ETM

ENGINEERING & TECHNOLOGY MANAGEMENT

Title: CAD Training: Look Before You Leap

Course:

Year: 1988

Author(s): M. Chamberlain, R. Jellesed, J. Mohr and K. Walker

Report No: P88012

Abstract: Too often during the purchase and introduction of CAD tools, the training aspects are not given full consideration. A false sense of security may be generated by the CAD vendor in an attempt to secure the sale. This report provides guidance for planning the training needs for the introduction of CAD into the environment.

CAD TRAINING: LOOK BEFORE YOU LEAP

M. Chamberlain, R. Jellesed, J. Mohr,
and D. Walker

EMP - P8812

CONTENTS

CAD TRAINING: LOOK BEFORE YOU LEAP

Mark Chamberlain
Robert Jellesed
Joe Mohr
Karen Walker

Submitted to Dr. Kocaoglu
Director of Engineering Management Program
Portland State University
Fall 1988

1. Introduction

At the last board of directors meeting of the XYZ Widget company the president, Carl Worldly, was told his engineering organization was technologically falling behind his competitors and he was responsible to reverse the downward trend. As a first step, he plans to introduce a CAD system into the company before the end of the year. In the distribution of work to his staff, Frank Stucky was told to come up with a training plan to meet Mr. Worldly's goal.

This paper examines factors that may aid management in implementing a successful and strategic CAD training program during the introduction of CAD within the engineering environment.

1.1 The Promise of CAD

Most people have had the dubious pleasure of attending a large CAD/CAM show, may have noticed the similarities between the vendor area and a carnival side show. Hawkers and salesmen/saleswomen come from all sides, telling you about the enormous productivity gains that will be experienced if your company will just walk with them toward the future.[18] You are told that your workers will be happy because they are freed from the laborious manual methods to be creative and innovative in their designs. You are blinded with the promise that designs will be cheaper and more reliable because manufacturing is tied into the same system.

After attending the seminars of the CAD vendors and reading the literature senior management may feel confident that a CAD system will pay for itself in a short period of time. [16] The company plans to reduce its staff without any productivity loss.

In an article presented at the CAD ED 83 conference, D.C. Smith gives us some general guidelines on how a CAD system is sold: [26]

> Turnkey CAD systems are sold on the following premisis:
>
> - They are installed 'ready to use'. That system can do what a customer requires had been previously demonstrated and the need for a staff of computer software and hardware specialists is obviated.
> - The system is easy to use. Draftsmen and designers with no previous computer experience can easily operate the system.
> - The system is menu-operated and the menus can be changed or updated by the designers at any time.

- A series of commands can be combined so that they are initiated by one command called a macro.

The system relieves the designer of the more mundane tasks of drawing, for example, cross hatching, dimensioning, updating drawings and writing bills of material. This leaves him or her with more time to devote to solving engineering and design problems.

How can anyone go wrong?

1.2 The Reality of CAD

In the article by Beatty and Gordon, a fictitious company president, Bill Horton of ACME Automotive, leaps onto the CAD/CAM bandwagon only to be disappointed:

> Horton signed that order three years ago. Today a pained expression crosses his face as he explains that CAD/CAM has not improved productivity at all. As a matter of fact, it has turned out to be little more than an expensive drafting board, and he wonders what went wrong.[16]

Unfortunately this is not an uncommon problem, but it is one that is not well documented. Companies don't want to talk about failures or the fact that they have wasted a substantial amount of money.

1.3 Can Training Turn the Promise Into Reality?

The introduction of CAD, or any new technology, into a living organization, is analogous to the transplant of an heart into a living organism. Painstaking work must be done up front for the introduction of the new heart. Even after the operation there is time to recover before the organism is fully functional. There is always a chance that the organism will try to reject the heart treating it as a foreign body that is to be attacked. Standard procedure is to control the immune system until the body has a chance to accept the new heart.

The same holds true for an organization. Great care needs to be taken during the introduction to reduce the damage done to the organization. Plans need to be made to deal with the immune response of the culture within the organization. Just as in the living organism, a rejection of a new technology will have serious consequences on the whole organization.

If it is an accepted fact that the introduction of a technology is inevitable, then planning must be done to manage the change. A major tool in the management arsenal is effective training.[27]

2. Addressing the Human Aspects of CAD Introduction

2.1 Fears and Phobias Encountered

The introduction of CAD into an existing engineering group represents a major change and is often accompanied by the fears associated with change. With CAD, the fears differ with the level of the people involved [16].

At the senior levels, there is fear of poor outcome associated with CAD introduction. Those who made the decision to bring in a CAD system now face the task of proving that decision to be beneficial. Others, not directly responsible for the decision, but responsible for introducing the CAD system, may resist the change. There is an aversion to associate with the new system until it proves successful.

Those at lower levels must deal with the uncertainty of learning a new system as well as being evaluated on their new skills and ability to make the transition. Some workers worry that they may be laid off or their jobs may be downgraded [18].

In addition to fears of displacement and impact to future job opportunities, people often fear the new technology itself. Research done in 1982 showed that at least thirty percent of the business community dealing daily with computers experiences some form of anxiety about computers [1]. Users can experience anxiety due to feelings of control loss and lack of experience with input devices such as a keyboard or mouse. Some users fear they will do major damage to existing data or files during input [2]. This anxiety may be based on prior experience and therefore, may more easily be overcome as opposed to anxieties associated with deeply entrenched attitudes or personality traits [1]. Fear of the hardware may be eradicated by allowing the new user to become familiar with the system through hands-on training.

2.2 Worker Attitudes

Introduction of a CAD system may represent a major change to its users. Resistance to CAD by individuals is as a natural, though irrational tendency of humans to resist change, even beneficial change [16].

When top management shows support of new technology through presentations of corporate priorities and sessions in which employees' questions are answered, employees see the new technology as being important[2]. They develop a better understanding of how the new introduction fits into the future plans for their organization and how they as individuals can help in those plans [3]. Another study showed that the inclusion of supervisors in training can be particularly beneficial since they have a major influence on workers' acceptance of automation [19]. When the management "buys in" the workers resistance to change will be lessened.

Another area which needs to be addressed during the introduction of a CAD system is its effect on older workers. Older workers may fear that their skills are no longer needed and they will be phased out. They see CAD as less of an advantage to their careers since they have often reached the limit of their growth and advancement. Some workers may be near retirement and feel there is no reason to learn new skills given the length of time remaining in their careers. Older workers may also resist the new technology because they have developed unique skills better suited to using manual methods [18].

Training represents a way to bring these users' CAD skills up to their present level using manual methods.

Younger workers seem better able to accept the transition to CAD. They often see CAD as an opportunity for career advancement since it can broaden the jobs available to them. Even when younger workers have not be selected for the initial training on a CAD system, they often feel that it is only a matter of time before they will have the opportunity to use the system and often look forward to future training [18]. The younger CAD users see CAD as a major part of their future, and perceive it as a skill which will provide them career growth in the future.

2.3 Worker Displacement

When new technology is introduced, workers often fear being displaced to lower paying jobs or even losing their employment [18]. One study shows that, in many plants, workers are either laid off or shifted to other parts of the plant not requiring new training [19]. However, another source cites case studies which show that drafters are not laid off with CAD [18]. This source found that demand for personnel to input designs actually increases and therefore creates jobs for those who would otherwise be shifted to new jobs or laid off.

A study of skill requirements for CAD/CAM shows that the introduction of CAD causes a shift toward higher skill level, as well as change in the knowledge base and thinking process required [22]. This might imply that workers, who would otherwise have been displaced, can be shifted to new jobs through the use of training. One study discussed GE's training program and indicated that GE found that it was cheaper to retrain personnel than to layoff and hire already-trained personnel [19]. Competition for trained CAD personnel is strong enough that some companies avoid vendor training courses which would allow their employees contact with employees from other companies fearing that they will be paying for training of their own workers only to have them "stolen" away by the other company [17].

Due to the upgrading of worker skill-requirements, additional training is required for potential CAD users. It was found that companies are finding it necessary to send workers through training programs to shift their skill level upward [22,17,4]. In fact, one source claims that it is now commonly accepted that the introduction of computer based technologies demands increased training [4].

2.4 Rewards and Incentives

In creating incentives to participate in CAD training, the new career path should be emphasized. For workers who have reached a plateau in their advancement, training in CAD represents an opportunity to move into a growth phase again. This can aid the organization itself by helping combat technical obsolescence. Several studies showed that there is a demand for workers with CAD skills. The number of workers with those skills is significantly less than the demand. This can offer the prospective CAD trainee more job security once they acquire CAD skills.

Companies seem to be developing entire CAD departments. This provides the opportunity for new jobs for those trained in CAD skills. Possible new jobs are CAD system administrator, CAD coordinator, and CAD trainer.

In talking with career placement personnel, it seems that people with CAD skills are placed in higher-paying positions than persons with manual skills. This would seem to follow from the requirement of increased skill level when dealing with CAD systems. This is another possible incentive for people to participate in training for CAD.

3. Criteria Selection, Employee Training, and Implementation Strategies

Organizational objectives and existing workforce skills should be primary factors in determining a strategic training plan. The plan should be specific to the organization. Among engineering organizations, training programs differ as much as the organizations themselves (and rightly so). This variation precludes this report from concluding the "best" methods, or approaches for training. Instead, this section illustrates and discusses factors that lead to different approaches and methods used for training implementation. A discussion of personnel chosen for CAD training follows.

3.1 Criteria Used to Select CAD Trainees

Engineering organizations purchase and implement CAD systems over a period of time rather than overnight [22, 23]. This is due, in part, to the initial purchase price of the system, the lack of trained manpower, and supporting procedures to use the CAD system. A CAD system, especially an integrated one, is something that must be "phased in" and "grown" within an organization rather than merely purchased. Firms which are phasing in CAD must often choose only a select handful of employees to obtain initial CAD training. As the CAD system grow within the organization the number of people to be trained increases. The phasing in and selection process may have strategic implications. To examine this concept let us ask ourselves some important questions: 1) What criteria should be used to select CAD personnel? 2) How can training be implemented to gain strategic advantage?

3.1.1 The Selection Process:

A study surveyed two large design organizations, both major users of CAD. Neither company used formal criteria to select CAD trainees nor could any of the survey respondents "articulate" the methods used. The results of the survey seem revealing: the mean age of the CAD users (n=54) was 9.3 years younger ($p<.01$) than the nonusers (n=30); non users had been with the company 6.3 years longer than the CAD users ($p<.05$); the non users had 6.7 years more manual drafting experience than the CAD users ($p<.05$) [18].

Why would a company select younger less experienced personnel to work on the CAD systems? Another study may suggest a probable answer. Michigan automobile suppliers were surveyed to determine the criteria they used to select CAD trainees (see Figure 1) [17]. Employee interest and skill level were the leading positive factors in selection. Seniority was the least significant factor. If younger people are selected for CAD training, and skill level and interest are primary factors in selection, could one assume that younger people are more interested and have a higher skill? Certainly, this is an area in need of further study.

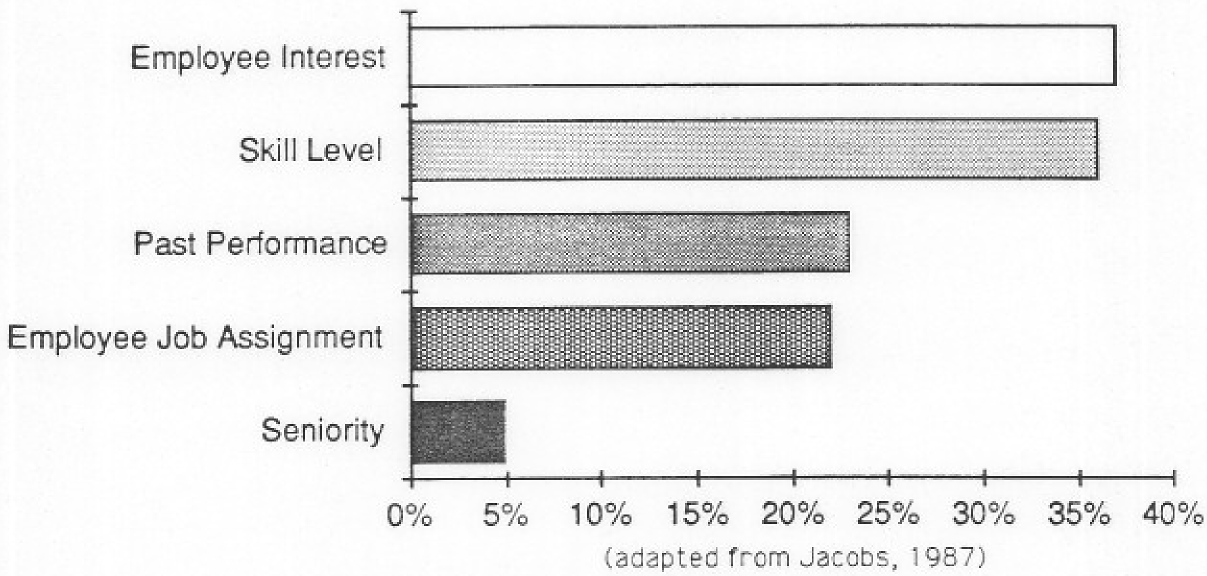

Figure 1, CAD Training Selection Criteria

Thus far we have discussed informal selection methods and biases which continue to be used. At this writing no formal studies correlating specific pre-training skills with post-training CAD success have been found. However, several desirable pre-training prerequisites have been determined. According to Majchrzak, "strong basic skills in math, science, reading and computer literacy will constitute the foundation for all new technology instruction [19]." Not only will technicians and operators of CAD (and CAD related) equipment need new and broader skills but so also will engineers, CAD support and development staffs, and manufacturing personnel [22]. CAD may reduce overall headcount in the lower skilled workforce, but it necessitates a greater skill level in remaining personnel [22] which Adler sums up as "fewer but better [23]."

Knowing CAD is not necessarily productive An engineer must first be knowledgeable in the engineering application and have an understanding of design methodology (Figure 2 predicts the level of familiarity personnel should have with CAD). If this were not the case it would be feasible to think that an unskilled workforce with a knowledge of CAD could substitute for application educated engineers and technicians.

Adler's [22] research suggests that technologies will result in a skill upgrading rather than a "deskilling" of engineers and technicians and states that "highly automated design tools do not allow technicians to replace design engineers." This dispels the notion of an engineering workforce composed primarily of ill-educated push button CAD users.

Figure 2*
Depth of CAD Familiarity by Function

Engineering Personel	CAD Tool	Design Methodologies	Engineering Application
Supervisor/Managers	Med-High	Med-High	Med-High
Operators/Users	Med-High	Med	Med
Downstream Interfacers	Med-High	Med-High	Med
Support & Development	High	Med-High	Low-High
Others	Low	Low	Low

High=> detailed knowledge, Med=> working knowledge, Low=> general knowledge
*The idea for this figure was taken from [15]. However, the content varies considerably.

3.2 Employee Training

Majchrzak hypothesized that the "effects of implementing CAD/CAM reverberate throughout enough of the organization that CAD/CAM related training will be provided to all occupational levels [19]." Figure 2 predicted five categories of personnel that should be educated in CAD. They are (1) supervisor/managers, (2) operators/users, (3) downstream/ upstream interfacers, (4) support & development, and (5) others. The remainder of this section examines and provides some detail regarding the functions within these groups and their necessity for CAD training.

3.2.1 Training For Supervisors and Managers:

Supervisors and managers at all levels constitute this group. Upper and middle level managers may need executive development which includes the cost/benefits and feasibility of CAD integration. They need to be aware that the returns may not be swift and the investment should be considered as long term. Many of the advantages for implementing CAD are seemingly intangible: reduced lead time to market, flexibility for making customer or product changes, reduced scrap, ease of make-froms, and more accurate drawings which reduce manufacturing problems. Middle and lower level managers will need to be educated in the way that CAD fits into the engineering business and the resources that must be acquired. Lower level managers and supervisors must have a knowledge of the CAD system as a tool (albeit, not at the user level).

When multiple technologies are integrated, CAD managers from all levels must understand how the pieces of each technology fit together. Jacobs' study indicates that firms with CAD and CNC are more interested in pursuing engineering and management training than are firms with only one of these computer technologies [17].

Many managers feel that CAD (and CAM) should dramatically change the way that tasks are carried out in their companies [16]. This change may be reflected in process flow and organizational structure changes. In reality however, it has been shown that the structure of the engineering organization has shown little response to the implementation of CAD [18]. Why? Because the "impacts of CAD may have more to do with how managers choose to organize work than any natural consequences of the technology itself [16]". Therefore, it stands to reason that the more training a manager receives the greater will be the managers understanding of the potential benefits of CAD within the organization. Furthermore, the increased understanding coupled with the authority for change may provide a basis for innovative restructuring in order to take greatest advantage of the technology.

To use CAD "technology successfully, companies have to rethink the way they operate and question previous rules of thumb. Disasters occur when inefficiencies that have crept into processes over time are computerized [16]." Managers should be taught to simplify and debug current processes prior to implementing a new technology like CAD. Stand-alone CAD systems can "offer extraordinary possibilities for simplifying the elaborate administrative and control system for cost estimation, lot release, shop orders, materials and performance tracking [22]". Process redefinition may take many forms (e.g. eliminating bottle-necks in processes by excluding a needless checkpoint or including a new checkpoint that will increase the product quality). Blindly imitating existing processes may prove both "expensive and ineffective", especially when the current processes are inefficient [16]. It is better to have new processes outlined and functional prior to implementing CAD training so that they may become part of the training.

Some managers may need basic management update training. The CAD (and CAM) floor managers are predicted to need skills that aid in directing, organizing, and integrating technology and people. Leadership and human relations skills will be necessary for motivating and helping workers adapt to the new technologies [19]. Managers should be educated to know the capabilities of the CAD system and the level of CAD output they can expect from CAD using subordinates.

Project managers must have training on (the precesses used in) information accessibility. They may be concerned about the integrity and validity of the data within the CAD system.

3.2.2 Training For Operators and Users:

The operators and users considered in this group are those on the engineering staff (engineers, designers, and draftsman) that use CAD as a tool in the engineering process.

First, and foremost, engineering data must still communicate the design intent and requirements to other disciplines, such as manufacturing and quality. Learning CAD will not substitute for an understanding of the engineering process. Poor organization of data and sloppy construction of geometry in a CAD file is as unacceptable as a poorly drafted drawing [15]." Downstream use of the design database will become increasingly more productive when upstream design engineers are educated and trained to accurately develop the CAD database (e.g. capture producibility rules). More than ever, these people need to be trained and cultured to regard the integrity of the engineering drawing process. Poor engineers/draftsman will be faster, though equally poor with CAD.

An overall increase in skill requirement will be necessary when the engineering staff can access work, done by one another, to optimize the entire product [23]. "Additional training in the production process, mathematics and the ability to visualize objects and motions in three dimensions [19]" should be given to the engineering staff. Designers need higher skill levels for abstract problem solving, and a greater understanding of the processes and rules that combine to make the end product [23]. The engineering staff will also need a degree of computer competency.

3.2.3 Training For Downstream and Upstream Interfacers:

The term 'Downstream' refers to those that operate on information extracted from the CAD database, 'upstream' refers to those functions that supply information to the CAD database (for further reference see [25]). Functions in this area are typically those related to the manufacturing group or documentation services. They include: CAM computer-aided manufacturing, manufacturing engineering, robotics, NC numerical-control, CAPP computer-aided process planning, MRP manufacturing resource planning, technical publications and documentation.

An increase in skill requirements will be necessary to understand and tie into the CAD database so that design data can be used directly during the manufacturing process. Computer literacy and expertise will be necessary to program and customize the CAM systems. One study (of two companies) indicates a dramatic short term increase in degreed manufacturing engineers from 40% in 1980 to 68% in 1986, another study from 15% in 1976 to 100% in 1986 [23].

People within all levels of these functions are "expected to need increased conceptual skills, perceptual aptitudes, and the ability to read and write operating instructions [19]."

3.2.4 Training For Support and Development Employees:

The support and development group should consist of people with both an engineering and computer science background. Typical titles for people in this group would include: system manager, applications engineer, applications programmer, training specialist, development engineer, network specialist, system analyst, workstation consultant, systems integrator, etc.

This group will need much broader skill than is typically taught by in-house training programs. In fact, this group should have the collective knowledge to establish and provide the initial and on-going in-house training necessary to implement the CAD/CAM system. In-house training as a source of training will be discussed elsewhere in the paper. These people are essential in identifying enhancements to the CAD system and therefore should be educated in the workflow production process.

It has been shown that "firms that planned to buy rather than to develop their own software found that both maintenance requirements and the value of customizing their software drove them to establish and maintain significant staffs of highly-skilled systems developers. In engineering and design drafting, this was particularly the case for CAD software [22]." It is essential that this group receive training from the vendor in all areas of the product the organization intends to use.

Adler believes that automation and technology lead to more automation and technology. This belief provides a basis for his prediction that over time the ratio of system designers to system users will increase [22,23]. Therefore, it may be reasoned that training for the support and development group is of the most primary importance, especially when they serve as an in-house training source.

3.2.5 Others:

Business managers, purchasing agents, accountants, lawyers, salesman, etc., are a part of this "others" group. They are involved with the following functions: administration and business, legal affairs, CAD vendor, engineering standards, and the drawing management control.

The purchase and maintenance agreements of the CAD system are often administered by business managers rather than the engineering department. "Others" that are educated regarding the general intent of the CAD system, its' components (hardware, software, network), and their interrelationship are better able to provide administrative support to the engineering function. Most engineering organizations are not only interested in the original purchase of the system's components but also in subsequent upgrades. This necessitates setting up longer term contractual business relationships with the vending companies; a task perhaps best done through coordination of the engineering department and the business/legal professionals. Although the material was not available for citation, the authors are aware of at least one legal firm that lectures on hi-tech hardware/software contractual agreements. Ignorant contractual mistakes made either by or for the engineering department may be more costly than an hour of general training.

A training alliance between the CAD vendor and the engineering company may be mutually beneficial. Vendor supplied training is important to companies, especially if they are integrating CAD with other technologies [17]. Consequently, the more CAD integration an engineering company performs the greater benefit the engineering company will receive from a vendor having an accurate understanding of its applications and business. That understanding comes through training.

Small discrepancies between the output of the CAD system and the accepted standards of the customer may cause considerable problems. The organization responsible for standards needs to be aware of and educated in the discrepancies that exist so the problems can be rectified. A small discrepancy can hold up the release of an important drawing package.

Underlying the need for data control is the requirement that released drawings be stored, cataloged, and retrievable for modification and/or review. "The ability to disseminate product/manufacturing information quickly also gives you the ability to rapidly distribute erroneous and out dated information as well! [20]" Efficient data control requires training in the CAD database structure and the procedural dataflow to ensure that one and only one "secured" master copy of a released design exists and is disseminated.

4. Training Program Strategies

The time elapsed between a users initial introduction to the CAD system and "successfully" mastering the techniques necessary to operate at a functional level is often depicted as a curve on a graph and termed the "learning curve." The learning curve for CAD varies depending on the quality of the training program, the person, the complexity of the application software, and the criteria that "success" is based on. Figure 3 depicts important elements of the learning curve. The hands-on training is of utmost importance during the basic conceptual training. After a period of time the user will be at the functional level and ready to learn the more advanced applications and techniques.

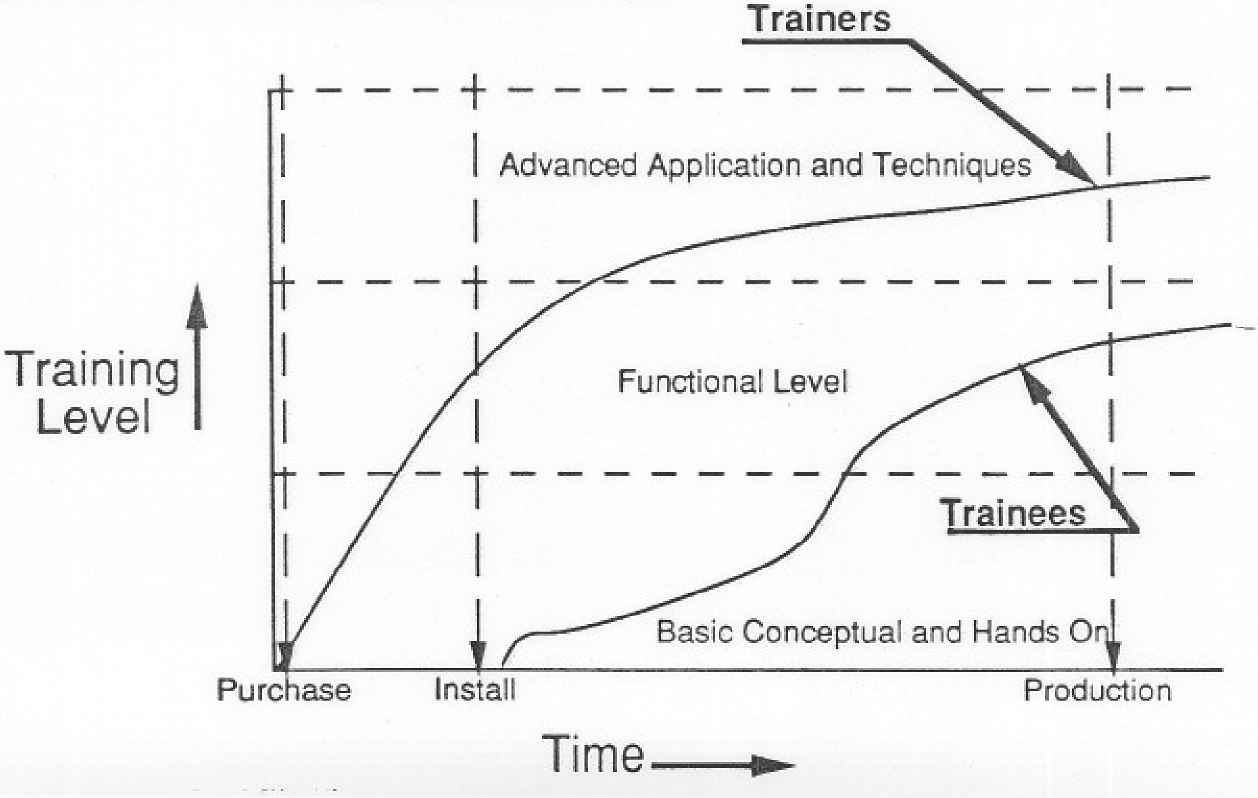

Figure 3

More research is needed in the area of predicting learning curves under a given set of conditions. In the absence of such studies the authors present the following recommendations. Figure 3 illustrates a chronological interrelationship between the learning curves of the in-house support staff and the operators and users. The slopes of the curves differ with the hope that the in-house support staff will assimilate the ideas more rapidly than the operators and users. If so, the company can begin an in-house training program soon after installation. As the support staff gains more advanced knowledge they will be able to provide more customizing, and customized training. The vertical line labeled "production" was placed at the far right to indicate that an installed system is not production ready until the users are functionally trained.

Consider the rows and columns matrix of Figure 4. The following discussion presents the pro's and con's of implementing different training approaches.

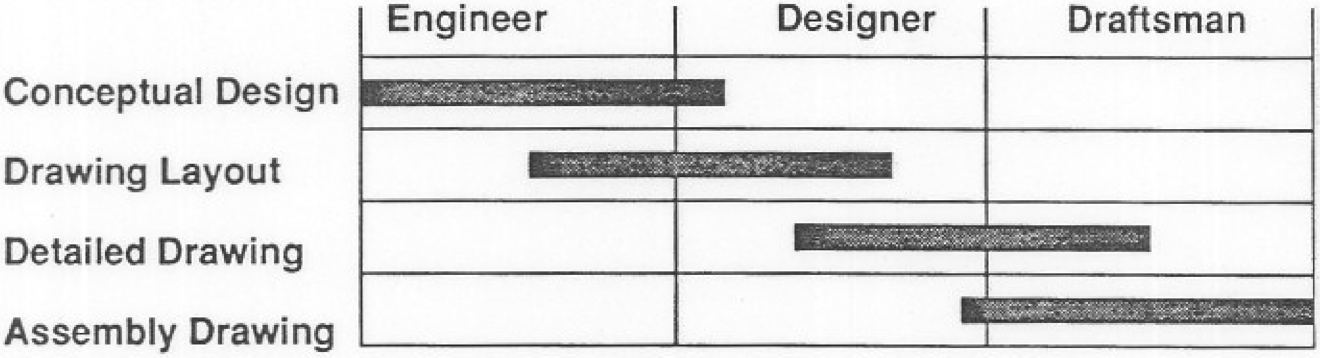

Figure 4

Beginning training with the engineers (i.e. the engineers are trained first) may mean that conceptual design will be the first application on the system. The advantage of CAD during conceptual design is the ability to iterate the conceptual design process more rapidly. Errors caught during the conceptual design process cut down on rework and may provide great potential savings. When the engineer is satisfied with the conceptual design it may be passed on to the designers to make layouts. However, (in our example) the designers and draftsman have not been trained yet. Two way interaction between the conceptual design and any layout/detail or assembly drawing at this point, is like having one foot in the computer and the other out--a very rough approach at best. The CAD system becomes a "tar baby". How does one go about exchanging electronic data to paper data and back again without wasted duplication of effort? The possibility of having to "spare an engineer" to learn CAD may also produce the ramifications of having to reschedule one or two designers and a few draftsman to other projects while "their engineer" is in training and progressing up the learning curve.

Now suppose that the draftsman is trained first. Draftsman are often scheduled more freely than their designer/engineer workmates. Drafting applications on CAD may result in much greater productivity, especially if the draftsman has progressed up the curve, and the system is fully customized (e.g. standard libraries and symbols, etc.). The disadvantages to this approach are again related the tar baby concept. Paper layouts presented to the draftsman must be redrawn electronically at the CAD system -- an inefficient process.

It seems obvious that the best solution is to train an engineer along with the designers and draftsman that work for him/her. Greater benefits accrue when a project is begun in CAD and stays there through the entire engineering drawing process. Future interfaces to solid modelers and analytic packages only increase the benefits. While this method bypasses the tar baby, it too is not without disadvantage. The opportunity to spare and fund an entire project group to learn CAD is rare. If it is true that the younger and less experienced employees are selected to learn CAD, and CAD is used for new project design, then it would seem that the new projects would not benefit from the expertise of the older more experienced employees. This conflict would make a worthwhile study.

The strategic implementation of the training program should be planned considering the organizations engineering staff, projects, and engineering drawing process. A mistake worse than those mentioned above would be to not implement formal training at all.

5. The Training Environment

5.1 Sources of Training

Training can be accomplished through the use of vendor-proveded programs, in-house training programs, private training companies, community colleges, and universities. Each of these approaches involves differences in cost, time, numbers of workers involved, and follow-up training. Large companies can usually afford to send employees to training classes offsite. They also often have the resources to provide in-house training [17]. Sometimes these companies use their own in-house trainers to customize vendor-provided training programs.

Small companies are often limited by cost and ability to be without key personnel. Sneding workers to training sessions often impacts work schedules since there often is no one left to take over during the training. One article [17] suggests the use of community colleges for providing training for smaller companies. The advantages listed include less impact to work schedule, since workers being trained do not have to leave town, and continued follow-up training, since community colleges are often willing to continue providing support after the initial training has been completed. The article cites that a community college is often more flexible in tailoring training than vendors or private training companies and will be less expensive.

5.2 Curriculum and Content

CAD/CAM requires new and broader skills. One source [22] found a shift toward greater training needs virtually across the board. It was also found that there was a shift upward in the level of education of personnel involved in CAD/CAM areas. Maintenance skill requirements also required upgrading when CAD was introduced.

One source noted that the time required for learning is important [23]. Introduction of a new technology can be represented by an S-curve. Management needs to get people into the steeper part of the S-curve sooner rather than later in order to compete with other companies. An effective training program is required to achieve this.

One study showed that many CAD users were not fully utilizing the CAD systems [18]. The CAD systems were often used as nothing more than an "electronic drawing board". Training of users can help get them beyond this stage.

5.2.1 In-House Instruction

The advantages of in-house training include having a trainer that has an in- depth knowledge of the company's processes, procedures, and products, and is well grounded in the engineering fundamentals used by the organization. {1} The trainer is familiar with the framework of the organization and may be with the company long past the initial in-house training. The choice of training instructors is imperative to the success of the training programs. The organizational level and prestige of the persons chosen to be instructors is an indication of the importance management places on the training program.{1}

It is the recommendation of the authors that all members of the CAD Support Staff also double as CAD Trainers. The system manager teaches the system concepts, the applications specialist teaches the applications, the network specialist teaches the network, etc... This method engenders a greater feeling of support to the students and puts the Support Staff in a responsible supporting position from the beginning. The Support Staff would also benefit from cross-training (the applications specialist knows the system managers duties, etc...).

The problem with using dedicated in-house experts is making dedicated in- house experts [see Figure 5]. An ideal way to begin to educate the in-house trainers is to use them on the team that specifies, selects, acquires, and installs the CAD system. "Lusterman {11} and the Bureau of Labor Statistics {12} have found that large firms were more likely to have in-house training programs than small firms. This finding has been explained by the more extensive in-house resource base of larger firms as well as the opportunity larger firms have to capitalize on training activities of other parts of the organization {9}." Jacobs' points out that firms with multiple computer technologies are more likely to increase the number of in-house instructors {7}.

5.3 Scheduling and Allocation

5.3.1 Machines

In order to maximize the usefulness of training, hands-on experience is required. It has been found that it is best to have one machine per person to maximize the effectiveness of training.

5.4 Measurement of Effective Training

One source suggests a survey type of evaluation tool. The survey would ask training participants to evaluate how valuable the training was, how well training met its objectives, whether the person is able to use the new knowledge or skills on the job. Participants should be surveyed again after six months. Additionally, a formal cost-benefit analysis can be conducted six months to one year after training [3].

Did you find any info. on the effectiveness (or the lack thereof) of training programs?

6. TRAINING COSTS

During the CAD acquisition process, management may require an accounting of the proposed training costs. Determining these cost is a subjective task. Both quantifiable and non-quantifiable costs should be considered.

The cost of training personnel on a CAD system depends on several factors:

1 Giving the correct people the correct training (as discussed in Strategies of Training).

2 Selecting the most efficient and productive method(s) of training (as discussed in Training Environment).

3 The degree to which vendor supplied training extends (cost-included or low cost training maybe available).

Literature on projecting training cost is primarily available through CAD vendors. These cost projections may tend to be slightly deflated as to appear more attractive in the initial cost estimates. They do not take into account such factors as cost for machine time and the trainees' productivity losses.

The definition of cost as it is used here can be broken down into several factors:

6.1 Productivity Loss Cost Factors:

These are the costs involved when a worker is removed from the workforce to be trained. Such things as workload and personal productivity can influence this cost factor. Another factor is opportunity cost which is the cost of computer time lost while the student is using it to learn.

6.2 Instructional Costs Factors

When estimating the cost of training for a CAD system the instructional costs will vary as to individual training strategies. Such factors as the number of students, the availability of teaching materials (remember: the CAD station that is used for training could also used for production work) and the size of the CAD system will determine the approach taken in training.

Many firms bring in an expert as a consultant. Cost of this service will vary depending on the location of the company relative to the consultant and the duration of the training. For more common CAD software packages consultants are usually available locally. Pricing is usually done on an hourly basis with instructional materials included. A typical example would be KETIV Technologies, Inc., a general CAD consulting service, charges $40.00 per hour for individualized training. If group training is desired they charge a flat rate of $120.00 an hour for eight or less students. Their training scope ranges from introductory CAD skills to some of the advanced third party software packages. They will come to your workplace to teach class or they can accommodate 5-8 people at their own offices. [11]

In contrast, some vendors like Intergraph offer no training locally. Training is done either by a third party consultant (usually a fellow CAD operator moonlighting) or at their corporate business offices. Considerable cost may be involved in transportation and accommodations for your prospective training class. Their training seminars are usually a week long and incorporate the more advanced CAD application packages with very little focus on basic CAD skills. [12]

One should note that Intergraph CAD packages are typically purchased already customized for the specific application, therefore no basic customization skills are required for the average user.

Training courses that include introductory CAD skills are generally less expensive then the more advanced customized training courses. In addition, not every one need have the more advanced training course work.

More and more CAD training is being done off-site. Kelly Eaton of CAD Oregon, another local CAD training and consulting firm, states:

"In the last year our total floor space dedicated to training has increased 200%. We are finding that employers do not want to tie up CAD workstation time with training and the students feel that they are less likely to get distracted if they go off-site to a remote training facility." [10]

CAD Oregons' training fees are very close to KETIV's but much less expensive then a third party Intergraph consultant.

Many local community colleges offer short courses in introductory CAD training. Their course curriculum is geared primarily to industrial applications. Evening classes are available and the ratio of students to computers is 1:1. The cost of tuition for these courses is about the same as third party consultants. These courses are held on a quarterly basis with some abbreviated sections being offered on weekends.

Computer Aided Design trade shows are held periodically through- out the year. They offer insight on where the industry is going and what products are available to the end-user. In addition they offer educational seminars on different aspects of CAD training and implementation. For instance COMDEX 88 was held this spring in Chicago Ill. In additional to many new product announcements there were seminars that pertained directly to the technical aspects of CAD. This form of training is relatively expensive when compared to other training strategies. Such items as transportation, accommodations and registration fees must be included when estimating these costs. [9]

6.3 SECONDARY TRAINING COSTS

Factors that would represent secondary training cost might include:

1 Books: A small library of reference material should be on hand to assist the new user in learning about their CAD system. These books (not necessarily the owners manuals) will allow the users to have more than one interpretation or explanation of a command.

2 Magazines: Many user magazines are available for specific CAD software packages. They offer additional insight and trouble- shooting techniques not available in the manuals. They also seem to integrate the command structure of the CAD software into a more readable and easy to learn manner. The cost per subscription varies for each magazine. Occasionally, however, fee subscriptions are incorporated into the CAD packages. [13]

3 User Group Fees: Local user groups are formed for popular CAD software packages. These user groups can assist the user in helping them adjust totheir new system and help them to make contact with other CAD professionals in the region.

6.4 COST MODEL

A simple CAD training cost model can be constructed when the training strategy has been identified (see Figure 5). There were no examples available in the literature that addressed this, however, one can pattern a model from a generalized CAD cost model as presented by Teicholz [1988].

$$\sum_{i=1}^{j} \left[I_i * \left[[TC * P] + [H * O] \right] \right] = \text{TOTAL TRAINING COST}$$

TC - THE TOTAL NUMBER OF TRAINING COURSES FOR EACH CLASSIFICATION

P - COST PER COURSE PER PERSON

H - TOTAL HOURS FOR TRAINING FOR EACH JOB CLASSIFACATION.

O - EMPLOYEE OVERHEAD COSTS..

I - TOTAL NUMBER OF EMPLOYEES IN JOB CLASSIFACATION.

j - TOTAL NUMBER OF JOB CLASSIFACTIONS BEING TRAINED.

Figure 5. A simple cost model for training.

To set up this model:

1 Determine how many individuals you have in your organization that are in each job classification.

2 Determine the number of training courses required for each classification.

3 Determine the cost per course. (tuition, course fees etc.)

4 Determine the total course cost per classification:

(3)*(2) = total cost per course per classification.
[Refer to Figure 6]

$$\sum_{i=1}^{j} \left[I_i * \left[\underbrace{[TC * P]}_{\text{TRAINING COSTS}} + [H * O] \right] \right] = \text{TOTAL TRAINING COST}$$

TC - THE TOTAL NUMBER OF TRAINING COURSES FOR EACH CLASSIFICATION

P - COST PER COURSE PER PERSON.

Figure 6. Training costs portion of the cost model

5 Determine the total hours required to complete the training courses for each job classification.

6 Multiply (5) by the overhead for each employee in that classification. [Refer to Figure 7]

$$\sum_{i=1}^{j} \left[I_i * \left[[TC * P] + \underbrace{[H * O]}_{\text{PRODUCTIVITY COSTS}} \right] \right] = \text{TOTAL TRAINING COST}$$

H - TOTAL HOURS FOR TRAINING FOR EACH JOB CLASSIFACATION.

O - EMPLOYEE OVERHEAD COSTS..

Figure 7. Productivity costs portion of the cost model.

7 Determine the training cost per classification by :

(1)*(6) + (1)*(4)

(Productivity cost) + (Training cost)

8 Total these up for each classification to arrive at the total training cost. [Refer to Figure 8].

$$\sum_{i=1}^{j} \underbrace{\left[I_i * \left[\left[TC * P \right] + \left[H * O \right] \right] \right]}_{\text{TOTAL COST PER CLASSIFACTION}} = \text{TOTAL TRAINING COST}$$

I - TOTAL NUMBER OF EMPLOYEES IN JOB CLASSIFACATION.

j - TOTAL NUMBER OF JOB CLASSIFACTIONS BEING TRAINED.

Figure 8. Total training cost per classification.

This model assumes that:

1 There is a training scenario established for each job function. A hypothetical training matrix is presented in Figure 9. This matrix represents a typical training schedule for each job classification.

TRAINING COURSE

JOB CLASSIFICATION	INTRO	CAD I	CAD II	SPECIAL APPLIC.	SYSTEM MANG.	CUSTOM
DRAFTSPERSON	•	•	•			
DESIGNER	•	•	•	•		
DESIGN ENGINEER	•	•	•	•		
STAFF ENGINEER	•	•	•			
SECTION HEAD	•					
CAD TECHNICIAN	•	•	•		•	•
CAD MANAGER	•	•	•		•	
PROJECT ENGINEER	•	•	•			
PROJECT MANAGER	•					

Figure 9. Hypothetical training matrix.

2 There is an established over-head figure for each individual and this over-head figure is a function of job classification only.

3 All individuals in that job function are at the same skill level.

4 All individuals in that job classification will require the same amount of training to achieve the same level of expertise.

Note that hiring someone of a higher CAD skill level will lower the total training cost (lower number of training courses required). Also note that this model does not take into account such items as the cost of additional manuals, instructional aides and magazines that have been previously mentioned.

A number of models have been developed to estimate cost/benefit ratios and total cost of CAD implementation. Chasen and Dow developed a comprehensive cost model. Another excellent costmodel called Ju$tify which was developed by Demand Inc. (Englewood, CO) is highly sophisticated and runs on a personal computer. Both models are designed for highly organized and structured firms. Neither one however has an unique training cost function that can be separated from the model. [6, 7, 8]

More sophisticated models can be constructed that describe CAD training costs. No matter what the complexity of the model the real value lies in its ability to describe its variables and predict the training cost of your own system.

7. Summary

As companies make the transition toward increased levels of technology, CAD systems are becoming more prevalent. The successful introduction of a CAD system within an organization may depend on a strategically designed and implemented training program. Concepts discussed within this paper may be of use as a guidance tool for managers who are involved with CAD training. When planning training, managers should consider the following:

1. Training is an essential element necessary to turn the CAD promise (increased productivity, higher quality, etc.) into reality. Skillful training will help reduce CAD shock during its introduction into the workplace.

2. Strategic ramifications may result from the choice of CAD trainees. Younger employees, with less experience, are generally more interested, and more often chosen for CAD training. Therefore, designs done on CAD may be less likely to be influenced by the older, more experienced employees.

3. CAD training for employees in a variety of functions (administrators, managers, engineering personnel, interfacers, etc.) will benefit the organization. This training could range from a general overview to technical specifics and should be dependent on the function of the employee. This is especially true if CAD is integrated with other technologies.

4. Trade-offs should be examined when implementing training to a specific group of employees (e.g.:all engineers, versus all draftsman, versus all designers, versus all employees working on a given project). Planning should be strategic when deciding the methods and approaches used to implement training.

5. To employees, the importance of the CAD training and implementation process will be signified by the degree of management participation in the process. When management "buys-in", "techno-phobia" and other CAD user fears are reduced. Managers should be prepared to deal with the fears of potentially displaced workers, as well as the fear of skill downgrading.

6. Employees involved with CAD are expected to need a higher level of skill. This is true for the manager as

well as the technician.

7. CAD training can be received from a variety of sources, each with a different cost and quality. In-house training programs offer greater benefits over the long term.

8. A training cost model may be used to aid the manager in planning and forecasting training costs. A step-by-step outline for using a cost model for training has been discussed.

BIBLIOGRAPHY

[1] Morrow, P. Prell, E. & McElroy, J. 1986. "Attitudinal and Behavioral Correlates of Computer Anxiety", Psychological Reports, Vol 59, 1199-1204.

[2] Shore, J. 1985. "The Sachertorte Algorithm and Other Antidotes to Computer Anxiety", The Book Press, Brattleboro, Vermont.

[3] Bernhard, H. & Ingols, C. 1988. "Six Lessons for the Corporate Classroom", Harvard Business Review, Sept.- Oct., 1988 pp ?.

[4] Sturges, M. 1987. "Finding the Right Training Center", Cadence, Vol. 5 No.2, pgs 88-92.

[5] Adler, P. 1988. "Managing High-tech Processes: the Challenge of CAD/CAM", Draft chapter for Managing Complexity in High Technology Industries, Systems and People, edited by Mary Ann Von Glinow and Susan Albers Mohrman, Oxford University Press, forthcoming.

[6] Teicholz, Eric. 1988. Selecting Your Architectural CAD System. A/E/C Systems 88 Training Seminar, Chicago Ill.

[7] Chasen S. H. and J.W. Dow. The Guide for the Evaluation and Implementation of CAD/CAM Systems. CAD/CAM Decisions, Atlanta, GA.

[8] Ju$tify, Computer Software Program for CADD Cost Benefits Analysis. DEMAND Inc. Englewood CO.

[9] Campo, R.C. CAD Manager, RUST International Corp. Portland, OR Personal Communication. Conversation with Robert Jellesed on 10/26/88

[10] Eaton, Kelly, Principle Owner, CAD Oregon, Portland, OR. Personal Communication. Conversation with Robert Jellesed on 9/28/88

[11] Palioca, Robert, Owner, KETIV Technologies, Portland OR. Personal Communication. Conversation with Robert Jellesed on 11/20/88.

[12] Hopkins, Cynthia, Western Regional Sales Manager, Intergraph Corp. Huntsville, AL. Personal Communication. Conversation with Robert Jellesed on 10/03/88.

[13] Griffin, Melody, Managing Editor, CADlyst Magazine, Vancouver BC. Canada, Personal Communication. Conversation with Robert Jellesed on 10/22/88

[14] Bernhard, H. & C. Ingols. 1988. "Six Lessons for the Corporate Classroom", Harvard Business Review, Sept-Oct Vol.96 pgs 93-99.

[15] Meister, A. 1988. "The Challenge of Learning", CADalyst, Vol.15 No.9 Sept

[16] Beatty C. & J. Gordon. 1988 "Barriers to the Implementation of CAD/CAM Systems", Sloan Management Review (MIT), Summer.

[17] Jacobs, J. 1987. "Training Needs of Small and Medium Size Firms in Advanced Manufacturing

Technologies", Proceedings of the 1987 IEEE Conference on Management and Technology (Atlanta, GA., Oct. 27-30), Sponsor IEEE.

[18] Liker J. & M. Fleischer. 1987. "Effects of Implementing Computer-Aided Design on Work Lives of Users and Non-users", Prepublished Draft for special issue on "Social Impacts of Computer-Aided Design" in IEEE Transactions on Engineering Management, University of Michigan, Industrial Technology Institute, Ann Arbor, Michigan.

[19] Majchrzak, A. 1986. "A National Probability Survey on Education and Training for CAD/CAM", IEEE Transactions on Engineering Management, Vol. EM-33, No. 4, November.

[20] Engelke, W. D. 1987."How To Integrate CAD/CAM Systems", New York: Marcel Dekker, Inc., p158.

[21] Lusterman, S. 1977. Education in Industry. New York: Conference Board,

[22] Bureau of Labor Statistics (BLS), Occupational Training in Selected Metalworking Industries. Washington, DC: U.S. Department of Labor, BLS Bulletin 1976/ETA R&D Monograph #53.

[22] Adler, P. 1988 "The Skill Requirements of CAD/CAM: An Exploratory Study", Draft, Dept. of Industrial Engineering and Engineering Management, Stanford University, Research funded by McKinsey & Co. .

[23] Adler, P. 1988. "Managing high-tech processes: the challenge of CAD/CAM", Draft chapter for Managing Complexity in High Technology Industries, Systems and People, Oxford University Press, forthcoming.

[24] David, P. 1984. "A comprehensive approach for CAD ED curriculum elaboration", CADCAM in Education and Training Proceddings, Dr. Paul Aurthur Ed. London

[25] Cutkosky, M. R. and Meindl, J., "Applying Object-Flow Programming to Concurrent Product and Process Design for Mechanical Components," a proposal submitted to the National Science Foundation, August, 1986.

[26] Smith, D.C. 1984. "A Practical Approach to the Training of Engineers. elaboration", CADCAM in Education and Training Proceddings, Dr. Paul Aurthur Ed. London pgs 230-235

[27] Spoonley, C. 1984. " Training needs of CADCAM", CADCAM in Education and Training Proceddings, Dr. Paul Aurthur Ed. London pgs 59-61