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ADVANCED MANUFACTURING TECHNOLOGY

"The future aspects in manufacturing industries"

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Abstract— Within the last decade, the importance of flexibility and efficiency has increased in the manufacturing sector. The rising level of uncertainty in consumer preferences has caused many organizations to aggressively search for cost reductions and other sources of competitive advantage. The small and medium scale industries (SMIs) are the backbone of the industrialization process in developing and developed countries. They play a crucial role in increasing the country's economy. With globalization and free trade agreements, the SMIs are under increasing pressure to adopt advanced manufacturing technologies (AMTs) to be competitive or simply to survive. Even though studies have shown that AMT can be implemented in smaller firms and are more successful than bigger firms, the implementation of AMT requires the SMIs to adopt new ways of thinking and doing work. The successful implementation of AMT will require the companies to have a workforce with higher level of skills, a flexible organizational structure and inculcate a new culture in managing, training and planning of the manufacturing industries. A study was conducted using survey questionnaire to investigate the ability of the SMIs of Malaysia to implement AMT successfully. The results of the survey showed that the main factors preventing the SMIs from obtaining the strategic benefits of AMT are the lack of an organic structure and understanding of the technologies, planning, the level of skilled workers and engineers and the culture of the industries. To increase competitiveness and flexibility of the organizations, a flexible structure is required. There is a need for the SMIs to increase the number of engineers and training provided in the companies to enable a positive contribution to AMT implementation. The ability of the workers to run multiple machines, stopping production when problem occurs, communication of organizational goals, and participation in idea generation and decision- making are important in achieving the flexible benefits of AMT. The SMIs have to increase the educational and training needs of the workers and also have a higher understanding of the technology to realize its potential. Consistently high levels of quality, accuracy, and repeatability will be demanded, as well as permitted by the technology.

Index Terms- advanced manufacturing technology (AMT) , Computer Integrated Manufacturing (CIM), AMT Implementation, SMIs, Developing Country, Organizational Structure.

I. INTRODUCTION

Historically, the process of manufacturing goods has evolved from craftsmanship to a highly organized factory system. The factory system itself has changed dynamically from mechanized powered systems to the present day trend towards application of advanced manufacturing technology (computerized design, planning, and manufacturing tools such as CAD, CAM, MRP, etc.). Paralleling this evolution have been dramatic changes in the skills required of the human component of the system. Such improved skills are needed in both cognitive and psychomotor areas. Although recent developments in technology have made very significant contributions towards improving productivity in the manufacturing sector, there has been an increase in the skill demands placed on the human as an integral component of the continually evolving work system. For example, the introduction of automation has increased the cognitive skill demands, and in many cases, it has not addressed its primary objective of decreasing the level of physical demands placed upon workers. Nevins and Whitney (1989) state that the drive to automate has led to automating simpler activities, leaving difficult tasks for humans to perform. Further, the changes in the organizational structure, workplace philosophy, and the market demands for product mix, volume, economy, and quick response times have placed additional burdens on the skill demands of the entire workforce, ranging from the hourly worker to the professional manager. As a result, a member of the workforce in a modern manufacturing setting frequently has to work as member of a team and is required to make decisions while being confronted with a continual row of vast amounts of information. The worker must be able to make effective use of the tools of modern technology. Members of workteams have been relegated to the roles of system monitor and controller as opposed to routine performers of a task. Organizationally, changes in the expected role of the human component in a manufacturing environment demand that workers possess a wide variety of skills at various levels. Currently, most manufacturing organizations train their employees in various ways, using different means, and achieving different levels of proficiency. Rarely does one end standardized and consistent training programs to develop worker skills; optimal training programs are not generally known. This leads to workers acquiring industry or company-specific skills, often leaving them with only a few transferrable skills. It is well recognized that the failure of many companies to transition to modern competitive manufacturing organizations is primarily due to their mismanagement of human resources (Ettlie, 1988; Majchrzak, 1988). Specifically, many organizations have failed to upgrade worker skills to levels compatible with advanced manufacturing technologies (Butera and Thurman, 1984; Gerwin and Tarondeau, 1982; Shaiken, 1984; King and Majchrzak, 1996). It has been shown that variables such as comprehensive training are essential to human resource management practices, particularly in advanced manufacturing environments (Walton and Susman, 1987; Commission on the Skills of the American Workforce, 1990; Hitt et al., 1991; Perry, 1991; Snell and Dean, 1992). A number of investigators have shown that worker skill levels are a direct determinant of levels of quality performance (Flynn et al., 1995; Hackman and Wageman, 1995). It is also reasonable to suggest that investments in human resources should keep pace with the changing technology particularly if the workers are to take responsibility for quality, productivity, and customers (Majchrzak and Wang, 1996).

II. Overview

Manufacturing systems are considered essential by most nations for the creation and propagation of wealth, and for improving the standard of living of its people. Estimates show that developed countries, such as USA, Japan, Germany, and other nations in the Pan-Pacific region, such as Taiwan, South Korea, Singapore, and Hong Kong, have a manufacturing base comprising at least 20% of their gross domestic product which provides for at least 30% of their traded goods. Given the extent of manufacturing activities carried out in many different countries in the World, the design and operation of manufacturing systems assumes tremendous importance from the perspective of making nations competitive. The ability to compete is vital for contemporary manufacturing due to the globalization, or internationalization, of all aspects of product manufacture (quality, product variations, labor, technology, markets, etc.). In the United States, the issue of designing and operating manufacturing systems that can retain the global economic advantage is a major concern to industry leaders, academic researchers, Congressional policymakers, and socials in the Federal Government. The Report of the President's Commission on Industrial Competitiveness (1985), and research reports generated by the National Academy of Engineering (1988), the National Research Council (1990), and the National Science Foundation sponsored workshops conducted at the University of Cincinnati (Mital et al., 1994b; Mital, 1995, 1996) demonstrate the seriousness of this concern. Some of these reports also contrast the relative importance of advanced technology with human resource-based technology and highlight the fact that, among countries with a large manufacturing base, the United States no longer dominates in the creation of new and advanced technologies. According to Farnum (1987), the worldwide share of American advanced machine tool production in 1987 dropped to 7.8% as compared to Japan's share of 20.5% and Germany's share of 19.9%. Also, in advanced machine tool exports, the US share was low (4.4%) compared to Japan (20.8%) and Germany (22.6%). Further, many countries now have the scientific and technological infrastructure to create new technologies. What then must make a positive difference to the United States industrial competitiveness, these reports conclude, is the development of a skilled human resource base Benexts of training Overall, training leads to acquiring new skills and/or improvements in existing skills (Carnevale and Goldstein, 1990). These, in turn, lead to two distinct economic benefits: (1) improvements in individual choices and earnings, and (2) cost savings for the organization. According to Carnevale and Goldstein (1990), on the average, about half of one's lifetime earnings are driven by learning in school and on the job. People with low skills, or skills not needed by employers, have limited choices and low earnings (Lillard and Tan, 1986). Increasingly, we are encountering situations where people with low or unneeded skills are unable to and employment that will maintain their standard of living, or are being forced to accept jobs that result in a substantial lowering of their earnings. Since the skills learned on the job complement educational experiences and lead to individuals' having more choices, on-task training is critical. Economic benefits of training for organizations include significant improvements in productivity (through improvements in quality, reduction in scrap and waste, reduction in throughput time, greater flexibility to respond to needs, etc.), and a competitive advantage of employers and the nation as a whole (e.g. Denison, 1984; Mincer, 1988; Carnevale and Goldstein, 1990). The United States Department of Labor (1993b) has reported that formal worker training introduced in 180 manufacturing firms in the United States increased overall productivity by 17% in 3 years when compared to industries that did not introduce any training program. The Department of Labor also reported that another survey of 157 small manufacturers observed a drop of 7% in scrap and an increase of 20% in the productivity of production workers. The economic bene"ts of training, thus, point out the necessity of introducing formal training programs in manufacturing industry. Moreover, the greater the complexity of technology, the greater will be the training and human resource management needs.

III. Difficulties with Existing Training Programs and Training Research

A review of training literature reveals that the wealth of learning and training studies are concerned to collecting data in laboratory settings, needs assessment, individual and cultural differences or deal with mathematical or behavior modeling of training (e.g. Bilodeau, 1966; Special Issue of Human Factors, vol. 27(3), 1985; Adams, 1987; Mayer and Russell, 1987; Campbell, 1988; Black et al., 1990; Park, 1991; Glencross, 1992; Felan et al., 1993; Stewart et al., 1994; Gilbert and Rogers, 1996; Volpe et al., 1996; Prislin et al., 1996). Analytically based training techniques have generally been concerned to the military (e.g. Johnson, 1981; Travillian et al., 1993; Goettl et al., 1996). Reviewers, in general, have concluded that training theory and practice do not complement each other, and that research findings are not interpreted into effective training methods (Cannon-Bowers et al., 1991). Wexley (1984) stated that certain critical areas of training need systematic study which includes factors such as the organization, task and program design, individual differences for training strategies, and workplace factors affecting the transfer of training. In fact, very few research studies using systematic procedures for developing employee training protocols have been conducted and validated within an industrial setting. Also, statistically designed experiments to test various training methods have not been formulated and evaluated within the workplace. Thus, there is a need to develop training protocols using a systematic procedure and conduct empirical assessments using these developed training protocols within an industrial setting to determine the effectiveness, efficiency, and productivity of training. There is also the issue of the lifespan of learning for adults. In the era of rapidly changing technology, ability to learn new things is more critical than experience or years on the job. The ability to learn is particularly critical for adult employees as employers tend to believe that workers who have been on a job for sometime have difficulty in adapting to new methods (Hall and Mirvis, 1994). The learning also needs to be holistic and systemic, and less linear (Senge, 1990; Bolman and Deal, 1991; Schein, 1992; Stacey, 1992; Fullan, 1993; Muncie and McQuillan, 1996). While significant work has been done on child learning (goal oriented), relatively little has been done in the area of goaloriented adult learning (Tannenbaum and Yukl, 1992; Froman, 1994). Adult learning has implications for the development of comprehensive performance- based goal-oriented training programs. Many adult workers and themselves in a transition period, particularly in mid-career, and question and reappraise their life and career structure. In such periods, individuals may experience conflict between the motivation to learn, on the one hand, and perceptions, fears, and habits that block change, on the other. Any effective training program will need to consider employee needs, their motivation, career plans, etc. Despite the economic advantages of training and the need to prepare the American workers for global competitiveness, training studies dealing with industrial applications, particularly those that are performed in field, are scarce. It is also worth noting that critical review articles dealing with the training issues are lacking (Howell, 1996). Workers in modern manufacturing environments not only need training in depth (level of proficiency in a skill) but breadth (different skills) as well (Jacobs, 1994). Moreover, these skills need to be updated and modified regularly as the technology changes. In contrast, the traditional model of industry training, if any, requires an apprenticeship, sometimes an extended one (e.g. 5 years) only at the beginning of a career. At present, relatively few American industry workers receive training. Those trained, in turn, train others. A survey of auto workers at a General Motors assembly plant revealed that less than 20% of production workers received technical training, although nearly 83% received some form of training. A survey of contract labor in the US petrochemical industry by the John Gray Institute (1991) revealed less than 33% of workers to have received company training upon entering the industry. Further, 20% of this same labor force reported receiving no on-going training throughout their employment. Also relevant is the question `How well current training programs work? This question has been partially answered at the Federal Government level. According to Senator Mike DeWine, the current Chairman of the Senate Labor and Human Resources Committee, there are over 160 different job training programs sponsored by the Federal Government. These programs are frequently not only duplicative, they are short on proven results. Such job training programs, considered essential to improving the American work force, need to be consolidated, to just 4 or 5 primary programs with training success being quantified and documented (Senator Mike DeWine in The Cincinnati Enquirer, 3 January 1997). It is also known that the amount of training is a function of professional position managers receive far more training than line workers (Carnevale, 1991), and professional associations union labor receive significantly greater training than non-union labor (John Gray Institute, 1991), and direct-hires receive double the level of on-going training as contract labor (John Gray Institute, 1991).

IV. Conclusion

The discussion in previous sections has revealed the scarcity of industrial training research, particularly, field studies. Given the complexities of modern manufacturing, the national need to be globally competitive, the need to retain and enhance the standard of living of Americans through gainful employment, and the increased burden placed on the skills required of the workforce at all levels line and maintenance workers, supervisors, professionals, and managers, it is absolutely essential that the United States initiate a comprehensive industrial training program. The dire necessity for such a program is further demonstrated by the fact that we have: workers who do not have skills industry needs (and such workers often remain without jobs for prolonged periods of time); a proliferation of training programs that do not meet worker, industry, and national needs; inadequate training given to line workers; few transferrable skills possessed by workers; etc. Realizing that the economic growth of our country is dependent upon developing our human resources

(e.g. Coleman, 1988; Boothroyd, 1990; St. Charles, 1990) and the productivity of Americans is directly proportional to America's economy, it is essential that we develop an industry-based generic 180 A. Mital et al. / International Journal of Industrial Ergonomics 24 (1999) 173,184 training process that, at the very least:

1. Can enhance the skills of workers at all levels,
2. Allow them to dynamically cope with changing Technology,
3. Give them options for personal and professional Growth,
4. Cut costs, increase productivity, and quality of Products manufactured, and
5. Make the U.S. human resource base second to none in the world.

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