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ABSTRACT

A study was conducted of the training programs used by plants with Computer Automated Design/Computer Automated Manufacturing (CAD/CAM) to help their employees adapt to automated manufacturing. The study sought to determine the relative priorities of manufacturing establishments for training certain workers in certain skills; the status of education and training among manufacturing plants with CAD/CAM; training most likely to occur with different types of CAD/CAM equipment; and factors explaining variations among plants with respect to education and training. Two data sources were used for the study: a national probability survey of 393 firms conducted in August 1982, and Census Bureau data on industry-level characteristics from 1960 to 1980. Study results included the following: (1) 45% of the plants with CAD/CAM sponsored an educational and training program; (2) on the average, 25% of the workforce at a plant received training, with the least attention given to design engineers and programs, and shopfloor staff displaced by the new equipment; (3) skills and knowledge areas covered by the training ranged from basic engineering to safety; however, many aspects of CAD/CAM were ignored; (4) most plants used vendors to provide training, and most offered either partial or full reimbursement for instruction outside the plant; (5) as CAD/CAM equipment was integrated, training needs dramatically increased; and (6) factors related to the provision of training programs included the integration and prevalence of automated equipment, and organizational factors such as size, workforce composition and firm age. Recommendations and a discussion of implications are included. (LAL)

EDUCATION & TRAINING FOR CAD/CAM:

Results of a National Probability Survey*

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EDUCATION & TRAINING

FOR CAD/CAM

ABSTRACT

Training programs that plants with CAD/CAM use to help their employees adapt to automated manufacturing are examined to assess the relative priorities of manufacturing establishments to train certain workers in certain skills. The types of training programs offered are described, the relationship of type of training to the type of CAD/CAM equipment in place are examined, and reasons why automated plants would choose not to adopt any or very limited training programs are explored. For managers implementing CAD/CAM, the data suggest that first, training programs must be tailored to the hardware and needs of individual plants, not all plants have seen the need for training (especially those which are smaller and have less equipment automated), as equipment is integrated training needs dramatically increase, and training programs should teach at a minimum machine operation, safety, and knowledge of technological advances in the plant to at least machine operators and shopfloor supervisors. Additional training needs will depend on the equipment introduced (e.g., robots necessitate training in human relations), the plant's size and workforce composition, and the extensiveness of the automation.

EDUCATION & TRAINING
FOR CAD/CAM[1]

Advocates of computerized manufacturing technologies tout the many benefits of these innovations. However, new technologies can only yield productivity gains if workers are prepared for the new requirements of the technologies. Congressman Douglas Walgren (D-Pa), Chairman of the House Science, Research, and Technology Subcommittee, stated that he believes that American industry is unable to take advantage of the robotics revolution because of a lack of trained people (Training, 1982, p. 31). Furthermore, a Bureau of Labor Statistics (BLS) survey of machine tool manufacturers cited the lack of adequate training and preparation of workers as the principal obstacles to maintaining and increasing production levels with technological change (BLS, 1982).

Predictive studies, case examples, and conjecture have universally suggested that adaptations in workers' skills due to CAD/CAM will be broad and far-ranging. Example predictions have included:

- Production staff will need to have increased conceptual skills, perceptual aptitudes, and the ability to read and write operating instructions (Riche, 1982).

- Professional/technical staff will need additional training in the production process, mathematics and the ability to visualize objects and motions in three dimensions (BLS, 1982).

- Supervisors will need to be trained in organizing and integrating shopfloor operations, leadership skills to motivate workers on potentially boring jobs, and human relations skills to help workers adapt to the new technology (Blumberg & Gerwin, 1982; Skinner, 1983).

- Strong basic skills in math, science, reading, and computer literacy will constitute the foundation for all new technology instruction (OTA, 1984).

While there is little doubt that CAD/CAM will create some retraining needs, systematic quantitative assessments of the extent to which the predicted changes in workers' skills actually occur are rare. The few quantitative assessments that exist have either examined only a few occupations or skills, or have made inferences of skills changes from occupational trend data (e.g., BLS, 1982; Rumberger, 1981).

The most direct approach to examining training needs with CAD/CAM is to conduct systematic task analyses of a large number of jobs in many organizations before and after CAD/CAM. Such an approach, however, is not generally feasible. Short of that, an alternative approach is to examine the training programs that firms with CAD/CAM have to help their employees adapt to automated manufacturing. Such an examination does not indicate if certain changes are occurring which firms are choosing to ignore. Nevertheless, such an examination does indicate the relative priorities of manufacturing establishments to train certain workers in certain skills. Therefore, it provides an initial opportunity to identify what firms are doing to adapt workers to CAD/CAM.

The research described here examined three questions:

1. What is the status of education and training (E&T) among manufacturing plants with CAD/CAM?

2. What training is most likely to occur with different types of CAD/CAM equipment?

3. What factors might explain why some plants adopt E&T and others do not, and why some plants have more E&T than others?

After a brief description of the study methodology, expectations from the literature and findings from the study are addressed separately for each question. The paper concludes with a discussion on the implications of these results for managers implementing CAD/CAM.

Study Methodology

CAD/CAM training was examined using a combination of two data sources. The first source was a national probability survey conducted in August, 1982. Three-hundred-and-ninety-three manufacturing establishments were selected in a multistage probability sampling approach stratified by major industry type, size, and regional location from a population of 24,142 establishments. A 76% response rate yielded a usable sample of 303 establishments. Three manufacturing industries — transportation equipment (SIC 37)[2], electric and electronic (SIC 36), and industrial and metalworking machinery (SIC 35) — were selected since the nature of their production processes (small batch) make them the most likely users of CAD/CAM technology (Gunn, 1982). Plant representatives (including plant managers, human resource directors, and chief executive officers) were interviewed by telephone concerning the use of various CAD/CAM technologies.[3] Those firms indicating that they had some CAD/CAM in place on the shopfloor were asked questions about characteristics of the plant and company-supported structured education and training programs focused on adapting to the CAD/CAM equipment. In total, 44% of the 303 plants interviewed had some CAD/CAM equipment in place and were therefore asked questions about their education and training for CAD/CAM.

Data from this survey were weighted up to their representation in the population. The 303 plants were weighted to 24,142 since the plants had been intentionally and proportionately sampled to represent the population, rather than randomly and independently selected. In such situations, when the purpose is to make judgments about the population, weighting the sample is preferable (Frankel, 1971; Kish, 1965).

The second data source, with which the survey data were combined, was Census Bureau data on industry-level characteristics for the period from 1960 to 1980 (obtained from the Annual Survey and Census of Manufacturers). Industry data included employment levels, wages, value-added, and capital expenditures. The data were obtained at the four-digit SIC level, adjusted for constant dollars, and merged with the survey data for analyses.

Research Question #1: What is the Status of Education & Training (E&T) Among Plants with CAD/CAM?

To assess the status of E&T, respondents from automated plants were asked if they sponsored structured E&T for computer-automated technology. If they did, a series of questions followed concerning which occupational groups received training, which skill and knowledge areas were taught, which sources were used to administer the training, in what format the training was provided, how many employees received the training, how many inhouse instructors were involved, and what provisions the plant had for additional individualized instruction outside the plant. Table 1 lists the items asked and responses.

Insert Table 1 about here

Of those plants with CAD/CAM, an E&T program for the use of the CAD/CAM was sponsored by 45%, or a weighted group of 4,604 plants. This percent is comparable to a 1982 Plant Engineering survey which found that slightly under 50% of the responding firms indicated having training for skills related to automated equipment (Training/HRD, 1982).

On the average, 25% of the workforce at a plant received CAD/CAM training. The occupations receiving the most instructional attention were shopfloor staff who operate CAD/CAM equipment and supervisors or managers of shopfloor personnel. Occupations receiving the least attention were workers who count, distribute, assemble, load, or handle materials. At least half of the plants provided training to all occupational groups, although on the average, each plant provided E&T to two occupations.

Skills and knowledge areas covered by the training ranged from basic engineering to safety. Those skills taught by most plants were safety, specific machine operation, and a general knowledge of technological advances in manufacturing. The least popular skills were basic physical science and the "3 R's" of reading, writing, and arithmetic. On the average, each plant provided training in three skills.

To provide this training, most plants with CAD/CAM used vendors and some inhouse instruction. The typical format for the instruction was a single course offered occasionally, although apprenticeships and a program of courses were also popular. Finally, to supplement sponsored structured programs, most of the plants offered either partial or full reimbursement for instruction outside the plant.

This description of CAD/CAM training in 1982 suggests that there is substantial variation in the scope and focus of the programs. With only one-half of the firms covering many of the occupations and skills queried, few firms agree on a common description of CAD/CAM training.

Despite this variation, a few general conclusions can be advanced. Compared to results of a 1975 Conference Board survey which found 13% of the production workforce receiving any training (Lusterman, 1977), the plants in this survey with CAD/CAM were training a larger proportion of their workforces. This suggests that automation-training may involve a larger proportion of a plant's workforce than more general types of training. Moreover, the automation-training seems to be relatively broadly focused by training, on the average, three skills to employees in two occupational groups. In addition, this focus seems to go beyond teaching machine operation and safety only to equipment operators. The fact that supervisors and managers were one of the more popular occupations trained followed closely by production engineers and programmers indicate that multiple and diverse occupations must be prepared for CAD/CAM. Furthermore, the high frequency with which a general knowledge of technological advances, maintenance, troubleshooting, and computer programming were taught clearly indicate that CAD/CAM is creating a need to train production employees in ways not heretofore emphasized. For example, in research by Argote, Goodman, & Schkade (1983), first-line supervisors were found to have a major influence on workers' acceptance of automation. Therefore, failing to educate supervisors on the broader picture of how technological changes fit into the corporate mission may have detrimental effects on adapting subordinates to the change.

While the training on the average appears fairly broad, it is interesting to note the heavy reliance of plants on vendors to provide instruction rather than on existing educational institutions or inhouse trainers. This reliance on vendors may reflect both the inadequacy and prohibitive cost of other instructional sources as well as the complexity of CAD/CAM technologies. However, in the words of Donald Gerwin (1982):

> "This complexity prompts some companies to rely too heavily on vendors to solve problems, even though vendors are not completely knowledgeable about what new technologies can and cannot do. Building up in-house experience is critical" (p. 115).

Finally, while several skills were taught to several occupations, many aspects of CAD/CAM were ignored by a large number of the training programs. Basic knowledge of science, engineering, and the 3 R's were left to be taught elsewhere (e.g., possibly through educational institutions). This neglect of basic skills is contrary to popular belief (e.g., Riche, 1982; OTA, 1984) of the need to retrain the future workforce in basic skills. The reason for a neglect of basic skills among our sample is not clear. It may be that the increased need for such basic skills has not materialized with CAD/CAM or that the plants are delaying basic skills instruction in hopes that educational institutions will step in. Furthermore, training in human relations has not received nearly the attention expected (e.g., Blumberg & Gerwin, 1982). As examined in the next research question, the unexpected low emphasis on human relations may be a function of the CAD/CAM equipment implemented.

In addition to a de-emphasis of certain skills, occupations receiving the least attention were design engineers and programmers as well as those shopfloor staff displaced by the new equipment. Professional staff responsible for design probably received little training due to a comparatively small diffusion of CAD. However, the relatively small emphasis on retraining of displaced workers to operate CAD/CAM equipment implies that the labor needs of CAD/CAM are sufficiently reduced that displaced workers have been laid-off or shifted to other parts of the plant not requiring new training rather than trained to operate the new equipment.

Research Question #2: What Training is Most Likely to Occur With Different Types of CAD/CAM Equipment?

Respondents in automated plants were asked to indicate the prevalence of computerized equipment on the shopfloor and the extent to which the equipment was integrated using computer-based links. Prevalence was coded as low (1-15% of equipment computerized) or moderate (16% or more). Integration was measured as either none, some, or most of the computer-automated equipment as being integrated. Prevalence and integration were combined into a single index constituting automation profiles of plants (e.g., plants with few but highly integrated equipment versus plants with a moderate amount of stand-alone equipment). E&T programs for plants in each profile were then examined to identify important features of the programs that varied with the different profiles. To aid with this examination, an index of the scope or extent of E&T was computed. The index was composed of the number of occupations and skills taught by the plant, level of supplementary benefits provided, percent of plant workforce trained, number of inhouse instructors, and provision of a program of courses as opposed to individual courses. The index was standardized on the plants with CAD/CAM E&T so that a score of 0 indicated an average amount of training and a positive (negative) score indicated above (below) the average. Features of the plants' E&T programs (and the index of E&T extent) are presented in Table 2 for each automation profile.

Insert Table 2 about here

A first finding apparent from Table 2 is that the different levels of prevalence and integration lead to different types of E&T programs. Those firms with stand-alone (non-integrated) machines concentrate on teaching primarily machine skills to shopfloor personnel only. Those firms that adopted a few somewhat integrated computerized machines emphasize a few skills to selected occupations. Those firms which have chosen to adopt either many somewhat integrated machines or a few but highly integrated equipment share a similar approach to E&T. Both types of firms primarily teach most skills to most occupations; however, the investment in E&T is clearly greater for the heavily integrated machines. Finally, those firms that have adopted a large number of highly integrated machines provide training primarily to the skilled laborforce only.

A second finding from the table is that certain skills tend to become relevant when certain levels of prevalence and integration are reached. Human relations skills tend to be considered only in firms that have computerized small portions of their production floors. Knowledge of the manufacturing process and advances in new technology are primarily relevant with integrated equipment. A knowledge of engineering is applicable mostly for highly integrated equipment.

Finally, the extent of the E&T effort depends on both prevalence and integration. Those firms with highly integrated equipment have the greatest investment in E&T. Furthermore, firms with more equipment computerized generally have a greater scope of E&T ($\bar{X}$ = .44) than firms with less equipment computerized ($\bar{X}$ = .10). However, it is interesting to note that the firms with the greatest investment in E&T are those which have greatly integrated only a small part of their computerized production equipment rather than all the equipment. E&T is probably greater under such circumstances because of the increased focus promoted by such "pilot" projects of automation.

In addition to examining E&T for each automation profile, the E&T programs of the automated plants were examined for plants with the most frequently mentioned combinations of CAD/CAM equipment. Five equipment combinations were identified as most frequent: 1) computerized and/or direct numerical control alone; 2) computer-automated storage equipment, either alone or with NC; 3) robots, either alone or with NC; 4) CAD, either alone or with NC; and 5) a three-equipment combination of NC, storage, and CAD. Apparent from these combinations is the overwhelming presence of NC as the core of CAD/CAM, despite the availability of more sophisticated technologies. For each of the five combinations, E&T programs were examined.

<u>NC alone</u>. Of those firms with NC alone, about 39% sponsored an E&T program which is only slightly above average in extent. The training was concerned with a range of occupations. The skills taught primarily focused on those related to machines such as machine operation, maintenance, and programing. There was less emphasis on the more integrative skills of human relations and knowledge of the manufacturing process. Given that firms with NC alone are neither very computerized nor integrated (Majchrzak, Nieva, & Newman,

1985), such a machine-related focus across occupations may be appropriate (Hazelhurst et al, 1969).

Storage and NC. Firms with automated storage equipment in addition to their NC had a very high proportion sponsoring E&T programs. Despite this high proportion, the firms generally sponsored a low level of E&T effort. The firms primarily sponsored a training program that taught specific machine skills only to those workers most directly involved in the new technology. Since computerized storage does not necessarily involve massive skill changes in knowledge and coordination, the training seems tailored to minimally meet their new needs.

Robots and NC. About half of the firms with robots sponsored E&T for new technology. The E&T programs tended to be cross-occupational, although counters and design professionals received little training. The E&T programs sponsored by these firms provided the highest amount of training in basic science and human relations. The importance of the latter skill is particularly interesting given the prediction by some that robots may create a more isolated rather than communicative laborforce. Clearly these data indicate that robots may have the opposite effect.

CAD and NC. Few firms with CAD offered E&T for new technology. Those firms that do offer training, however, had very extensive programs; the training covered all occupations and virtually all skills. This chasm between those without an E&T program and those with an extensive one suggests that CAD may be used in plants in two ways. On the one hand, CAD may simply serve as a substitute for the manual drafting board or as an individual tool in which little training is needed beyond CAD machine operation. On the other hand, CAD may be used as a system necessitating the restructuring of how parts are designed, how departments are coordinated and how decisions are made (e.g., Majchrzak & Collins, 1985; Shaiken, 1983; Taylor, Gustavson, & Carter, 1985). With such use a far more extensive training program is needed.

NC and Storage and CAD. The one three-equipment combination with the greatest frequency was the use of NC with storage and CAD. In contrast to the plants using just NC and CAD, almost all of the firms with the three types of technologies offered an E&T program. The extent of training conducted by the programs was also quite high, although the focus tended to be primarily on the skilled workforce - professionals, supervisors, and machinists. Given that these plants also had the greatest prevalence and integration of their automation, a concomitantly heavy emphasis on training is not surprising.

To summarize the results for the second research question, the specific type of CAD/CAM technology in a plant is apparently strongly related to the type and extent of E&T sponsored by that firm. Plants with stand-alone equipment (e.g., NC) primarily taught machine skills only, essentially ignoring the broader implications of CAD/CAM. The highest extent of E&T was found among plants with a few highly-integrated equipment, possibly because the high integration creates extensive training needs which are overlooked if the plant implements too much equipment too quickly. When integrated equipment was implemented, new training needs for knowledge of the entire manufacturing process and advances in technology were created. These skills are necessary since the integrated equipment forces coordination among departments and workflows heretofore managed separately. While broader knowledge of the manufacturing processes and equipment are needed with integration, the implementation of integrated equipment did not seem to be related to the need for human relations training. Despite the increasing interdependence that integration necessitates, plants did not couple that interdependence with human relations skills. However, more human relations skills were taught in those plants with less equipment computerized (perhaps because the CAD/CAM has increased visibility and therefore an increased need to succeed), and where robots and/or CAD were introduced. Clearly, the precise role or need for human relations skills is not yet well-understood under a CAD/CAM system.

Research Question #3: What Factors Might Explain Why Some Plants Adopt E&T And Others Not And Why Some Plants Have More E&T Than Others?

As described earlier, only 45% of the automated plants sponsored E&T programs for CAD/CAM. Furthermore, of those with an E&T program, there was substantial variation in the extent or scope of the programs. In this final analysis, an exploratory attempt to understand the factors which explain these variations was undertaken. This analysis was driven by literature and interviews that helped to identify factors that might potentially be related to E&T. The identified factors were:

- Integration of automated equipment. Mann (1962) points out that the implementation of stand-alone NC machines may not necessitate extensive training. However, with greater systems integration comes a greater need for workers to have sufficient knowledge and competence to handle interlocked systems of machines. Moreover, earlier analyses had indicated that E&T varied with different levels of integration.

- Prevalence of automated equipment. Many in the field (e.g., Chorafas, 1982; Skinner & Chakraborty, 1982; Crowley, 1981) argue that with increased computerization, there will be sufficient skills changes to necessitate training programs specifically focused on technological adaptation. Earlier analyses had indicated that prevalence might be statistically related to E&T.

- Organizational factors such as size, workforce composition and firm age. Lusterman (1977) and BLS (1976) found, for example, that large firms were more likely to have inhouse training programs than small firms. Size was measured as an index of company gross sales in 1981 and total number of plant employees. Workforce composition was measured as the percent of hourly workers in the plant relative to the total number of workers. Age was measured as the year the company was founded.

- Centrality of manufacturing operations in the entire plant. It was expected that plants for which manufacturing operations constituted the major activity would put a higher priority on training than a multi-function plant. Centrality was measured as the proportion of the plant workforce involved in manufacturing operations.

- Market supply factors, such as value-added, has been suggested as important in determining a plant's E&T since increased value could be translated into increased resources available for training expenditures (e.g., Weinberg, 1970; Training, 1982). Value-added industry data for 1980 and 1970-80 growth were merged to four-digit SICs for each plant.

- Market demand factors, such as high wages, has been suggested as increasing the need for developing inhouse training programs to retrain workers rather than hiring new workers (Lusterman, 1977; Belitsky, 1978). For example, in describing the GE training program, Zukowski (1984) indicated that the major reasons GE had the program was that it was cheaper by a 2.6 to 1 margin to retrain engineers and managers in the digital technology than to layoff and hire already-trained replacements. Wages in 1980 and wage growth from 1970 to 1980 were merged to four-digit SICs for each plant.

To determine which of these numerous variables were related to variations in E&T, several analyses were conducted. A series of hierarchical regressions of the decision to adopt an E&T program and the extent of the adopted E&T program were conducted on the set of factors described above. Since many of these factors were too highly related to offer unique contribution in any single equation (and therefore presented a multicollinearity problem), regressions on subsets of the factors were run. From the regression results, subsets of factors accounting for the most variance in adoption and extent of E&T were identified. To verify these results, a discriminant analysis predicting to the adoption of E&T was conducted. Results of the analyses are described separately for adoption and extent of E&T.

Decision to Adopt an E&T Program. Since earlier results had indicated important relationships of integration and prevalence of a plant's automation with a plant's decisions to adopt E&T, integration & prevalence were entered as the first step in all regression equations. These two variables together accounted for an adjusted 24% of the variance in E&T adoption decisions. The remaining factors (market supply and demand, and organizational characteristics) were entered second; they together accounted for an additional 6-10% of the variance in E&T adoption.

Two main findings resulted from this analysis.[4] First, the degree to which the automated equipment is integrated had little effect on a plant's decision to adopt an automation E&T program (standardized Beta weights ranged from .01 to .05). However, the amount of equipment automated on the shopfloor had a great effect (weights ranged from .41 to .47). In other words, plants with few computerized equipment were not more likely to adopt an E&T program if they purchased integrated or stand-alone equipment. One plausible reason for this finding may be that plant managers choose to respond to training needs based more on the numbers of people directly affected by the equipment than the way in which they are affected. That is, when equipment affects too few employees, the benefits of the training do not outweigh the costs.

A second finding was the relatively small contribution of factors other than prevalence to explaining decisions to adopt (no more than 10% of variance accounted for by all additional variables together). The most stable contributors included size (larger plants were more likely to have E&T) and centrality of manufacturing operations (plants where manufacturing was less central were more likely to have E&T), with Beta weights of .33 and -.16 respectively. These findings were confirmed with a discriminant analysis in which 73% to 79% of the cases were classified correctly.

The findings thus far suggest that plants adopted E&T programs not in response to external factors such as market demand or supply. Rather, plants adopted E&T programs when enough automated equipment had been implemented to affect a large proportion of the manufacturing workforce, when the plant was sufficiently large to have resources to bring to bear on training, and when the manufacturing functions represented a smaller and therefore more manageable part of the plant's entire operations. By implication, then, those plants not sponsoring any CAD/CAM E&T were the smaller ones, those for which manufacturing was a large proportion of their operations, and plants with few new CAD/CAM equipment in place. While basing the decision to sponsor a CAD/CAM training program in part on the amount of CAD/CAM in place has some credence, the fact that smaller, single-function manufacturing plants were not adopting E&T may be some cause for concern. For example, in a study on successful implementations of CAM, Ettlie (1985) found training of properly selected participants in the implementation process to be crucial for success. Smaller plants depend dramatically on the skills of their workforces and therefore cannot afford inadequate preparation and training. Single-function plants centered around manufacturing are even more dependent than multi-function plants on the adequate preparation of manufacturing personnel. Therefore, despite costs associated with training, the lack of any CAD/CAM training for such automated plants may be short-sighted.

Extent of E&T once program adopted. The standardized index of the extent of E&T programs offered was also analyzed to determine which variables explained variations among plants. As with the previous analysis, high intercorrelations among the factors made it necessary to regress E&T extent on subsets of relatively unrelated factors. As before, for each regression, prevalence and integration of automated equipment were entered into the equation first. These two variables accounted for 20% of the variance in extensiveness of the E&T program. Market and organizational factors were entered into the equation second accounting for 13-15% additional variance.

Comparing results of the regressions for E&T extent with those for the decision to adopt an E&T program yields several findings. First, integration of automated equipment was more important to determining the extensiveness of an E&T program (with standardized Beta weights ranging from .32 to .43) than in determining whether or not to adopt a program. As described earlier, integrated equipment typically demand increased attention to a broad range of skills. These skills canot be taught with a minimal, narrowly focused E&T program.

Second, market variables on both the supply and demand side help to explain extent of E&T much more so than explaining the decision to adopt. Growth in value-added (with weights of .10 to .21) seemed to provide the resources to retrain larger numbers of workers, while increased wages over time (with weights of .06 to .12) tended to provide the impetus to have broader programs. As labor becomes more expensive, the costs and risks associated with hiring new employees increase. Therefore, efforts to train multiple occupations in multiple skills among the existing proven workforce may be preferred.

Finally, organizational variables also help to explain extent of inhouse E&T programs. The larger the plant size (Beta = .33), the more employees there were to be trained and the more resources the plant had to conduct the training. The older the firm (Beta = -.15), the better prepared it was to focus some of its investments on training. Finally, since plants were defined as having a larger E&T program when they provided training to numerous occupations and skills, the more extensive E&T programs were more likely to be found among those firms that have sufficient numbers of both salaried and hourly workers to make such broad programs worthwhile (Beta = from -.13 to -.20). Therefore, plants with more salaried workers had reason to move beyond training shopfloor operators to training professionals.

Implications for Managers Implementing CAD/CAM

These results offer several recommendations for the manager implementing CAD/CAM. First and foremost, training programs need to be tailored to the particular needs of the plant. There is no one type of training program applied under all (or even most) circumstances. Therefore, in using vendors to provide the training, managers must expect to supplement or modify the programs offered.

Second, suggestions for minimal training programs are also offered by the data. At a minimum, both shopfloor supervisors as well as machine operators need to be trained. Research would suggest that, in addition to machine operation, these supervisors need to be taught human relations skills, information about manufacturing processes at the plant, and an understanding of where the technological advances fit in the corporate strategy. Moreover, skills to be taught in a CAD/CAM training program go beyond specific machine operation. Offering training in safety procedures as well as a general knowledge of technological advances in manufacturing provide the employee exposed to CAD/CAM a better understanding of proper expectations for the new equipment. Employees' expectations about safety hazards, changes to jobs & benefits, and how a plant's modernization effort compares to others can be adjusted to be more realistic for a plant's situation and therefore help to avoid later frustration and discontent. Moreover, providing education and training about technological advances can serve two additional purposes as well: it can force management to clarify their own expectations and understandings about CAD/CAM before conveying them to the employees, and it can reduce fear and suspicion aroused by ignorance and insecurity.

The data described here also suggest that the precise composition of the E&T program will be determined in large measure by decisions made about the equipment itself. The more equipment purchased, the more likely an extensive E&T program will be considered. Integrated equipment will also create a need for more extensive training. With CNC, machine-related training may be sufficient; however, with integrated equipment (e.g., automated materials handling), a broader range of skills and occupations will be touched. Knowledge of the manufacturing process and advances in technology become particularly important with integrated equipment. Finally, human relations training appears to be important in adapting to CAD/CAM. The research would clearly predict that with automation, the ability to effectively communicate and work with others becomes even more important at all levels. Furthermore, in the data presented here, plants with CAD and/or robots had substantially more training in human relations than that provided by plants with NC alone.

The final analysis of this study suggested that, holding the automation of the plant constant for the moment, not all plants will choose to adopt an E&T program. The choice to adopt, while based primarily on the amount of equipment purchased, will be based in part on the plant's size and centrality of manufacturing operations. While data were not available on the effectiveness of the E&T programs, managers of small firms as well as single-function manufacturing plants should be cautioned that they may be as much (if not more) in need of training than larger, multi-function plants. Simply because the inhouse resources are not as easily available should not be an excuse to ignore the training needs under CAD/CAM. Finally, in determining the extent of training needed, an examination of market variables such as high labor costs may help to determine the extensiveness of the program needed. When the replacement of workers may involve risks too costly to incur, the option of proactively training workers to adapt to the technological change may be the best strategy.

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Footnotes

[1] Computer-Automated Design/Computer-Automated Manufacturing.

[2] SIC stands for Standard Industrial Classification. Details of the sampling methodology are found in a report to the Office of Technology Assessment, entitled Education and Training in Computer-Automated Manufacturing, 1982 (by Nieva, V.F., Majchrzak, A., and Huneycutt, M.)

[3] Use of CAD/CAM was assessed by having respondents indicate the percent of manufacturing equipment on the production floor that was computerized and whether the plant had in use any of six computer-automated technologies (robots, CNC, DNC, CAD, computer-automated storage, and computer-automated materials handling).

[4] Detailed results of regression analyses are available upon request.

Table Captions

Table 1

Description of CAD/CAM E&T Programs[1]

	All Industries N = 4604
Format of E&T	
a. Apprenticeship	49%
b. Single courses	69%
c. Series of courses	59%
Sources for Delivering E&T	
a. Inhouse instructors	80%
b. Training industry and management consultants	47%
c. Traditional educational institutions	54%
d. Proprietary educational institutions (e.g., ITT, Control Data)	21%
e. Vendors or manufacturers of computer-automated equipment	87%
f. Unions	5%
g. Other gov't sponsored instructional programs (e.g., Private Sector Initiative Program)	13%
Number of E&T Instructors in Plant	
a. 0	10%
b. 1-5	71%
c. 6 or more	19%

[1] Percent of plants with automation-related E&T indicating that their E&T program included each of the following provisions.

Table 1 (continued)

	All Industries
Occupational Groups Receiving E&T	
a. Shopfloor staff who assemble, handle or load material	59%
b. Individuals who count materials (pre-production) or distribute products (post-production)	47%
c. Shopfloor staff who set up the equipment	61%
d. Shopfloor staff who operate equipment	86%
e. Repair and maintenance staff	61%
f. Production engineers and programmers	74%
g. Design engineers and programmers	44%
h. Supervisors or managers of shopfloor personnel	77%
Skill or Knowledge Areas Covered	
a. Basic physical science	34%
b. Basic reading, writing & arithmetic	44%
c. Specific machine operation	89%
d. Maintenance and troubleshooting	74%
e. Computer programming	74%
f. Problem-solving (e.g., making use of objective data for decisionmaking)	69%
g. Developing sufficient knowledge of the entire manufacturing process in order to work with others in different departments and at different levels	69%
h. Human relations (e.g., dealing with worker morale)	53%

Table 1 (continued)

	All Industries
Skill or Knowledge (continued)	
i. General knowledge of safety procedures............	95%
j. Knowledge of basic engineering concepts...........	52%
k. General knowledge of technological advances in manufacturing................................	82%
Percent of Plant Workforce Receiving E&T	
a. 0%...	11%
b. 1 - 24%...	56%
c. 25 - 49%..	18%
d. 50 - 74%..	9%
e. 75 - 99%..	2%
f. 100%..	6%
Company Provisions for External E&T	
a. Partial reimbursement of instructional costs......	54%
b. Full reimbursement of instructional costs.........	62%
c. Paid time off to take courses.....................	30%
d. There is no definite policy.......................	27%
Mean scope of E&T effort in plant (standardized for all industries).....................	0

Table 2

Description of E&T for Prevalence-Integration Combinations*

	No integr/ Low comp (N = 3,198)	No integr/ Mod. comp (N = 836)	Some integr/ Low comp (N = 3,729)	Some integr/ Mod. comp (N = 1,200)	High integr/ Low comp (N = 102)	High integr/ Mod. comp (N = 938)
E&T at all						
Number with E&T...........	1,226	557	1,349	893	59	447
Percent of firms with E&T................	38%	67%	36%	74%	58%	48%
Extent of E&T (mean)..........	-.13	-.01	-.11	+.54	+1.55	+.72
Occupations						
Assemblers, loaders, handlers..................	80	57	44	75	83	23
Counters, distributors......	60	64	53	27	81	14
Set-up......................	79	59	35	65	98	92
Operators...................	88	96	84	80	100	92
Repair, Maintenance.........	50	69	50	94	100	40
Production engineers and programmers...............	74	55	59	99	100	100
Design engineers and programmers...............	43	15	45	35	100	96
Supervisors.................	76	72	71	80	100	96
Skills						
Basic physical science......	22	10	38	64	66	23
3 R's.......................	64	56	68	67	50	31
Machine operations..........	95	100	67	100	100	92
Maintenance.................	53	69	71	93	100	100
Programming.................	71	70	65	81	100	98
Problem-solving.............	60	21	72	93	100	96

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*Percentages refer to proportion of firms in automation level indicating that they provided the specific E&T feature.

Table 2 (continued)

	No integr/ Low comp	No integr/ Mod. comp	Some integr/ Low comp	Some integr/ Mod. comp	High integr/ Low comp	High integr/ Mod. comp
Skills (continued)						
Manufacturing process.......	59%	22%	97%	98%	98%	30%
Human Relations.............	55	13	79	48	98	28
Safety......................	89	87	97	99	100	100
Basic engineering concepts..	39	50	64	25	81	100
High technology.............	60	73	96	90	83	94
Forms of E&T						
Apprenticeship..............	46	4	30	92	33	82
Single courses..............	86	15	76	82	81	40
Series of courses...........	42	57	55	75	69	96
Sources						
Inhouse instructors.........	85	70	72	79	100	91
Training consultants........	54	15	53	57	81	23
Traditional education.......	36	44	67	48	100	90
Proprietary education.......	25	20	22	5	64	35
Vendors.....................	87	72	87	95	33	100
Unions......................	8	19	0	0	0	1
Government..................	13	0	23	1	0	27
# Instructors						
0...........................	4	3	26	2	0	4
1-5.........................	85	86	43	89	63	69
6 or more...................	11	10	31	9	37	27
% workforce get E&T						
0%..........................	5	0	30	0	0	0
1 - 24%.....................	87	55	49	47	3	19
25 - 49%....................	0	0	20	51	31	16
50 - 74%....................	7	0	0	0	17	64
75 - 99%....................	2	0	0	2	48	0
100%........................	0	45	0	0	0	1