

Determining the Cost-Benefits of Ergonomic Interventions and Factors that Lead to Their Success

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Abstract

Managers usually can justify financially supporting a proposed ergonomics intervention only when it is supported by a sound cost benefit analysis. The factors to consider and sources of information for calculating the costs and benefits of proposed ergonomic projects are described. Based upon his review of numerous ergonomics projects, the common characteristics of successful ergonomics interventions gleaned by the author are described and then illustrated by actual documented cases.

Introduction

Regardless of other benefits that may be realized from ergonomic improvements, managers usually are not able to justify the intervention unless there is a clear *economic* benefit to be derived. Accordingly, in developing an ergonomic intervention proposal for management, it is extremely important to clearly identify the costs and economic benefits that can be expected, and outline how they will be measured. The good news is that properly planned and implemented ergonomics projects usually do result in significant economic benefits. Further, as will be described later and illustrated with actual cases, there are some common characteristics of successful ergonomics projects, which, if followed, greatly enhance the likelihood of a high cost-benefit result.

Determining The Costs

Although both can be complex, measuring the costs of ergonomics projects usually is easier than measuring the benefits. This is because the cost factors often are fewer in number, and the necessary accounting data often already are available within the organization. For most ergonomics projects, there are four major classes of costs to consider: (1) Personnel, (2) equipment and materials, (3) reduced productivity or sales, and (4) overhead.

1. **Personnel.** The cost of hiring an ergonomics consultant, or consulting group comes directly from the consultant's schedule of rates and projected time commitment for the project, or contract proposal. If the project is to be carried out by one or more internal professionals, then their salary, benefits and overhead simply are pro-rated, based on their time commitment to the project. This also is true for any additional company personnel who are to work on the project.

If the project will require modifications which will result in employees not being able to perform their normal work for a period of time, then their "down time" also needs to be factored into the cost. Often, during this down time, the employees are put to work on other tasks or the time is used for required training. In these cases, the "down time" should not be charged against the project.

Not infrequently, the down time would have resulted anyway, simply because the ergonomics intervention is being carried out as part of a changeover of equipment or product line, remodeling, or moving to a new facility, and so the related costs would have been incurred anyway. In these cases, only those *additional* costs resulting from the ergonomics intervention, *per se*, should be considered.

2. **Equipment and Materials.** Since most equipment and materials are purchased directly, the actual purchase costs can be used directly. Note that equipment costs can be treated either as one-time (capital) costs or as continuing, which considers the life of the application. For example, a new tool might cost \$600 to purchase, but could be charged at \$ 100 per year for six years. If only several of these years of use related directly to the project,

then only the amount for those years should be charged to the project. Also, if purchased via a loan, then the interest charges also must be included. If parts or equipment are fabricated internally, then these costs can be determined using the company's cost accounting data. Similarly, if there are storage charges associated with the equipment or materials, either the storage rate for external storage or the company's internal expense rate for the storage space can be used. Here again, though, the costs of those equipment and materials and related installation or storage expenses that would have been incurred if there were no ergonomics intervention should *not* be included.

Sometimes, the equipment being replaced is either resold or used elsewhere in the company. If this equipment would not have been replaced except for the ergonomics intervention, then its resale price or book value should be *credited* to the intervention project. Although rare, ergonomic interventions can result in increased maintenance costs over and above those that otherwise would have been incurred. Where this happens, these additional costs also need to be charged against the project. In most cases, ergonomics interventions actually *reduce* maintenance costs, and thus show up as a *benefit*.

3. **Reduced Productivity or Sales.** Ergonomic interventions may temporarily disrupt ongoing operations, thereby resulting in a reduction in productivity or sales for a period of time. The cost of this lost revenue also needs to be considered.
4. **Overhead.** Overhead costs, such as facilities maintenance, utilities, and general administration, typically are calculated by the organization's accounting department, and then applied as a percentage of direct costs. Sometimes, an ergonomics intervention may reduce some of these actual costs. Under these circumstances, the accounting department should be requested to reassess the unit's overhead rate.

Determining The Benefits: Personnel – Related

Although it sometimes can take more effort than figuring the costs, determining many of the financial benefits of ergonomic interventions is easier than it might first appear. These fall into two general classes of economic benefits: Those associated with personnel, and those associated with materials and equipment. Personnel benefits include (1) Increased output per worker, (2) reduced accidents, injuries and illness, (3) reduced training time, (4) reduced skill requirements, (5) reduced maintenance time, and (6) reduced absenteeism.

1. **Increased output per worker.** A major benefit often can be improvements to the work system structure and processes that result in a greater output per worker. These can be calculated in terms of the labor cost of each additional item produced per worker. If the output is a service, the economic benefit of the increased service can be calculated in terms of the charge per hour for that additional service provided.
2. **Reduced accidents, injuries, and illness.** This is one of the most frequently encountered benefits of ergonomic interventions in production and maintenance organizations. A common measure is the reduction in lost time from accidents, injuries and illness, which can be multiplied by the labor cost per unit of time to determine the economic benefit. Alternately, in the US and some other countries, the economic benefit may be the savings in workers' compensation insurance premiums that result.
3. **Reduced training time.** Reductions in training requirements may come about because work system changes result in easier to perform functions and processes that require less time to learn. Alternately, training requirements may be reduced because of (a) less turnover, (b) reductions in lost time from accidents and injuries, (c) less absenteeism, or (d) because fewer people are required to perform a given function. Savings in training time can be converted to savings in training costs to derive the direct economic benefit.
4. **Reduced skill requirements.** Improved job designs and related work system processes also may result in reducing the skill requirements required to perform some jobs. In addition to any savings that may result from reduced training requirements, persons possessing lower skill le-

vels may be hired to perform the job, thus lowering the salary levels. The resultant salary savings constitute a direct economic benefit.

5. **Reduced maintenance time.** Often, ergonomic improvements to jobs, worksites, equipment, or work systems also result in reducing the system's maintenance requirements, thus requiring fewer maintenance personnel (or enabling them to do other things). These savings in maintenance personnel can be converted into savings in salary and benefits to derive the economic benefit.
6. **Reduced absenteeism.** Reductions in lost time from persons failing to show up to work for reasons other than accidents, injuries, or illness, already noted, also is a common outcome of effective ergonomic interventions – particularly those at the macroergonomic level. Any savings in salaries and benefits for replacement personnel is a direct economic benefit. Reduced absenteeism also can result in (a) *productivity increases*, because there is less disruption of the work system and less work being done by replacement personnel (who often are less experienced and skilled in the specific job), and (b) *reduced training* because fewer replacement personnel have to be trained.

Determining The Benefits: Materials And Equipment

In addition to economic benefits related to increased employee productivity and reduced personnel expenses, ergonomics improvements also frequently result in materials and equipment savings. These include savings from reduced (1) scrap, (2) equipment, (3) production parts and materials, and (4) maintenance tools and materials.

1. **Reduced scrap.** Improved job and worksite design, and/or work system structures and processes, can reduce production errors and the resultant production of defective items or wastage of materials. These savings can be calculated directly from the company's cost accounting data. This benefit may be shown on a per annum basis for a specified number of years.
2. **Equipment savings.** Ergonomic improvements also can result in (a) reducing the number of pieces of equipment required, (b) performing a given function with less expensive equipment, or (c) equipment lasting longer because of better employee care and usage of the equipment. These cost savings can be calculated directly from the vendors' prices. In addition, there may be savings in reduced equipment installation and testing costs.
3. **Reduced production parts and materials.** Ergonomic interventions sometimes enable products to be produced with fewer parts or less expensive materials. These savings readily can be calculated based on the purchase price of the parts and materials; or, if produced internally, the production cost.
4. **Reduced maintenance tools and materials.** Reductions in maintenance requirements not only can reduce personnel requirements, but also may reduce the number of tools and amounts of materials required for maintenance. The resulting economic benefit can be calculated in the same manner as used for production parts and materials, noted above.

Factors Leading To Cost Benefit Ergonomic Interventions

Based on an analysis of numerous ergonomics interventions, I have noted the following common characteristics of successful ergonomics projects.

Participatory Ergonomics.

The most successful interventions have utilized the knowledge and expertise of the workers in a participatory ergonomics process where a professional ergonomist serves as the facilitator and resource person. Two excellent examples are provided by my former University of Southern California Colleague, Andy Imada.

Food service stand redesign. Through use of a participatory ergonomics approach with food service personnel, two food service stands at Dodger Stadium in Los Angeles were modified. Prior to implementation, using two ergonomists as the facilitators and resource experts, an analysis of the work system and related micro-ergonomic analyses of specific workstation layouts and human-machine interfaces were conducted. The results of these analyses then were used by the ergonomists and workers to develop the ergonomic changes. The total cost for the modification project was \$40,000. Average customer transaction time was reduced 8 seconds, representing a productivity increase in sales of approximately \$1,200 per baseball game. Modifying the other 50 stands in Dodger Stadium is planned at a price of \$12,000 per stand. (Imada & Stawowy, 1996).

Petroleum distribution company. A macroergonomics analysis and intervention program in a large petroleum distribution company was carried out by Andy Imada. The key components of this intervention included an organizational assessment that generated a strategic plan for improving safety, equipment changes to improve working conditions and enhance safety, and three macroergonomics classes of action items: improving employee involvement and communication and integrating safety into the broader organizational culture. Imada used a participatory ergonomics approach involving all levels of the division's management and workers. Work system structures and processes were examined from a macroergonomics perspective and, when the analyses indicated a need for change, modified. Employee-initiated ergonomics modifications were made to some of the equipment. New employee-designed safety training methods and structures were implemented. Employees were given a greater role in selecting new tools and equipment related to their jobs. Two years after installation of the program, industrial injuries were reduced by 54%, motor vehicle accidents by 51%, off-the-job injuries by 84%, and lost workdays by 94%. Four years later, some further reductions were realized (Nagamachi & Imada, 1992). Imada reports that as of 2001, these reductions have largely been sustained and that the company continues to save about \$60,000 per year in petroleum delivery. Perhaps the greatest reason for these sustained improvements has been the successful installation of safety as part of the organization's culture (Andrew Imada, personal communication, November 2000). This is a good illustration of how institutionalizing participatory ergonomics within a work system as part of a macroergonomics intervention program can lead to sustained improvements.

Macroergonomic Approach

The second example above not only used participation, but began with a macroergonomic analysis of the overall work system's structure and processes. When a purely micro-ergonomic approach is taken, significant improvements are possible. Often, however, far greater improvements in health, safety, and productivity are possible when a true macroergonomic approach is taken (see Hendrick & Kleiner, 2001 for information on macroergonomic analyses of work systems).

Designing a new university college. I had a unique opportunity to apply macroergonomics in the development of a new, semi-autonomous organization, a new university college (Hendrick, 1988). The opportunity occurred in the mid-1980s when a geographically dispersed master's program in systems management was transferred from the University of Southern California (USC) to the University of Denver and was used as the core program for developing a new College of Systems Science. I transferred with the program for three years to serve as the college's dean during its design and initial development phase.

The systems management program was being taught in university study centers (mini-campuses) at more than 30 locations in the United States and Germany. I conducted a macroergonomics analysis, as outlined in Chapter 4 of Hendrick & Kleiner (2001), with assistance from a special educational technology analysis group from IBM to determine the structure and processes that would be used for the entire work system. Compared with the program as it had existed at USC, this analysis enabled us to streamline the organizational structure to be more compatible with the college's sociotechnical characteristics (see the description in Hendrick, 1988), improve processes, better design jobs, and make more efficient use of available technology, including computers and software programs.

The college's work system realized a 23% reduction in staffing requirements and about a 25% savings in operating expenses compared with the work system as it had existed at USC. The

time required for processing student registrations, grades, and other related administrative activities for the off-campus locations was reduced from an average of three weeks to less than one week. The administrative time demands on the study center managers also decreased approximately 20%, giving them more time to devote to current and prospective students.

Integrate with TQM or Other On-Going Continuous Improvement Efforts.

Ergonomics often is most successful when it is carried out as an integral part of the organization's Total Quality Management (TQM) or similar on-going program to improve the organization's effectiveness. A good example of this was the use of macroergonomics as a TQM implementation strategy by the L. L. Bean Company in the U.S. – a company that makes and sells quality sports clothing and other items by mail order.

Using macroergonomics as a TQM strategy. Rooney, Morency, and Herrick (1993) reported on the use of macroergonomics as an approach and methodology for introducing total quality management (TQM) at the L. L. Bean Corporation. Using methods similar to those described above for Imada's petroleum distribution company intervention, but with TQM as the primary objective, over a 70% reduction in lost time accidents and injuries was achieved in two years in both the company's production and distribution divisions. Other benefits, such as greater employee satisfaction and improvements in additional quality measures, also were achieved. Given the present emphasis in many organizations on implementing ISO 9000, the ISO TQM standard, these results take on even greater significance.

Look for Simple Solutions First.

Worksite analyses often identify problems of awkward postures, excessive lifting, twisting, etc. Many of these problems often can be solved by simple economic solutions, such as providing a simple footrest for short computer operators, raising the table height of assembly workers, properly arranging and adjusting a work station's components, providing a simple jig to hold a component in proper position for assembly, or substituting an ergonomically designed tool for a poor one for the job.

Poultry de-boning knife. A conventional type butcher's knife was being used for de-boning chickens and turkeys at a poultry packaging plant. The knife did a poor job of de-boning; and a high incident rate of carpal tunnel syndrome, tendinitis, and tenosynovitis, resulted in a \$100,000 per annum increase in worker compensation premiums. A new, ergonomically designed pistol-shaped knife was introduced by ergonomist Ian Chong, Principal of Ergonomics, Inc. of Seattle Washington. Less pain and happier cutting crews were reported almost immediately. Over a five year period, upper extremity work-related Musculoskeletal disorders were greatly reduced, line speeds increased by 2% to 6%, profits increased because of more efficient de-boning, and \$500,000 was saved in workers' compensation premiums (Ian Chong, personal communication). This is a good example of how a simple, inexpensive ergonomic solution sometimes can have a very high cost-benefit payoff

User-Centered, Rather Than Technology-Centered Design

Replacement for forklift truck lines. Alan Hedge and his colleagues at the Human Factors Laboratory at Cornell University participated with Pelican Design, a New York industrial design company, and the Raymond Corporation in the design and development of a new generation of forklift trucks to replace Raymond's two existing product lines. Human factors design principles were given prime consideration and an "inside-out" human-centered approach was taken, with the form of the truck being built around the operator's needs. The goal was to maximize operator comfort, minimize accident risks, and maximize productivity by optimizing task cycle times. At the time the development project was begun, Raymond's market share had eroded from its former position of dominance in the market of over 70% of sales to about 30%, and shrinking. Both the new narrow aisle and swing-reach truck lines were introduced in the U.S. in 1992 and the swing-reach in Europe in 1993. Order books at Raymond are full and once again the company is enjoying

success. Raymond stock rose from around \$6 per share at the start of the project to around \$21 three years later. (Alan Hedge, personal communication)

TV and VCR remote controls. Thompson Consumer Electronics first developed their highly successful approach to user-centered design when they developed "System Link", an ergonomically oriented remote control that can operate various types of products made by different manufacturers. The original Thompson remote control design differed little from the competitors: A rectangular box with rows of small, identical buttons. Using their user-centered design approach, the initial design was replaced with a new ergonomic one. Among other things, the new one was easier to grasp, used color-coded, soft-touch rubber buttons in distinctive sizes and shapes, and the VCR and TV buttons were separated above and below the keypad. When introduced in 1988, this new, ergonomically designed, "System Link" remote control gained the jump on the competition and Thompson has since sold literally millions of them. As a result of this success, user-centered ergonomic design has become a key aspect of all new Thompson development projects, including their highly successful RCA DSS digital satellite TV system.

Other Examples of Documented Cost-Benefit Ergonomics Projects

The cases of successful ergonomics interventions described above, and numerous others that illustrate the above factors, may be found in my HFES publication, *Good Ergonomics is Good Economics* (Hendrick, 1996). A number of them also are described in Hendrick and Kleiner (2001).

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