Ergonomics in Manufacturing: Cost as an Issue

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Abstract

Ergonomics for Manufacturing Systems is a course that was developed to address the needs of a joint engineering and business curriculum at New Mexico State University. Both manufacturing design and production are studied in light of human performance and human variability. This leads to a unique focus on productivity, quality, and cost issues when addressing fitting the task to the human.

Students are drawn from master's level programs in engineering and business, providing a rich mixture of backgrounds for analysis and discussion. Problems studied include human-computer interfaces in planning, scheduling, and accounting systems, workplace designs for various types of teams, human error, and other ergonomics topics appropriate to the manufacturing environment. The legal and regulatory environment of the manufacturing workplace are introduced to the design process. A design project including workplace evaluation, analysis, and improvement proposals, is conducted with the assistance of NMSU's Advanced Manufacturing Center.

The term "ergonomic design" is often abused in the marketing of manufacturing equipment and systems. In this course, future manufacturing decisionmakers gain insights and experience that will be used in industry. This paper discusses experience to date, lessons learned, and future plans.

I. Introduction

Do manufacturing business decision makers fully understand the financial and other effects resulting from workplace and job design? Another way to ask this question is: How does one assess the costs of ergonomic improvements against benefits to be derived from the improvements? It is easy to demonstrate improvements in safety that result from workplace redesign but can students demonstrate, to themselves and others, the financial role of such improvements in the manufacturing business? In a sense, risks of injuries, lost productivity, and business malfunctions can be balanced with costs of potential improvements. Considerations of benefits of ergonomic improvements are often lost in fears of potential costs under federal and state statutes.

New Mexico State University offers a joint minor in Manufacturing Engineering and Management to students in engineering and business administration programs. This program was designed to help develop the manufacturing business leaders of the future. As part of this program, a course entitled Ergonomics in Manufacturing Systems was developed by the

Department of Industrial Engineering. Offered as an elective to all students in the joint program, this course gives students an opportunity to study issues of workplace and job design for manufacturing and other production organizations. As students study these issues, they develop a background in cognitive and physical ergonomics that will serve them when they interact with specialists in these areas. An appreciation of the potential benefits, costs, and risks in workplace and job design is the purpose of this course. It is designed for those who will make financial decisions on the recommendations in these areas.

Ergonomics for Manufacturing Systems has been offered once as a joint course. From student surveys and informal conversations, data have been acquired regarding quality of the joint course. The current set of students will soon enter industry, providing additional feedback with which to improve this course.

This paper discusses the design and development of Ergonomics for Manufacturing Systems. First, the course context is developed by discussing the creation of the Manufacturing Engineering and Management minor. Next, the design of the course and its associated project is presented. Lessons learned from the first joint offering of the course are then discussed. Finally, conclusions and future plans are offered.

II. Background

To address the issues of understanding and communication in the manufacturing business setting, NMSU created a joint engineering and business master's level minor (Pines, Powers, Mulholland, and Lambert 1996). This program was developed under a Technology Reinvestment Project grant and was a cooperative effort involving industrial and mechanical engineering faculty members from the College of Engineering and accounting, management, and marketing faculty members from the College of Business Administration and Economics.

The master's level minor consists of nine to 15 credits within a Master of Science in mechanical or industrial engineering or Master of Business Administration (offered as a concentration rather than a minor) program. One survey course is offered by each college for students of the other college. The survey course in business covers the various areas of business that engineers may encounter in the workplace. Business students learn the manufacturing and engineering life cycle from concept through customer delivery. After completing the survey course, students take a project course in which they work in joint college teams on an actual business problem. Students effectively take a product from design through delivery to the customer. The remaining credits in the minor are taken as electives; one elective must be taken in the partner college. Ergonomics for Manufacturing Systems is in this category so MBA students may use it as their engineering elective. Engineering students may take it as an elective within the minor or as a general elective.

III. Course Development

To start, the intent of the curriculum designers was surveyed (Lambert, 1995). Interestingly, an

important purpose for including this course was a concern for human information processing and human error including its results in manufacturing systems. An example of this concern would be coding bills of material for manufacturing resource planning. The problems that result from such errors are notorious in manufacturing and associated costing systems. Sanderson (1989) first described these types of issues in the human factors and ergonomics literature.

Added to the focus on cognitive ergonomics for decision making and information processing was the variety of issues resulting from physical workplace design. Frequently, students are not exposed to this area in curricula other than in industrial engineering.

The next step was to survey NMSU's industrial partners. As part of its manufacturing engineering education program, NMSU has developed partnerships with a variety of industrial firms and two national laboratories. A telephone survey was made of human factors specialists at the industrial partners. Respondents indicated a need for actual facility use. It was suggested that as much actual equipment and workplace experience as possible be built into the class. Additionally, a telephone survey was made of colleagues working in the ergonomics area. This survey was undertaken to further develop the academic content of the course.

A set of course objectives and topics were finally developed and discussed with the curriculum coordinator. This agreed-on set of topics became the basis for the course syllabus. Incorporation of an analysis and redesign project in an actual workplace setting was agreed on.

IV. Objectives and Topics

The course's focus was agreed to be based on the requirements of manufacturing planning, scheduling, and management tasks. This emphasis on cognitive ergonomics, i.e., human information processing, situation awareness, computer interfaces, was to be supported by discussion of traditional workplace analysis. Workplace analysis, of course, requires a study of physical ergonomics including anthropometry, biomechanics, and physiology, etc. Thus, the course was to become a survey of the various areas of cognitive and physical ergonomics using manufacturing situations as examples. Additionally, discussion of the various legal and regulatory issues, e.g., Occupational Safety and Health Act, Americans with Disabilities Act, Fair Labor Standards Act, etc., was added to the topics list.

One important objective of the course developer was to ensure the course was relevant to typical worker concerns as much as possible. In addition to academic literature, use of the popular press was to be made. Manufacturing managers and workers may not read academic ergonomics journals but they do read newspaper and magazine articles, and World Wide Web pages. These information sources may be used to make decisions regardless of the current state of research. Many of our graduate students have full-time or part-time jobs in manufacturing or computer systems firms. Their workplaces can then become a source of experiential learning through their analysis and classroom discussion.

Concern for popular press interpretations led to discussion of workplace ethics. Ethics becomes a critical topic when people are going to discuss injuries and errors, and costs to avoid them.

Engineers and managers should be aware of the total costs of decisions they make.

Last, an important purpose was the introduction of a vocabulary and a way of looking at the workplace. This was an additional concern in developing class lectures and the class project. As one purpose of the course was to provide a background to students who would work with industrial engineers and ergonomists in the future, development of students' understanding of how job and workplace designs come about was necessary.

V. Implementation

Ergonomics for Manufacturing Systems was first offered to a joint business/engineering audience in the Fall Semester 1996. The format was lecture, class discussion, and a team project. Open class discussion was designed into every class. Students were encouraged to bring examples of interesting design or implementation scenarios to class. This often resulted in exciting debates based on notions of job design, workplace design, and work itself.

The team project was based on analysis and design of a workplace in NMSU's Advanced Manufacturing Center (AMC). Project teams were created by the instructor with one business student per group. Student teams chose from five work areas offered by the AMC. They included such areas as: inspection area, manual electronic assembly, CAD/CAM room, and mechanical manufacturing areas. Each offered a unique set of challenges for the student analysts/designers. Their objectives were to survey the area and develop a set of recommendations and a cost analysis for the facility director. Each student team was expected to study the selected area, identify opportunities for job or workplace redesign, design appropriate solutions, and assess impacts of their proposed solutions. Additionally, the project reinforced the message of the manufacturing minor to the students: teamwork, concurrent project analysis, etc. A mid-semester project presentation was required. This presentation was made to the class with comment and challenge encouraged. One interesting result was that the students often encouraged their colleagues to be more aggressive in their analysis and design solutions.

This offering of the course attracted six engineering and three business students. Several important lessons have been learned.

VI. Lessons Learned

A joint curriculum course has several important advantages. Students focus on their common language of cost and risk. Ethical concerns become an important issue that results in many classroom discussions. A model of risk assessment, such as expected cost of injuries per year, can become a topic of serious and exciting debate. Additionally, such notions as engineering versus administrative controls of workplace hazards take on a new meaning. Effectively, when students who will become manufacturing managers look at specific details of the job or workplace, they look with an eye toward issues of which they were previously unaware.

Business students address a variety of important ergonomics issues with sensitivity and insight, often perceiving organizational and motivational issues before the engineers. Graduates from

this minor are likely to be involved with large manufacturing or purchasing systems with significant data entry and data analysis requirements. These areas, as noted above, are fertile grounds for ergonomics projects.

The use of the popular press was important to students. This semester, for example, articles from the *Wall Street Journal* and other news sources on such topics as automotive cockpit design, back belts, musical ergonomics, pilot error and keyboard design were discussed. Again, this focuses students on an important reality of the workplace: data comes from all types of sources. They may be faced with concerns generated from similar sources of information while working with manufacturing managers and workers. Additionally, students are exposed to how research is presented by nonacademic sources and potential results of this presentation.

Legal and regulatory issues such as the Occupational Safety and Health Act need to be introduced at the beginning of the class. Originally, the intent was to build a case for the laws and then discuss them. It is clear that early discussion motivates an interest in how the laws function and affect workers and workplaces. The research basis for regulatory issues also attracts student interest.

Last, ergonomic design is an area that has been much abused (or misused) in advertisements, catalogs, and the like. Discussion of such claims is regularly encouraged. For example, a chair was discussed with one of the students by a university physical plant employee. This ergonomically correct (due to adjustability) chair sold for $400. The student was offered a sample to bring to class. In class, students tried the various features of the chair. No comments on the chair, its purposes, or advertising claims were offered by the instructor. The results were (i) A debate over the features of the chair and how they addressed ergonomic design of a chair, (ii) A discussion over how to train individuals to use the features of the chair, and (iii) a discussion of cost versus the perceived gains from adopting the chair. Encouraging such discussions is of significant value to students in terms of reinforcing lecture topics. Student learning over the semester was evident from the sophistication of the analysis. More of this type of activity will be incorporated in the next course offering.

VII. Conclusions

One of the most intriguing comments made by a student was: “Now I understand my own workplace.” Ergonomics for Manufacturing Systems provides a nontraditional audience an understanding of ergonomics, workplaces, and job design. Feedback to date indicates that business students have benefitted from developing a new perspective on job and workplace design and engineering students have benefitted from the detailed focus on the human and fitting the job to the human. Students from the respective colleges have found a common language of risk, cost, and productivity. They have an excellent start toward being able to assess the need for ergonomic design and the resulting benefits. It has been exciting to watch the joint project teams attack their ergonomic projects. Most important, however, the students were astonished by the breadth and depth of the possible workplace and task redesign opportunities.

VIII. References

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Biographical Information

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