences Influencing Ergonomic Design

Susan M. Evans and Don B. Chaffin

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ORGANIZATIONAL AND PROCESS DIFFERENCES INFLUENCING ERGONOMIC DESIGN

Susan M. Evans
Vector Research, Inc.
P.O. Box 1506
Ann Arbor, MI 48106

and

Don B. Chaffin
Center for Ergonomics
The University of Michigan
Ann Arbor, MI 48109

ABSTRACT

A study of current design practices was conducted to identify organizational and design process differences influencing the use of ergonomic information in manual workspace design. Significant differences regarding the design information sources and objectives existed between preliminary, or division-level, and detailed, or plant-level, design activities. Ergonomic concerns, e.g., health and safety factors and operator feedback, were most clearly present in plant-level design; unfortunately, plant designers also had the least flexibility, in terms of design parameters to vary, and dollars to spend, to retrofit inadequate designs. Results indicate specific factors, (such as designer temporal and geographic proximity to the design implementation), to consider during the development of an effective industrial ergonomics training program.

INTRODUCTION

Investigations of existing industrial work-spaces and associated medical data suggest inadequate concern is directed toward the human operator in these manual systems. While handbooks and "ergonomic awareness" courses are available to designers, the application of the information appears to be sporadic. Several authors (Shackel, 1980; Saric, 1979) have suggested that organizational factors, such as proximity to the design implementation and design team composition, may influence the propensity to use ergonomic information.

The need for a more detailed understanding of these and other factors influencing the concern given to the human operator–workspace–task interface in manufacturing systems, and the use of ergonomic information in workspace design motivated a study of current design practices in selected industries. Identifying these factors was viewed as a critical first step in developing computer-based design aids for assessing and alleviating excess operator physical stresses in manual workspaces (see Evans, 1985, for a detailed description of the larger study).

This paper focuses on (1) specific differences in the ergonomic design process which stemmed from designer location, industry classification or type of design activity (e.g., new design or redesign); and (2) the implications of these differences on the consideration given to the human operator during manual workspace design.

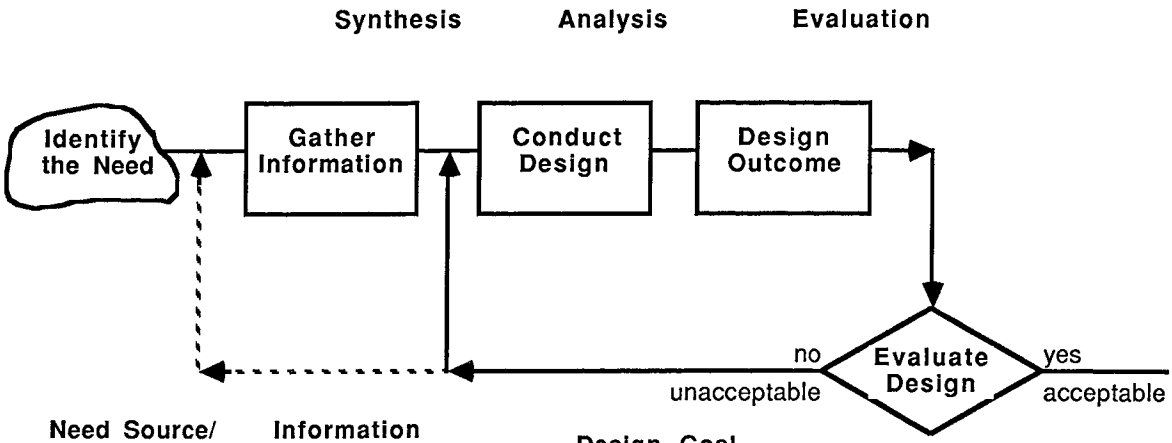
METHOD

Acquiring design information is viewed as a critical and often difficult phase in any design activity (Dieter, 1983). Obtaining timely, accurate and useful information is often a function of the current design phase, the degree of communication among the design groups, and the location of the design activity. A designer survey was constructed to serve as a tool for identifying what role, if any, the above elements played in the level of ergonomic design. Specific areas of the survey prompted designers for current design practices, deficiencies, parameters and information sources.

The survey was personally administered to 40 engineers in 5 companies. Roughly one-half of the respondents came from manufacturing or assembly industries, and the remainder were split between machine design and continuous processing companies. While the respondents were volunteers, they were selected with concern for their location, industrial classification and training. Respondents spanned a variety of professional specialties, with two-thirds representing some form of manufacturing engineering (i.e., tooling, processing, machine design, or manual materials handling), and the remainder divided among facilities layout, methods engineering, and industrial design.

Respondents included both managers and staff engineers (40% versus 60%, respectively), and were located at either plant or corporate/division locations (25% versus 75%, respectively). Managers were solicited for several reasons: first, the manager generally had access to data or insight on workforce characteristics, design practices and criteria sources and designer function within the organization; second, they had often completed design projects themselves, and could relate their own experiences; and third, they knew of company wide directives regarding the role of ergonomics.

Responses were coded and computer analyzed using appropriate statistical techniques.



	Need Source/ Problem Initiator	Information Source	Design Goal
Preliminary Design	product engineering division engineering customer	experience corporate/ division	establish functional requirements of workspace or manufacturing methods
Detailed Design	plant manager health & safety division engineering	plant division	final design optimization, with all parameters known

Figure 1. General Design Model for Manufacturing Workspace Design (from Evans, 1985). (Derived in part from existing engineering and computer-aided design models).

RESULTS

Results are divided among three categories – those which assisted in developing a model of the manufacturing workspace design process, those which identified the composition and location of design groups, and those which identified design responsibility or accountability. The perceived role of ergonomics, demonstrated through either the use of ergonomics reference materials, or stated concerns for operator health and safety, are also presented.

Workspace Design Process Model

Survey responses indicated a design model similar to that shown in Figure 1. It was derived, in part, from design process models found in engineering and CAD literature (Asimow, 1962; Siders, 1966; Dieter, 1983; and Encarnãçao and Schlechtendahl, 1983). The model's flow is consistent throughout all industries, but the design, methods, outcome, and characteristics at each stage varied based on the design objective.

A major dichotomy occured between **preliminary** and **detailed** design activities, when the design objective switched from establishing the functional requirements of the workspace, (i.e., the working principles, dimensional restrictions, or manufacturing methods), to assigning specific values to the attributes of the functional specification. In workspace design, the functional specification existed among division or corporate engineers, especially in discrete part assembly and machine design industries. The detailed design activity was most common among plant-level respondents as well as all designers in continuous process industries. Major differences in the activities stemmed from how the design information was obtained, the quality and quantity available, and how it was used.

Specifically, workspace design at the plant level differed from the division level in the seven critical areas listed in Table 1. The specific differences are also presented. Items 2 through 5 in Table 1 deal with gathering specific design information. Items 6 through 8 concern the design operation, outcome, and evaluation.

Ergonomic concerns were more clearly present at plant-level design, where health and safety concerns and operator feedback were most obvious. In fact, design problems were four times more likely to originate from health and safety concerns at the plant level that at the division level. In addition, designers at the plant level were more likely to identify operator-physical stresses as *sources* of workspace design deficiencies, than would their counterparts at the corporate or division level. Stated deficiencies included excessive back stress, shoulder problems due to overhead work, and excessive walking due to rack location. The sensitivity to the operator-workspace-task interaction suggested a stronger recognition for the specific

Table 1

Workspace design differences based on responses from plant and division engineers

Critical Area	Plant difference	Division difference
1. Allocation of time to new or redesign activities.	62% is redesign	32% is redesign
2. Design problem initiation	70% from plant production, Health & Safety, or worker initiation	26% from plant concerns other from division production or customer
3. Source of design specifications	plant or division group, plant supervisor/ manager	division or corporate group, or plant group
4. Critical design information sources	plant, company, non-standard (i.e., experience,common sense)	division, company, non-standard
5. Variable parameters of design	task description, workspace layout	workspace layout
6. Design tools available	NO Computer-Aided Design	Computer-Aided Design
7. Visual media used in design	sketches, photos, visual inspection	sketches, computer graphics, photos
8. Feedback mechanism	immediate, from production supervisor	delayed, or limited from plant engineers

effects of poor workspace design among plant-level designers.

Unfortunately, the plant designers also often had the least flexibility to retrofit existing inadequate designs, either in terms of parameters to vary or money available. Thus their activities were more often of a redesign nature, and concentrated on fine-tuning the details subject to known constraints. Similar differences occurred with designers at all levels in Continuous Process industries, where redesign was the rule, rather than the exception.

Design Group Structure

In workspace design, much of the design and analysis was conducted through group efforts, although the nature of the group varied with industry classification. Asking respondents to identify those who performed workspace design produced lists which included processing, layout, machine design or tooling, and industrial engineers. Each group had responsibility, or sometimes just provided input options, for a specific aspect of the resulting workspace. As a consequence of this approach, the workspace became a by-product resulting from design decisions regarding the production process, production rate, or the plant layout.

Among machine designers, the groups were product oriented, and relied on their own project leader for critical design decisions. With manufacturing or assembly engineers the groups were organized along functional lines (e.g., facilities layout, process engineering, materials handling). Thus, they depended on other sources both within and outside the organization for critical design information, such as product size and weight, available floor space, or part rack geometry. In addition, each had their own manager/ supervisor and formal chain of communication to follow. Lateral, or informal communication among functional groups or outside organizations varied with the companies. Interestingly, but perhaps not surprisingly, communi - cation in mature production industries was often limited to formal vertical lines, making collaboration among design groups and the associated exchange of information difficult (see Walker and Lorsch, 1978).

As noted by Shackel (1980), this functional organization made it especially difficult to design a workspace with ergonomic considerations in mind. Operator, workspace, and task data relevant to the final design were scattered throughout the organization. Product design defined the part size, weight, and shape. Division processing designed

fixtures or machines, which determined load height. Material handling designed part racks and dunnage, and determined product density. Layout allocated space for conveyors or transport lines. Outside vendors provided manufacturing equipment which affected part loading or task organization. Finally, the plant defined the line balance and specific workarea layout.

Workspace designs within these functional organizations tended to be more bottom-up, relying heavily on existing components (i.e., fixtures, processes), and generally ignoring or refusing feedback from users of operational components regarding the effectiveness of these components. Here, the shape of the whole workplace and task configuration, and its impact on the operator(s) could not be seen before construction was finished, usually much later, at the plant. Consequently, it was up to the plant engineers to fix bad designs, often at the plant's own expense, after all the components were in place and known.

Designer Responsibility

Of the 40 designers surveyed, none had the title of "*WORKSPACE DESIGNER*," yet all made significant contributions to the final design. Particularly at the division level in manufacturing/assembly operations, no one group in the organization had such responsibility. In some cases, plant-level Industrial Engineers were assigned such functions.

When asked to indicate the group(s) responsible for the final design and implementation, over 90% of the responses were nearly evenly split between plant groups, division groups and individual project supervisors. Response frequencies from plant and division designers are presented in Figure 2. Plant level designers mentioned authority for implementation resided with plant groups six times more frequently than with division groups. They also indicated that plant managers and line supervisors play a greater role in the final implementation than do groups at the division (by a 3 to 1 margin).

CONCLUSIONS

The high reliance on previous designs by all designers was a disadvantage to the product recipients when redesigns executed at the local level were neither documented nor filed with higher-level design records for subsequent design activities. Limited or non-existent interaction among division designers and plant engineers and operators during new design only perpetuated poor designs. The fragmented nature of manufacturing design also restricted design feedback, as the delay between division design and plant implementation was months or even years. These time and distance factors severely limited long-term improvements to workspace designs.

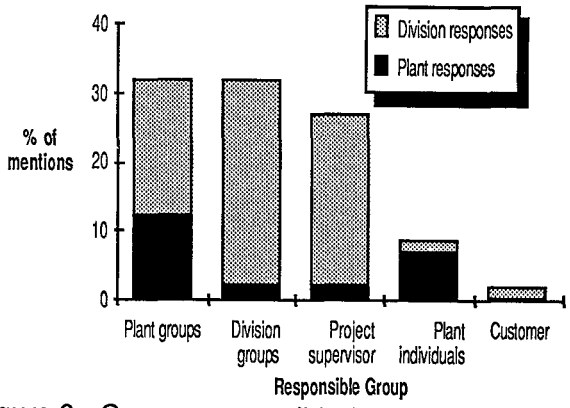


Figure 2. Groups responsible for final workspace implementation.

Although ergonomic awareness courses have been effective in sensitizing designers to potential problems (Smith and Smith, 1984), the hands-on experience gained through two to three day workshops may be more advantageous in reinforcing the cause-effect relationships of poor ergonomic designs.

A mini-design cycle consisting of (1) observation and information gathering, (2) design analysis, (3) alternative evaluation, and (4) possible implementation, would demonstrate and reinforce the principles gained in earlier awareness courses through a practical design environment. This training format may approximate the detailed design experience of plant level engineers and provide division designers with a glimpse of the final design outcome and any accompanying problems. If integrated with available contemporary ergonomic design aids, this format may also aid in replacing the *common sense* brand of ergonomics commonly practiced, with *enlightened observations* and quantitative analyses.

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